

PART 1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with the requirements of Section 210501 Common Work Results - Mechanical General Provisions
- .2 Comply with the requirements of Mechanical Equipment Schedule A Mechanical Specifications Approved Substitute Schedule
- .3 Comply with the requirements of Section 210504 Common Work Results - Mechanical Basic Materials And Methods.

1.2 REFERENCE STANDARDS

- .1 Conform with the requirements of the drawings and specifications, the local Authorities Having Jurisdiction and the Building Code. In the case of conflicting requirements, be governed by the most severe regulations.
- .2 Conform to the most recent Associated Air Balance Council's 'National Standards for Field Measurement and Instrumentation - Total System Balance'.

1.3 QUALIFICATIONS OF TESTING AGENCY

- .1 Minimum qualifications shall be General Membership Standards of Associated Air Balance Council, as published in the AABC 'National Standards for Field Measurement and Instrumentation - Total System Balance'.
- .2 Testing Agency must be independent of affiliation with manufacturers and contractors.
- .3 The testing agency shall be a certified member of Associated Air Balance Council (AABC).

1.4 ACCURACY OF INSTRUMENTATION

- .1 Measuring instruments shall be accurate. Factory re-calibrate and/or recheck calibration of equipment immediately prior to use on this project.
- .2 Include in the final air balance report, separate test results indicating accuracy of instrumentation.
- .3 The Contract Administrator may request re-calibration or use of other instruments where accuracy is questionable.
- .4 When requested by the The Contract Administrator, provide certified proof of accuracy of instrumentation at no extra cost.

1.5 GENERAL SCOPE OF WORK

- .1 Provide personnel for the purpose of making site visits, preparing reports and taking responsibility for ensuring that the specified air and water systems operate in accordance with specified requirements, within a tolerance of plus or minus 5%.
- .2 Review and check the Contract Drawings and specifications, and installed work, to ensure that modifications, if required, are implemented prior to the execution of the work. Provide a report to the The Contract Administrator as required, making whatever recommendations are necessary in the interests of ensuring proper system balance.

- .3 After the installation is adequately completed, inspect, test and balance the specified air and water systems. Co-operate with the Controls subcontractor to achieve required air quantities where modulating dampers etc., are installed.
- .4 After inspecting, testing and balancing the systems, provide a preliminary written report to the The Contract Administrator.
- .5 Make any modifications to the systems as recommended by the The Contract Administrator, Retest and Rebalance the System(s) as required, and submit a final report to the The Contract Administrator.
- .6 In general terms, the scope of work is comprised of the following:
 - .1 After construction, Balance/ Measure/ the New Systems, and provide a Report to the The Contract Administrator.
 - .1 Perform preliminary air system leak test.
 - .2 Perform all necessary testing, balancing and adjustments to provide peak performance of systems.
 - .3 Perform all necessary testing to confirm system conformance to the specifications and drawings.
 - .4 Items to be balanced, , measured and tested include:
 - .1 Hydronic Infloor Heating System Pumps.
 - .2 Test all fire dampers.
 - .3 Balance the Air Volumes for the Air Handling Units including the motorized mixed air damper systems.
 - .4 Balance the air volumes for the Fan-Coil Units.
 - .5 Balance the air volumes for the Exhaust Fans.
 - .6 Balance the air volumes for the HRV.
 - .7 Balance the fluid volumes for the hydronic systems and equipment.

1.6 START-UP AND COMMISSIONING

- .1 Start-up and Commissioning shall be undertaken prior to the Occupancy Stage of each Construction Phase.
- .2 Provide the Equipment, Personnel, Materials and Information necessary to assist the Mechanical subcontractor in completing the Commissioning Process. Refer to Specification Section 230805.
- .3 Assist in completing the required Forms as set forth in Specification Section 230805.
- .4 Provide instructions to The Contract Administrator as required. Refer to Specification Section 210501.

PART 2 PRODUCTS

2.1 REPORTS - GENERAL

- .1 The Contractor shall provide two copies of the preliminary Testing/Balancing Report The Contract Administrator for review and comment. Make any changes requested by the The Contract Administrator, and re-submit two copies. Submission and re-submission shall continue in this manner until the preliminary Testing/Balancing Report has been accepted by the The Contract Administrator. Copies of the final Testing/Balancing Report shall be included in the Operation and Maintenance Manuals.
- .2 Allow for technically qualified personnel to attend meetings at the The Contract Administrator office to discuss and clarify the preliminary Testing/Balancing Report.
- .3 The review of the Testing/Balancing Report is for the sole purpose of ascertaining conformance with the general design concept. The review shall not mean approval of the detailed testing and balancing procedures inherent in the work, the responsibility for which shall remain with the contractor. The review shall not relieve the contractor of the responsibility to meet the requirements of the contract documents. The contractor shall remain responsible for confirming and correlating the information on the jobsite, and for coordinating the work with the other contractors.

2.2 REPORTS

- .1 Reports shall contain the following:
 - .1 Preliminary Air System Leak testing.
 - .2 Installed Equipment Identification including:
 - .1 Location and Unit Identification data.
 - .2 Nameplate Data: Manufacturer, Model, Size, Discharge arrangement and class, HP, voltage, phase, cycles, and full load amps.
 - .3 Installed overload heater size and manufacturer.
 - .4 Identify all required pulleys, sheaves, belts, and adjustments, including sizes and quantities.
 - .3 Specified design data and achieved performance data, including:
 - .1 General: HP, voltage, phase, cycles, and full load amps.
 - .2 Air Systems: Total air flow, individual air flow per outlet with supporting schematic diagrams, fan total static pressures with breakdown showing inlet and discharge pressures, fan R.P.M., O/A and R/A and REL/A air volumes, and inlet and outlet dry bulb and wet bulb temperatures across thermal transmission and mixing equipment.
 - .3 Duct Systems: Air volumes and velocities at equipment and main branches.
 - .4 Hydronic Systems: Total fluid flow, Individual fluid flow of each pump, individual fluid flow per outlet with supporting schematic diagrams, pump total static pressures with breakdown showing inlet and discharge pressures, pump R.P.M., and inlet and outlet temperatures across thermal transmission and mixing equipment.

- .4 Verification of fire protection equipment, including:
 - .1 Permanent location number (eg. Rm-M02) where access to fire damper is possible including description as to which wall in that location fire damper is located (eg. north wall), verification that unit is accessible and has been tested and reset, and date of successful test.

PART 3 INSTALLATION AND EXECUTION

3.1 LEAK TESTING

- .1 Perform preliminary duct system leak test:
 - .1 Test only after securing the approval of the The Contract Administrator.
 - .2 Test after installation of related systems are complete, and before final balancing is done.
 - .3 Leak test low pressure ductwork in accordance with AABC standards. Leak test medium pressure ductwork at 1.5 times the normal duct operating pressure with leakage not to exceed 5% of design CFM for duct branch under test.
 - .4 Coordinate with Ventilation Contractor for installation of required equipment.

3.2 AIR SYSTEM PROCEDURE

- .1 Prior to final inspection, adjust air systems to provide required or specified design air flow quantities. Balance systems to suit space cooling requirements, unless otherwise specified.
- .2 Measure air flow in ducts by velocity traverse of entire cross-sectional area of duct. Measure air flow with appropriate micro-manometers and/or state of the art instruments. Instrument test holes must be approved by The Contract Administrator.
- .3 Measure air quantities at each inlet and outlet. Use approved tube or vane type meters.
- .4 Use volume control devices to regulate air quantities at supply air inlets and exhaust air outlets without creating objectionable air motion or sound levels.
- .5 Make final measurements only after air inlets and outlets are adjusted for optimum air distribution patterns.
- .6 Vary total system air quantities by adjustment of fan speeds. Vary branch duct air quantities by damper regulation.
- .7 Air inlet and outlet air quantities shall be within +/- 10% of specified values. Fan air quantities shall be +/- 5% of specified values.

3.3 WATER BALANCING

- .1 Where more than one pump is connected on a hydronic system, achieved performance shall be recorded when all pumps are operating at the same time, and also when each pump is operating without the other pumps.
- .2 Ensure specified temperature drops across, and fluid flows through, all thermal transmission equipment.

- .3 Instruct piping system installers on proper locations of flow measurement ports.

3.4 FIRE DAMPER TESTING

- .1 Testing shall be performed before air balancing has been started.

- .2 Testing shall include the following:

- .1 Visual inspection to confirm:

- .1 Appropriately rated unit has been installed and CSA/ULC label is affixed and visible through duct/ceiling access door.
- .2 Appropriate duct and/or ceiling access door is installed to permit servicing of unit. Confirm duct access door is openable without interference from adjacent ceiling, pipes, ducts, etc.
- .3 Unit has been installed in accordance to specifications and codes. Confirm clearances, angle framing in place, fire rated material in wall opening, breakaway joints, unit not painted.

- .2 Operational inspection to include:

- .1 Manual release of fusible link allowing unit to close. Confirm tight fit closure without binding.
- .2 Confirm that appropriate fusible link is installed.
- .3 Re-open unit and reset fusible link connection.

- .3 Balancing Contractor shall instruct Ventilation Contractor to repair all fire dampers that have been identified as being faulty. After faulty fire dampers have been repaired, retest them, as indicated above.

3.5 FINAL INSPECTION AND ACCEPTANCE

- .1 At final inspection, recheck to the approval of the The Contract Administrator, data recorded in certified report. Points or areas for check shall be selected by the The Contract Administrator.
- .2 If report is rejected, re-balance systems, submit new certified reports, and make re-inspection at no extra cost.
- .3 After acceptance of certified reports by the The Contract Administrator, permanently mark settings of valves, splitters, dampers and other adjustment devices so that adjustments can be restored if disturbed.

END OF SECTION 230593

PART 1 GENERAL

1.1 RELATED SECTIONS

- .1 Section 013300 - Submittal Procedures.
- .2 Section 230529 - Hangers and Supports for HVAC Piping and Equipment.

1.2 REFERENCES

- .1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - .1 ANSI/ASHRAE/IESNA 90.1; Energy Standard for Buildings Except Low-Rise Residential Buildings.
- .2 American Society for Testing and Materials International, (ASTM)
 - .1 ASTM C411, Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
 - .2 ASTM C449/C449M, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - .3 ASTM C553, Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
 - .4 ASTM C612, Specification for Mineral Fiber Block and Board Thermal Insulation.
 - .5 ASTM C795, Specification for Thermal Insulation for Use with Austenitic Stainless Steel.
 - .6 ASTM C921, Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
 - .7 ASTM C 1071, Specification for Thermal and Acoustical Insulation (Mineral Fiber, Duct Lining Material).
- .3 Canadian General Standards Board (CGSB)
 - .1 CGSB 51-GP-52Ma, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
- .4 Thermal Insulation Association of Canada (TIAC): National Insulation Standards 2005
- .5 Underwriters Laboratories of Canada (ULC)
 - .1 CAN/ULC-S102, Surface Burning Characteristics of Building Materials and Assemblies.
 - .2 CAN/ULC-S701, Thermal Insulation Polyotrene, Boards and Pipe Covering.

1.3 DEFINITIONS

.1 For purposes of this section:

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

1.4 SHOP DRAWINGS

- .1 Submit shop drawings in accordance with Section 013300 - Submittal Procedures.
- .2 Submit for approval manufacturer's catalogue literature related to installation, fabrication for duct jointing recommendations.

1.5 SAMPLES

- .1 Submit samples in accordance with Section 013300 - Submittal Procedures.
- .2 Submit for approval: complete assembly of each type of insulation system, insulation, coating, and adhesive proposed. Mount sample on 12 mm plywood board. Affix typewritten label beneath sample indicating service.

1.6 MANUFACTURERS' INSTRUCTIONS

- .1 Submit manufacturer's installation instructions in accordance with Section 013300 - Submittal Procedures.
- .2 Installation instructions to include procedures used, and installation standards achieved.

1.7 QUALIFICATIONS

- .1 Installer: specialist in performing work of this section, and have at least 3 years successful experience in this size and type of project, member of TIAC.

1.8 DELIVERY, STORAGE AND HANDLING

- .1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- .2 Protect from weather and construction traffic.
- .3 Protect against damage from any source.
- .4 Store at temperatures and conditions recommended by manufacturer.

PART 2 PRODUCTS

2.1 FIRE AND SMOKE RATING

- .1 In accordance with CAN/ULC-S102:
 - .1 Maximum flame spread rating: 25.
 - .2 Maximum smoke developed rating: 50.

2.2 INSULATION

- .1 Mineral fibre: as specified includes glass fibre, rock wool, slag wool.
- .2 Thermal conductivity ("k" factor) not to exceed specified values at 24°C mean temperature when tested in accordance with ASTM C335.
- .3 TIAC Code C-1: Rigid mineral fibre board to ASTM C612, with factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this Section).
- .4 TIAC Code C-2: Mineral fibre blanket to ASTM C553 faced with factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this section).
- .5 TIAC Code D: Acoustical Mineral fibre blanket or board Insulation to ASTM C 1071
 - .1 Acoustic Duct Liner Type 1, flexible, noncombustible blanket:
 - .1 Mineral fibre: to ASTM C 1071 Type 1,
 - .2 Maximum service temperature: 121°C.
 - .3 Density: minimum 24 kg/m³.
 - .4 Maximum velocity on coated air side: 20.3 m/sec.
 - .5 Minimum NRC of 0.45 at 25 mm thickness, based on Type A mounting, to ASTM C 423
 - .2 Acoustic Duct Liner Type 2, semi-rigid, noncombustible:
 - .1 Mineral fibre: to ASTM C 1071 Type 2,.
 - .2 Maximum service temperature: 121°C.
 - .3 Density: minimum 48 kg/m³.
 - .4 Maximum velocity on coated air side: 20.3 m/sec.
 - .5 Minimum NRC of 0.55 at 25 mm thickness, based on Type A mounting, to ASTM C 423

2.3 JACKETS

- .1 Canvas:
 - .1 220 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
 - .2 Lagging adhesive: Compatible with insulation.

2.4 ACCESSORIES

- .1 Vapour retarder lap adhesive:
 - .1 Water based, fire retardant type, compatible with insulation.
- .2 Indoor Vapour Retarder Finish:
 - .1 Vinyl emulsion type acrylic, compatible with insulation.
- .3 Insulating Cement: setting on mineral wool, to ASTM C449.
- .4 ULC Listed Canvas Jacket:
 - .1 220 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
- .5 Tape: self-adhesive, aluminum, reinforced, 50 mm wide minimum.
- .6 Contact adhesive: quick-setting
- .7 Canvas adhesive: washable.
- .8 Tie wire: 1.5 mm stainless steel.
- .9 Banding: 19 mm wide, 0.5 mm thick stainless steel.
- .10 Fasteners: pins with 35 mm square clips, length to suit thickness of insulation.

PART 3 EXECUTION

3.1 PRE-INSTALLATION REQUIREMENTS

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

3.2 INSTALLATION

- .1 Install in accordance with TIAC National Standards 2005.
- .2 Apply materials in accordance with manufacturers instructions and as indicated.
- .3 Use two layers with staggered joints when required nominal thickness exceeds 75 mm.
- .4 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
 - .1 Hangers, supports to be outside vapour retarder jacket.
- .5 Supports, Hangers in accordance with Section 230529 - Hangers and Supports for HVAC Piping and Equipment.
 - .1 Apply high compressive strength insulation where insulation may be compressed by weight of ductwork.
- .6 Fasteners: At 300 mm oc in horizontal and vertical directions, minimum two rows each side.

3.3 DUCT LINER

- .1 Duct dimensions, as indicated, are clear inside duct lining.
- .2 Install in accordance with manufacturer's recommendations, and as follows:
 - .1 Fasten to interior sheet metal surface to TIAC Code CIR/1 or CIF/1
 - .2 Exposed leading edges and transverse joints to be factory coated or coated with adhesive during fabrication.
 - .3 Seal butt joints, exposed edges, weld pin and clip penetrations and damaged areas of liner with joint tape and sealer. Install joint tape in accordance with manufacturer's written recommendations

3.4 DUCTWORK INSULATION SCHEDULE

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

Location (Service)	TIAC Product Code	Vapour Retarder	Insulation Thickness (mm)	TIAC Installation Code
Exposed Rectangular Ducts (Cold And Dual Air Temperature Supply Ducts)	C-1	yes	25	CER/2
Round Ducts or Concealed Rectangular Ducts (Cold And Dual Air Temperature Supply Ducts)	C-2	yes	25	CEF/2
Exposed Rectangular Ducts (Warm Air Supply Ducts)	C-1	no	25	CER/1
Round Ducts or Concealed Rectangular Ducts (Warm Air Supply Ducts)	C-2	no	25	CEF/1
Rectangular Outside Air Ducts (To Mixing Plenum)	C-1	yes	50	CEF/3
Round or Concealed Rectangular Outside Air Ducts (To Mixing Plenum)	C-1	yes	50	CEF/3
Exposed Rectangular Plenums (Outside Air Mixing Plenums)	C-1	yes	50	CEF/3
Round Or Concealed Rectangular Plenums (Outside Air Mixing Plenums)	C-1	yes	50	CEF/3
Exposed Rectangular Exhaust Duct (Between Dampers And Louvers)	C-1	yes	25	CER/2
Round Or Concealed Rectangular Exhaust Duct (Between Dampers And Louvers)	C-2	yes	25	CEF/2
Acoustically lined ducts (Indicated by single line hatching on ductwork.)	D	No	25	CIR/1; CIF/1
Exposed Round or Rectangular Ducts In Space Being Served (Supply, Return And Transfer Air Ducts)	none	none	none	none

- .2 Exposed round ducts 600 mm and larger, smaller sizes where subject to abuse:
 - .1 Use TIAC code C-1 insulation, scored to suit diameter of duct.

.3 Finishes: Conform to following table:

Location	TIAC Code	
	Rectangular	Round
Indoor, Concealed	none	none
Indoor, Exposed Within Mechanical Room	CRF/1	CRD/2
Indoor, Exposed Elsewhere	CRF/2	CRD/3

END OF SECTION 230713

PART 1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with the requirements of Section 210501, Mechanical General Provisions.

1.2 APPLICATION

- .1 This Section applies to and is part of all Parts of The Mechanical Division.

1.3 INTENT

- .1 The intent of the Commissioning Process is to provide assurance that the system(s) are:

- .1 Installed and complete as designed and specified.
- .2 Functioning as intended.
- .3 Optimized to meet the performance criteria specified and implied in the Contract Documents.

- .2 The The Contract Administrator will not take over the Systems without complete acceptable Verification and Certification.

1.4 THE COMMISSIONING AGENT

- .1 The Commissioning Agent:

- .1 May be in the direct employ of the Mechanical subcontractor, and may be the The Contract Administrator or Foreman.
- .2 May be an individual or agency hired on a Contract Basis to undertake the Commissioning Process.

1.5 GENERAL

- .1 Systems Commissioning and the Submission of the appropriate Check sheets will be required to be done at the Occupancy Stage of Construction Phase. Refer to Specification Section 210501.

- .2 Systems Commissioning will be conducted prior to turnover to the The Contract Administrator. The purpose of the Commissioning is to ensure all systems are functioning as designed prior to building turnover to the The Contract Administrator.

- .3 Commissioning will require the presence of knowledgeable representatives of the necessary Mechanical Sub-sub-contractors, Major Equipment Suppliers and Facility Maintenance Staff. Include all necessary costs for systems commissioning. The The Contract Administrator will participate to the extent deemed necessary.

- .4 All aspects of the mechanical systems operations will be operated, checked and verified. If any portion of the work fails to meet the design requirements, the Commissioning procedure will be halted and only resumed when all necessary repairs are completed.

- .1 All extra costs resulting from this postponement, including costs for the The Contract Administrator to revisit the site, will be borne by the Sub-Contractor.

- .5 Provide and pay for all required testing and repairs where, in the opinion of the The Contract Administrator, Manufacturer's ratings or specified performance is not being achieved.

1.6 COMMISSIONING PROCESS

- .1 The Commissioning Process will consist of the following:
 - .1 Periodic Inspections by the The Contract Administrator.
 - .2 Start-up of the Systems and Equipment by the Mechanical Subcontractor.
 - .3 Testing and Balancing of the System Components by the Mechanical Subcontractor and his Sub-sub-contractors.
 - .4 Verification and Certification of the System Components by the Commissioning Agent.
 - .5 Performance Testing by the The Contract Administrator and/or his Representatives.

1.7 INSPECTIONS

- .1 Periodic Inspections by the The Contract Administrator and/or his Representatives of the Mechanical Systems during Installation will be made as per Specification Section 210501 (Mechanical General Provisions), to ensure General Compliance with the Contract Documents.

1.8 START-UP

- .1 Start-up of Equipment and Systems is to be undertaken as per Specification Section 210501 (Mechanical General Provisions).
- .2 Start-up shall only be undertaken after a complete review of the Equipment and Systems
 - .1 All Systems must be clean and ready for use.
 - .2 All System Safeties must be in place.
- .3 Start-up of the Systems and Equipment is the responsibility of the Mechanical Subcontractor
 - .1 The presence of knowledgeable representatives of the necessary Mechanical Sub-sub-contractors and Major Equipment Suppliers may be required.
 - .2 In some instances, especially where existing Equipment and Systems are being used, the presence of the Facility Maintenance Staff will be required.
 - .3 The Mechanical Subcontractor will be responsible for Coordinating all necessary personnel, equipment and materials.
- .4 All System Start-up Check Sheets must be completed at the time of Start-up.
 - .1 Copies of the Start-up Check Sheets are to be submitted to the Commissioning Agent immediately after Start-up.

1.9 TESTING AND BALANCING

- .1 Testing and Balancing of the System Components is the responsibility of the Mechanical Subcontractor and his Sub-sub-contractors.
- .2 Testing and Balancing shall only be undertaken after the Systems and Equipment have been started-up and run-in to the extent that the Systems are relatively stable and there are no obvious deficiencies or problems.

- .3 Testing and Balancing shall be undertaken as per Specification Section 230593.
- .4 Preliminary Copies of the Testing and Balancing Report are to be submitted to the Commissioning Agent immediately after Testing and Balancing.

1.10 VERIFICATION AND CERTIFICATION

- .1 Verification and Certification shall be undertaken in stages:
 - .1 After Start-up, for review of the installed systems.
 - .2 After Testing and Balancing, for review of system operation.
- .2 Scope of Work:
 - .1 The Commissioning Agent shall perform the following tasks:
 - .1 Review all system documentation including:
 - .1 The Contract Documents.
 - .2 The Operation and Maintenance Manuals.
 - .3 The 'As-Built' and 'Record' Drawings.
 - .4 The Air and Water Balance Reports.
 - .5 All Test Results.
 - .2 Ensure all documentation is complete.
 - .1 Notify the Contractors of any deficiencies.
 - .1 Review corrected documentation.
 - .2 Review, Notification and re-review shall continue until all documentation is complete.
 - .3 Review the installed systems to ensure that they are complete and correct.
 - .1 Notify the Contractors of any deficiencies.
 - .1 Review corrected installations.
 - .2 Review, Notification and re-review shall continue until all installations are complete.
 - .4 Operate the systems to ensure they are functioning properly.
 - .1 Function Review shall include:
 - .1 All setpoints are properly set.
 - .2 All balance points are properly set.
 - .3 Sequences of Operation are correct.
 - .2 Notify the Contractors of any deficiencies.
 - .1 Review corrected installations.
 - .3 Review, Notification and re-review shall continue until all systems are functioning properly.
 - .5 Provide a Preliminary Report to the The Contract Administrator.
 - .6 Provide a copy of the final Report in each Operation and Maintenance Manual.

1.11 REPORT

- .1 The Report shall contain a detailed sequence of the Verification Procedure, with the appropriate system responses, and a Letter of Certification of Operation.
- .2 The Report shall contain a completed copy of all Start-up and Verification Check Sheets.
- .3 Provide a preliminary copy of the Report to the The Contract Administrator.
 - .1 The Contract Administrator will review the Report and request Clarifications and Revisions. After all Clarifications and Revisions have been completed, the Report will be deemed Final.
- .4 Provide a copy of the Final Report in each Maintenance Manual.

1.12 PERFORMANCE TESTING

- .1 Performance Testing by the The Contract Administrator and/or his Representatives will commence after the Systems have been turned over to the The Contract Administrator.
- .2 The The Contract Administrator reserves the right to call in Third Party Individuals or Companies to verify that the Systems and Equipment are operating as specified.

END OF SECTION 230805

PART 1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with the requirements of Section 210501 Common Work Results - Mechanical General Provisions
- .2 Comply with the requirements of Mechanical Equipment Schedule A Mechanical Specifications Approved Substitute Schedule
- .3 Comply with the requirements of Section 210504 Common Work Results - Mechanical Basic Materials And Methods.
- .4 Refer to Section 232106 for Radiant Floor Heating System (Infloor Heating System).

1.2 WORK PERFORMED UNDER THIS SECTION (BUT NOT LIMITED TO)

- .1 Supply and installation of Hydronic Infloor Heating System and pipeline devices.
- .2 Supply and installation of Pumps, Fan Coil Units, Infloor Heating System Piping, and Air Handling Units, for complete and fully operating systems.
- .3 Provide Equipment, Personnel and Material necessary to assist with Pipe Cleaning and Chemical Treatment.
- .4 Provide Equipment, Personnel and Material necessary to assist with Air and Water Balancing.

1.3 START-UP AND COMMISSIONING

- .1 Start-up and Commissioning shall be undertaken prior to the Occupancy stage of each Construction Phase.
- .2 Provide the Equipment, Personnel and Material necessary to put the Heating Systems into Operation.
- .3 Provide the Equipment, Personnel, Material and Information necessary to assist the Mechanical Subcontractor in completing the Commissioning Process.
- .4 Complete the required forms as set forth in Specification Section 230805.

1.4 QUALITY ASSURANCE

- .1 Qualifications: execute work of this section only by skilled tradesmen regularly employed in the installation of pressure piping systems and heating and cooling equipment.
- .2 The successful contractor shall have his QCM in place and available to the The Contract Administrator on request.

1.5 SUBMITTALS

- .1 Submit shop drawings on Pumps, Coils, Terminal Heat Transfer Units, and Air Handling Units, etc.

PART 2 PRODUCTS AND MATERIALS

2.1 PUMPS

- .1 Refer to the Mechanical Pump Schedule A of the Mechanical Equipment Schedules and Individual Pump Specifications on the drawings for operating characteristics, specific requirements, and any deviations.

2.3 UNIT HEATERS

- .1 Refer to the Mechanical Unit Heater Schedule M of the Mechanical Equipment Schedules.

2.4 AIR HANDLING UNIT AHU-1

- .1 Refer to the Mechanical Air Handling Unit Schedule B of the Mechanical Equipment Schedules.

2.5 EXPANSION TANK UNITS, AIR PURGERS, AIR VENTS

- .1 Expansion tanks shall be pressurized diaphragm type
 - .1 Construct for a maximum working pressure of 75 psi.
 - .2 Factory pre-charge with air to initial fill pressure of the system.
 - .3 Use sealed in elastomer EPDM diaphragm suitable for an operating temperature of 240°F.
 - .4 Furnish with base mount or saddles as required.
- 2. Air purger shall be constructed of cast iron for a maximum working pressure of 125 psi.
 - .1 Use threaded connections for sizes through 3" inclusive. Use flanged connections for sizes 4" and larger.
- 3. Air vents shall be brass automatic float type air vent.
 - .1 Construction to be suitable for a maximum working pressure of 125 psi and temperature of 240°F.
 - .2 Provide indirect drain line from air vent discharge to nearest approved point of discharge.
- .4 Provide expansion tanks, air purgers, and air vents as indicated and required. Standard of Acceptance: Hamlett Garneau.

2.6 CALIBRATED BALANCING VALVES

- .1 Combined Positive Drip Tight Shutoff, Precision Flow Balancing and Precise Flow Measurement Circuit Balancing Valves.
- .2 Valves 1/2" - 2" npt "Y" pattern equal percentage globe style bronze body and stem. Valves to provide 4 full 360 degree adjustment with micrometer type indicator and hidden memory feature. 90 degree adjustable valves are not acceptable.

- .3 Valves 2½" and above to be "Y" pattern ductile iron body with grooved ends, bronze valve stem and plug disc. Valve to provide 5 turns (2½" and 3"), 6 turns (4" 06") and 12 turns (8" and 10") of balancing adjustment with micrometer type indicator with hidden memory feature. Valves 2½" and above shall be field convertible to straight or 90° pattern. Anti-Rotation Flange Adapters shall be supplied for flanged connections.
- .4 Each valve shall have 2 - 1/4" metering ports with Nordel check valves located on both sides of valve seat. Provide 2 additional 1/4" not connections on opposite side for drain connections. Drain and metering ports shall be interchangeable to suit site conditions.
- .5 Acceptable material: Armstrong CBV, Tour and Anderson

PART 3 INSTALLATION AND EXECUTION

3.1 FLOW MEASURING DEVICES

- .1 To ensure proper balancing of the hydronic systems, provide flow measuring devices as indicated in the Mechanical Drawings and the Infloor Heating System Hydronic Flow Schematic.

3.2 EQUIPMENT AND INFLOOR HEATING PIPING

- .1 Comply with manufacturer's requirements for the installation of all equipment.
- .2 Provide accessories such as pressure relief valves, pressure regulating valves, back flow devices, and other safety devices, in compliance with Department of Labor standards.
- .3 Locate equipment to provide best possible connection arrangement and accessibility for servicing.
- .4 Refer to schematics for piping connections.

3.3 TESTING

- .1 Test piping in accordance with the procedures outlined in Section 210505.
- .2 Ensure that piping and equipment is tested and inspected prior to being insulated or permanently concealed.

3.4 START-UP AND COMMISSIONING

- .1 Prior to the Occupancy Stage of each Construction Phase:
 - .1 Start up the Equipment and Systems as per Specification Section 230805.
 - .2 Calibrate and adjust all items provided under this contract.
 - .3 Assist in the Commissioning Process as required. Refer to Specification Section 230805.
 - .4 Provide instructions to The City. Refer to Specification Section 210501.

END OF SECTION 232105

PART 1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with the requirements of Section 210501 Common Work Results - Mechanical General Provisions
- .2 Comply with the requirements of Mechanical Equipment Schedule A Mechanical Specifications Approved Substitute Schedule
- .3 Comply with the requirements of Section 210504 Common Work Results - Mechanical Basic Materials And Methods.

1.2 WORK PERFORMED UNDER THIS SECTION

- .1 Furnish and install Radiant Floor Heating (RFH) system piping, distribution manifold(s) with balancing and flow control valves, pipe-to-manifold compression nut fittings, manufacturer-approved cold-expansion compression sleeve pipe repair couplings, non-metallic pipe fasteners, controls and installation specialties, supervision and field engineering required for complete and proper function of the system.
 - .1 Provide 'In-Slab' piping as shown on drawing M-4.1.
- .2 Provide Equipment, Personnel and Material necessary to assist with Pipe Cleaning and Chemical Treatment.
- .3 Provide Equipment, Personnel and Material necessary to assist with Air and Water Balancing.

1.3 REGULATORY REQUIREMENTS

- .1 Cross-linked polyethylene (PEXa) pipe shall be manufactured by the high-pressure peroxide (Engel) method, and shall conform and be certified to ASTM F 876, F 877 and CSA B 137.5. Fittings shall conform and be certified to ASTM F 877 or F 2080, and CSA B 137.5. Pipes with an oxygen diffusion barrier shall conform to DIN 4726.

1.4 REFERENCES

- .1 ASTM F 876 - Standard Specification for Cross-linked Polyethylene (PEX) Tubing
- .2 ASTM F 877 – Cross-linked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems
- .3 ASTM F 2080 - Standard Specification for Cold Expansion Fittings with Metal Compression-sleeves for use with Cross-linked Polyethylene (PEX) pipe.
- .4 ASTM E 84 – Surface Burning Characteristics of Building Materials
- .5 CSA B 137.5 - Cross-linked Polyethylene (PEX) Tubing Systems for Pressure Applications.
- .6 CAN/ULC S102.2 – Standard for Surface Burning Characteristics of Flooring, Floor Covering and Miscellaneous Materials and Assemblies
- .7 DIN 4726 - German Standard for Plastic Piping Used in Warm Water Floor Heating Systems

1.5 START-UP AND COMMISSIONING

- .1 Start-up and Commissioning shall be undertaken prior to Occupancy
- .2 Provide the Equipment, Personnel and Material necessary to put the Radiant Floor Heating Systems into Operation.
- .3 Provide the Equipment, Personnel, Material and Information necessary to assist the Mechanical subcontractor in completing the Commissioning Process.

1.6 QUALITY ASSURANCE

- .1 Qualifications: execute work of this section only by skilled tradesmen regularly employed in the installation of Radiant Floor Heating Systems and Equipment.

1.7 SUBMITTALS

- .1 Provide submittals and shop drawings in accordance with the General Requirements and as specified herein.
- .2 Submit shop drawings indicating schematic layout of system, including equipment, critical dimensions and piping/slab penetration details as well as details for protecting exposed PEX piping.
- .3 Submit manufacturer's technical installation instructions.
- .4 Submit independent certification results for the piping systems from a recognized testing laboratory.
- .5 Submit computer-generated RFH system design indicating pipe sizing and panel performance at pipe spacing and water temperatures selected. RFH design calculations to be performed on pipe manufacturer's software.
- .6 Submit catalog data on all equipment, fittings, fasteners and associated items necessary for the installation of the piping and manifolds.

1.8 WARRANTY

- .1 The radiant floor heating pipe manufacturer shall warrant the cross-linked polyethylene piping to be free from defects in material and workmanship for a period of twenty-five (25) years. The design shall be approved either by submittal or stamped by a registered engineer as being complete and accurate.
- .2 Cold-expansion compression-sleeve pipe repair couplings shall be warranted to be free from defects in material and workmanship for a period of twenty-five (25) years.
- .3 All manifolds, distribution headers, thermostats and actuators shall be warranted to be free from defects in material and workmanship for a period of two (2) years.

PART 2 PRODUCTS AND MATERIALS

2.1 PIPING

- .1 Material: All radiant floor heating pipe shall be high-density cross-linked polyethylene manufactured using the high-pressure peroxide method of crosslinking (PEXa) with a minimum degree of cross-linking of 80% when tested in accordance with ASTM D 2765, Method B. Pipe shall conform to ASTM F 876, F 877 and CSA B 137.5, and be certified by CSA or equivalent third-party testing organization. All infloor piping shall be wirsbo HEPEX(TM) plus cross-linked polyethylene PEX-A tubing with oxygen diffusion barrier.
- .2 Temperature and Pressure Ratings: Pipe shall be rated for continuous operation of 100 psi gauge pressure at 180oF temperature (690 kPa @ 82°C), and 80 psi gauge pressure at 200oF temperature (550 kPa @ 93°C).
- .3 Oxygen Diffusion Barrier: Pipe shall have a co-extruded oxygen diffusion barrier capable of limiting oxygen diffusion through the pipe to less than 0.10 mg/l/day at 104oF (40°C) water temperature, in accordance with DIN 4726.
- .4 Bend Radius: The minimum bend radius for cold bending of the pipe shall be not less than five (5) times the outside diameter. Bends with a radius less than this shall require the use of a bending template as supplied by the pipe manufacturer, and/or hot air.
- .5 Flame and Smoke Spread: Pipe to have a Flame Spread Index of less than 25, and a Smoke Developed Index of less than 50, when tested in accordance with ASTM E 84 (US) or CAN/ULC S102.2 (Canada).
- .6 Pipe to be manufactured in an ISO 9001 certified production facility.
- .7 Refer to the Mechanical Drawings for the Locations and Extents of the Infloor Piping.

2.2 FITTINGS

- .1 Compression nut manifold fittings shall be manufactured of corrosion-resistant brass with a barbed insert and a reusable split compression ring.
- .2 Compression-sleeve fittings shall be manufactured of dezincification-resistant brass and shall be supplied by the piping manufacturer as part of a proven cataloged system.
- .3 Fittings shall be third-party certified to applicable standards ASTM F 877, F 2080 and CSA B 137.5 as part of the manufacturer's PEX piping system, with independent listings from IAPMO and ICC, as applicable.
- .4 Fittings embedded within the slab and/or gravel or encased behind walls or ceilings shall be cold-expansion compression-sleeve fittings certified to ASTM F 2080. Compression-sleeve fittings to have minimum inside diameter of 82% of pipe inside diameter.

2.3 MANIFOLDS

- .1 Material: Distribution manifolds shall be manufactured of brass or copper and be supplied by the piping manufacturer as a proven cataloged part of the manufacturer's system.
- .2 Brass manifolds shall be produced from extruded brass round pipe with tapped holes for connections, be pre-assembled and 100% air tested by the manufacturer.

- .3 Balancing Manifolds: Where required by design, brass balancing manifolds shall be equipped with integral visual flow gauges that read to 1 USGPM for each circuit, circuit balancing and flow control valves, isolation valves with integral thermometer housings, and air vent/fill ports. Each circuit valve shall be supplied with a manual actuating handle for filling/purging operation.
- .4 Copper manifolds shall be manufactured from type L copper. Copper and/or brass outlets shall be high-temperature brazed (lead-free) into headers. All outlets in copper headers shall be made using the t-drill process according to ASTM F 2014.
- .5 Refer to the Mechanical Drawings for the Locations of the Zone Manifold/Headers.

PART 3 INSTALLATION AND EXECUTION

3.1 DELIVERY, STORAGE AND HANDLING

- .1 Deliver and store piping and equipment in shipping containers with labeling in place. Pipe to be kept in original shipping boxes until required for installation. Do not expose pipe to ultraviolet light beyond published exposure limits.
- .2 Protect piping and manifolds from entry of contaminating materials by installing suitable plugs in all open pipe ends until installation. Where possible, connect pipes to assembled manifolds to eliminate possibility of contaminants and cross connections.
- .3 Piping shall not be dragged across the ground or concrete surfaces, and shall be stored on a flat surface with no sharp edges.
- .4 Pipe shall be protected from oil, grease, paint, direct sunlight and other elements as recommended by manufacturer.

3.2 INSTALLATION

- .1 Install in accordance with manufacturer's published installation manual and/or published guidelines
- .2 Route piping in orderly manner, according to layout and spacing shown in approved submittal drawings. All notes on drawings shall be followed.
- .3 At connections and fittings, use a plastic pipe cutter to ensure square and clean cuts, and join pipes immediately or cap ends of pipe to seal from contaminants. Where fittings are installed within the slab and they shall be wrapped in chloride-free tape or sealed within a heat-shrink material approved by the manufacturer.
- .4 Pipe should be dispensed using a suitable uncoiling device. Remove all twists prior to securing pipe. Pipe must lie flat on an even plane. Finished grade of a slab and/or gravel must be a minimum of 3/4" (19 mm) above the top of PEX heating pipes. Fasten piping at no more than 3 feet (90 cm) intervals, being careful not to twist the pipe. In thin concrete slabs, it may be necessary to secure piping every 2 feet (60 cm) to prevent floating of the pipes. Use only fasteners supplied or approved by the manufacturer of the PEX pipe.
- .5 Piping that must pass through expansion joints shall be covered in protective polyethylene convoluted sleeving (flexible conduit) extending 15 inches (38 cm) on each side of the joint. Sleeving must be secured on pipe to prevent movement during installation of slab and/or gravel.

- .6 Where piping exits the slab and/or gravel, a protective sleeving conduit shall be placed around the pipe, with the sleeve extending a minimum of 6 inches (15 cm) into the floor and exiting by a minimum of 6 inches (15 cm). For penetrations at manifolds, use rigid PVC bend supports secured in place to prevent movement.
- .7 At the time of installation of each circuit of pipe, connect the pipe to the correct manifold outlet and record pipe length for balancing. If manifold is not installed, cap the end of the pipe and label the pipe's circuit numbers along with S for supply and R for return. Connect pipes to manifold as soon as possible, and record circuit lengths. All circuits shall be labeled to indicate circuit length and serviced area.
- .8 The heating system should not be put into operation until the poured concrete has cured a minimum of 28 days, unless otherwise specified and approved by concrete supplier. If it is necessary to operate the heating system to prevent freezing, a maximum flow temperature of 72°F (22°C) must not be exceeded while the concrete is curing. After curing, gradually increase the flow temperature by no more than 10°F (6°C) each day until system reaches the required operating temperature.
- .9 Coordinate Piping locations with all Architectural and Structural Items, including but not limited to walls, columns, piles and bollards.
- .10 Specific Installation for IN-SLAB PIPING:
 - .1 In-slab piping is to be installed within the poured concrete.
 - .1 Sub-grade shall be compacted, flat and smooth to prevent damage to pipe.
 - .2 Reinforcing wire mesh, if required by structural design, must be flat and level, with all sharp ends pointing down.
 - .3 Finished grade of the concrete slab must be a minimum of 3/4" (19 mm) above the top of the PEX heating pipes, and must not exceed a maximum of 4" (100 mm) below the top of the PEX heating pipes.
 - .2 The following precautions shall be taken in areas intended for carpet:
 - .1 Notify carpet installer that radiant heating pipes have been installed.
 - .2 Keep pipes 6 inches (15 cm) from all wall baseplates.
 - .3 Install metal guards where pipe will pass through wall baseplates and where carpet tack strips will be installed.
 - .3 The following precautions shall be taken in areas intended for hardwood flooring:
 - .1 Ensure that nailing areas for hardwood flooring, if nailing is required, are clearly marked and known to hardwood installers.

3.3 FIELD QUALITY CONTROL

- .1 Filling, Testing & Balancing: Tests of hydronic heating systems shall comply with local codes, and, where required, shall be witnessed by the building official. (Reference BOCA, ICBO, SBCC, ICC or the acceptable code body for the jurisdiction).
- .2 Test piping in accordance with the procedures outlined in Section 210504 Common Work Results - Mechanical Basic Materials And Methods..

- .3 Ensure that piping and equipment is tested and inspected prior to being insulated or permanently concealed.
- .4 Pressure gauges used must show pressure increments of 1 psig and should be located at or near the lowest points in the distribution system.
- .5 Air Test for piping
 - .1 Pressure test the in-slab piping prior to pouring the concrete floor. The pipes cannot be left under pressure while the floor is poured as they will be in an expanded state, and when the pressure is removed and the pipes are cooled, they may shrink enough to break the bond between the pipe and the concrete, which would greatly reduce heat transfer rates.
- .6 Water Test for above slab piping
 - .1 Purge all air from pipes. Charge the completed, yet unconcealed pipes with water. Take necessary precautions to prevent water from freezing. Check the system for leakage, especially at all pipe joints.
- .7 Perform a preliminary pressure test pressurizing the system to the greater of 1.5 times the maximum operating pressure or 100 psig for 30 minutes. As the piping expands, restore pressure, first at 10 minutes into the test and again at 20 minutes. At the end of the 30-minute preliminary test, pressure must not fall by more than 8 psig from the maximum, and there shall be no leakage.
- .8 After performing the preliminary test, perform the main pressure test immediately. The main pressure test shall last 2 hours. The test pressure should be restored and must not fall more than 3 psig after 2 hours. No leakage should be detected.
- .9 Pressure shall be maintained and monitored during installation of the slab and/or gravel. If any leak is detected during installation of slab and/or gravel, leak must be found immediately and the area cleared for repair using manufacturer-approved repair coupling. Retest before covering repair.
- .10 Complete all inspection and test reports as supplied by the manufacturer of the system.

3.4 START-UP AND COMMISSIONING

- .1 Prior to Occupancy:
 - .1 Start up the Equipment and Systems as per Specification 230805 Commissioning.
 - .2 Calibrate and adjust all items provided under this contract.
 - .3 Assist in the Commissioning Process as required. Refer to Specification Section 230805 Commissioning.
 - .4 Provide instructions to The Contract Administrator as required. Section 210501 Common Work Results - Mechanical General Provisions.

END OF SECTION 232106

PART 1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with the requirements of Section 210501 Common Work Results - Mechanical General Provisions
- .2 Comply with the requirements of Mechanical Equipment Schedule A Mechanical Specifications Approved Substitute Schedule
- .3 Comply with the requirements of Section 210504 Common Work Results - Mechanical Basic Materials And Methods.

1.2 WORK PERFORMED UNDER THIS SECTION

- .1 Provision of all required equipment, piping, and chemicals, for the flushing, cleaning and degreasing of all piping systems.
- .2 Provision of all required equipment, piping, and chemicals, for scale, corrosion, algae, and bacteriological control of the closed-loop circulating piping system(s).
- .3 Provision of Propylene Glycol in sufficient quantity to provide 50% propylene glycol / 50% water solution in the piping system and the Fill/Mix tank, suitable for freeze protection to -33°C (-28°F).
- .4 Provide equipment, personnel, and material necessary to assist with water balancing.

1.3 START-UP AND COMMISSIONING

- .1 Provide the Equipment, Personnel, Material and Information necessary to assist the Mechanical Subcontractor in completing the Commissioning Process.
- .2 Complete the required forms as set forth in Specification Section 230805.

1.4 QUALITY ASSURANCE

- .1 Qualifications: Execute work of this section only by skilled tradesman, technicians, and manufacturers regularly employed in the administration of piping system chemical treatment.

1.5 SUBMITTALS

- .1 Submit shop drawings on all equipment and piping arrangements, and provide a list of chemicals.

PART 2 PRODUCTS AND MATERIALS

2.1 WATER TREATMENT

- .1 Domestic Water Piping:
 - .1 Thoroughly flush and disinfect all new Domestic Water Piping Systems as per Municipal Standards.
 - .2 Use Chlorine (gas or liquid). Calcium or Sodium Hypochlorite, or other approved disinfectant may also be used.

- .2 Hydronic Infloor Heating System piping system:
 - .1 Provide a water conditioning system to degrease the piping prior to use.
 - .2 Chemical Treatment in closed-loop systems for the control of corrosion, scaling, algae and bacteria will be provided by the The Contract Administrator after the system has been commissioned.
- .3 Provide welding sockets where required or shown on the drawings, and piping from there to the equipment required for water treatment such as pumps, chemical storage tanks, etc. Include all necessary piping, valves, accessories and control wiring.
- .4 Use only chemicals and methods that comply with local health codes and do not have a detrimental effect on non-metallic materials such as rubber, neoprene, etc., used in the systems.
- .5 Provide pot type feeders on all closed piping systems for the administration of chemical treatment.
- .6 Test equipment: Provide all test apparatus which shall include all required chemicals, comparator, titration equipment, test tubes, etc. to provide a complete testing facility for the treated systems, and turn over to the The Contract Administrator's authorized representative.

PART 3 INSTALLATION AND EXECUTION

3.1 GENERAL

- .1 Clean and disinfect systems only after all pipes, valves, fittings, fixtures and other components have been installed, tested, and proven ready for operation.
- .2 If at any time during the treatment, test results prove unsatisfactory, treatment shall be stopped and redone until results prove satisfactory.

3.2 PROCEDURE FOR CLOSED LOOP SYSTEMS

- .1 Fill and circulate all systems, cleaning strainer baskets as often as necessary to ensure that scale, metal particles, etc. have been completely removed.
- .2 Drain, flush and refill all systems.
- .3 Inject degreasants and circulate the fluid at temperatures, and for time periods, as required to ensure that the systems are thoroughly cleaned.
- .4 Drain and flush all systems.
- .5 Refill all circulating systems in preparation for administration of chemical treatment.
- .6 Administer chemical treatment and circulate the fluid.
- .7 Carefully monitor the condition of the systems from initial fill to the point at which the systems are considered under stable operating conditions.
- .8 Provide oral and written instructions to The Contract Administrator, for the monitoring and maintenance of the water conditioning program.
- .9 Submit a written report showing methods, tests and results.

- .10 Submit a written report of the system start-up showing water analysis and corrosion check test. Include copies in the O & M manuals.

3.3 PROCEDURE FOR OPEN SYSTEMS

- .1 Remove screens from faucets.
- .2 Flush systems with clean potable water to remove dirt and other contaminants.
- .3 Replace screens in faucets.
- .4 Inject the disinfectant at a service cock and ensure all sections of piping are treated.
- .5 Open each outlet at least twice during injection.
- .6 Test chlorine concentration before and after retention. Initial Chlorine concentration shall be not less than 50 ppm, and shall be retained in the system for a minimum of 24 hours. Concentration after retention shall be no less than 5 ppm.
- .7 Flush system with clean potable water until residual chlorine concentration is no greater than that of the incoming water supply. Test Chlorine concentration.
- .8 Submit a written report showing methods, tests and results.

END OF SECTION 232513

PART 1 GENERAL

1.1 GENERAL REQUIREMENTS

- .1 Comply with the requirements of Section 210501 Common Work Results - Mechanical General Provisions
- .2 Comply with the requirements of Mechanical Equipment Schedule A Mechanical Specifications Approved Substitute Schedule
- .3 Comply with the requirements of Section 210504 Common Work Results - Mechanical Basic Materials And Methods.

1.2 WORK PERFORMED UNDER THIS SECTION

- .1 The Mechanical Subcontractor shall provide all labour, materials, equipment and services necessary for and reasonably incidental to the supply and installation of the ductwork for the air conditioning systems as shown on the drawings and hereinafter specified. Generally, this shall include, but not be limited to the following:
 - .1 AHU-1 and all associated ductwork and appurtenances.
 - .2 Fan-Coil units.
 - .3 HRV-1 and all associated ductwork and appurtenances.
 - .4 Exhaust fans and all associated ductwork and appurtenances
 - .5 MAU-1 and all associated ductwork and appurtenances.
 - .6 Other systems as described on the Mechanical Drawings.
- .2 Provide a complete installation of all ventilation systems including fans, ductwork, grilles, diffusers, louvres, dampers, filters, etc.
- .3 Provide Equipment, Personnel and Material necessary to assist with Air and Water Balancing.

1.3 START-UP AND COMMISSIONING

- .1 Start-up and Commissioning shall be undertaken prior to the Occupancy stage of each Construction Phase.
- .2 Provide the Equipment, Personnel and Material necessary to put the Air Distribution Systems into Operation.
- .3 Provide the Equipment, Personnel, Material and Information necessary to assist the Mechanical Subcontractor in completing the Commissioning Process.
- .4 Complete the required forms as set forth in Specification Section 230805.

1.4 QUALITY ASSURANCE

- .1 Execute work of this Section only by skilled tradesmen regularly employed in the manufacture and installation of sheet metal ductwork and air handling equipment.

1.5 SUBMITTALS

- .1 Submit shop drawings on fans, grilles, diffusers, louvres, fire dampers, fire/smoke dampers, filters, and filter gauges.

PART 2 PRODUCTS AND MATERIALS

2.1 FANS

- .1 Refer to the Mechanical Fan Schedule E of the Mechanical Equipment Schedules.

2.2 FILTER GAUGES

- .1 Across the filter bank of each air handling unit, and each air-to-air heat exchanger provide magnehelic differential pressure gauges, Dwyer series 2000 range 0 to 2" w.c. (0 to 50 mm w.c.).

2.3 MOTORIZED DAMPERS

- .1 Unless noted otherwise, motorized dampers are to be provided on equipment, or supplied by the controls contractor and installed by the sheet metal contractor.
- .2 Where motorized dampers are to be provided by the sheet metal contractor, they shall be opposed blade style, with neoprene edge and blade seals, and rated for maximum 5% leakage.

2.4 FIRE DAMPERS AND FIRE STOP FLAPS

- .1 Provide where shown on the drawings and required to maintain fire separations, type 'B' or 'C', gravity or spring type, U.L.C. labeled and listed, curtain type fire dampers. Use type "A" only where mounted directly behind supply or return grilles.
- .2 Do not use asbestos in any form in the construction of fire dampers or fire stop flaps.

2.5 COMBINATION FIRE/SMOKE DAMPERS

- .1 Provide where shown on the drawings, and where required to maintain smoke separations, combination fire/smoke dampers meeting all requirements of ULC, UL, NBC and NFC.
- .2 Dampers shall be equipped with fusible linkages for fire operation.
- .3 Dampers shall be equipped with 120V (spring close) damper motors mounted outside of the airstream and wired to the fire alarm system. Motors shall be c/w an end switch, suitable for wiring to a test switch and light.
- .4 Motors shall be Honeywell Model ML-4115, or Belimo FS-NF-120-S, with no alternates or equals.

2.6 FLEXIBLE CONNECTIONS

- .1 General HVAC System: provide where indicated, at fans and at air handling units, neoprene coated glass fabric, factory fabricated, flexible connections, as approved by the Authorities Having Jurisdiction.
- .2 Except where noted otherwise, connections up to 750 mm (30") in the largest dimension shall be 100 mm (4"). Connections larger than 750 mm to be 150 mm (6").

2.7 TURNING VANES

- .1 Use in duct elbows which have a throat radius of 1-1/2 times the diameter.
- .2 Where use of above item is precluded by space limitations, use duct elbows fabricated with square throats and backs and fitted with "Rovane", single thickness turning vanes with trailing edge.

2.8 DUCTWORK

- .1 Flexible, insulated duct may be used for diffuser connections. Maximum length: 1800mm (6'-0").
- .2 Except as noted above, provide ductwork constructed of galvanized steel sheets as follows:
 - .1 Round spiral 4 ply seam
 - .1 Up to 450 mm (18") 26 Ga.
 - .2 457 to 750 mm (19" to 30") 24 Ga.
 - .3 Slip joint with 3 @ #8 screws evenly spaced.
 - .2 Rectangular with Longitudinal seam
 - .1 Up to 300 mm (12") S and Drive cleat 26 Ga.
 - .2 325 to 750 mm (13" to 30") S and Drive cleat 24 Ga.
 - .3 775 to 1275 mm (31" to 50") 22 Ga.
25 mm (1") bar slip or standing T @ 1.5 m (60") o.c. (max).
 - .4 1300 to 1500 mm (51" to 60") 20 Ga.
40 mm (1-1/2") bar slip or standing T @ 1.5 m (60") o.c. (max).
 - .3 Cross break all rectangular ductwork greater than 600 mm (24") wide.

2.9 ACOUSTIC INSULATION

- .1 Provide acoustic lining in all ductwork where indicated on the drawings, 25 mm (1") thick, 24 kg/m³ (1.5 lbs/Ft³) density, fibreglass with acoustical non-abradable, neoprene facing.
- .2 Duct sizes shown on the drawings are clear inside dimensions. Sheet metal sizes shall increase as required to accommodate the thickness of the internal insulation, to maintain the equivalent free area noted on the drawings.

2.10 DUCT ACCESS DOORS

- .1 Access doors shall be latched and gasketed, constructed of 22 gauge materials with flat iron or angle iron stiffening forms, so constructed that the door can be operated without twisting or distortion.
- .2 Doors in insulated ductwork: double panel construction with a 25 mm (1") insulating filler.

2.11 REGISTERS, GRILLES, DIFFUSERS

- .1 Refer to Grille and Diffuser Specifications on the Drawings.
- .2 Air extractors shall be provided where indicated and/or where supply outlets are directly connected to a trunk duct.
- .3 All supply diffusers shall be equipped with manufactured balancing dampers where branch duct dampers are not shown.

2.12 LOUVRES

- .1 Louvres shall be 100mm (4") thick, extruded aluminum, c/w bird screen, equal to Airolite K-609 or Ventex LVR-4.

2.13 SPLITTER AND QUADRANT DAMPERS

- .1 Provide splitter and quadrant dampers where shown on the drawings and as directed by the air balancing contractor.
- .2 Construct dampers of not less than 22 gauge material. Where installed in ducts up to 300 mm (12") high, provide single blade dampers. Where installed in ducts greater than 300 mm (12") high, provide multi-blade dampers, each blade being not higher than 228 mm (9").

2.14 DRIP PANS

- .1 Drip pans shall be constructed of galvanized steel one gauge heavier than indicated in duct gauge schedule, with all joints soldered. Line inside with two coats of mastic and insulate exterior.
- .2 Pans shall have 50 mm (2") high sides and shall be 150 mm (6") larger in both directions than the size of the device or opening requiring the pan.
- .3 Provide soldered drain fitting and 25mm (1") drain line to nearest floor drain, or to location noted on the drawings.

2.15 SECURITY BARS

- .1 Provide in all ductwork and openings penetrating exterior walls and roofs that are 300mmx300mm (12"x12") in size and over.
- .2 Security bars to be steel rods of ½" diameter at 6" on center in both directions, securely anchored to the structure.
- .3 Coordinate the installation with all trades.

PART 3 INSTALLATION AND EXECUTION

3.1 AIR BALANCING

- .1 Provide personnel and materials to assist and work under the direction of the air balancing firm for the removal and replacement of ceiling tiles; installation of pitot tube test opening enclosures; installation of dampers and baffles; provision of access openings and covers; provision of ladders and scaffolds; removal and replacement of guards; removal and replacement, and provision of, required sheave and belt sizes as directed; and other items as necessary for complete and acceptable air balancing procedures.

3.2 FANS

- .1 Comply with manufacturers requirements.
- .2 Ensure vibration free installation.
- .3 Leave access for servicing.

- .4 Install belt guards and weather proof covers as required.

3.3 MOTORIZED DAMPERS

- .1 Install automatic dampers free from distortion and binding of linkages.
- .2 Thoroughly caulk around damper frame.

3.4 FIRE DAMPERS AND FIRE STOP FLAPS

- .1 Locate in fire assemblies and where indicated on the Drawings.
- .2 Install to U.L.C. requirements. Refer to detail drawings.
- .3 Seal around fire damper assembly.
- .4 After completion, have installation approved prior to concealment.

3.5 FILTER GAUGES

- .1 Sensing Points: Locate as directed by the manufacturer and carefully clip tubing to avoid damage and interference with filter removal or servicing.
- .2 Mount gauges for convenient observation.

3.6 DUCT INSTALLATION

- .1 Install ductwork in accordance with SMACNA duct construction standards.
- .2 Ground across flexible connectors with No. 2/0 braided copper strap.
- .3 Install balancing dampers at branch ducts.
- .4 Seal all ductwork joints with high velocity duct sealer - maximum leakage 5%.
- .5 Hangers: Galvanized steel angle with supports rods, locking nuts and washers to the following table. For ducts up to 600mm (24") diameter, 25mm (1") x 20 ga strap hangers may be substituted. Strap hangers to be screw fastened at 100mm (4") o.c. along sides and with at least one screw through the bottom of the duct. Space strap hangers at 2400mm (8'-0") o.c.

<u>Duct Size</u>	<u>Angle Size</u>	<u>Rod Size</u>	<u>Spacing</u>
Up to 750mm (30")	25mm x 25mm x 3mm (1" x 1" x 1/8")	6mm (1/4")	3000mm (10'-0")
755mm to 1000mm (31" to 40")	40mm x 40mm x 3mm (1-1/2" x 1-1/2" x 1/8")	6mm (1/4")	3000mm (10'-0")
1005mm to 1500mm (41" to 60")	40mm x 40mm x 3mm (1-1/2" x 1-1/2" x 1/8")	10mm (3/8")	3000mm (10'-0")

- .6 During installation, protect open ends of ducts to prevent debris and dirt from entering.
- .7 Where ducts are shown alongside of partitions, place tight to the surface.
- .8 Provide baffles, where required to reduce problems of air stratification, as directed by the The Contract Administrator.

- .9 Provide flashings and counter-flashings to suit individual locations.

3.7 VIBRATION AND OBJECTIONABLE NOISES

- .1 Install ductwork free from pulsation, chatter, vibration or objectionable noises. Should any of these defects appear after the system is in operation, correct same by either removing, replacing or reinforcing the work as directed by the The Contract Administrator.

3.8 PLENUMS AND CASINGS

- .1 Install hinged doors to swing outward on the suction side of the fan and inward where a positive pressure may exist in the plenum.
- .2 Provide gasketting around all doors and seal all seams and joints with high velocity duct sealer.
- .3 Construct coil mounting racks to ensure capability of future removal.
- .4 Provide two coats of mastic compound on inner surface of drip trays.
- .5 Seal all joints in filler pieces to prevent by-pass and install filter banks for easy servicing.

3.9 GRILLES, REGISTERS AND DIFFUSERS

- .1 Set squarely in place parallel to adjacent building lines.
- .2 Floor grilles to be set flush with floor coverings except carpet. Frame to lap over carpet.
- .3 Ensure devices are set rigidly in place and properly secured.

3.10 FRESH AIR AND EXHAUST LOUVRES

- .1 Caulk all joints at louvre connection and make duct connection water tight.

3.11 DUCT AND PLENUM CLEANING

- .1 Responsibility: it is the responsibility of the sheet metal sub-trade to ensure that all ductwork installed or modified under this contract is internally and externally clean when handed over to the The Contract Administrator. It includes all ductwork whether lined or not, all plenums and all equipment within duct and plenums.
- .2 Installation Procedure: Wipe or brush ducts clean immediately before installation. Close all dampers immediately following installation thus checking the operation and retarding movement of contaminants through the system. Seal all openings at the end of each day and at such other time as site conditions dictate. Floor opening to be capped with sheet metal or floor grilles plus 0.15 mm thick poly. Other openings to be covered with 0.15 mm thick poly sheet taped so as to be air tight. The ducts must remain sealed until the systems area is ready to be started up and must be resealed if subsequent construction creates a risk of dust entering the ductwork.
- .3 Cleaning Procedure:
 - .1 On completion of the duct and plenum installation and prior to the installation of grilles, registers and diffusers and the use of air systems:
 - .2 Vacuum clean all plenums.
 - .3 Install air filters of the specified performance.
 - .4 Blow-out all supply ducts by operating the supply fan.
 - .5 Install grilles, registers and diffusers.
 - .6 Prior to balancing the air systems, but not until authorized by the Design Authority.
 - .7 Vacuum clean all supply and return air ducts, all plenums and all coils.

- .8 Submit a report that certifies all specified air systems have been cleaned. The Design Authority will inspect for cleanliness of ductwork at Substantial Performance.
- .9 The cleaning shall be to the satisfaction of the The Contract Administrator.

3.12

START-UP AND COMMISSIONING

- .1 Prior to the Occupancy Stage of each Construction Phase:
 - .1 Start up the Equipment and Systems as per Specification Section 230805.
 - .2 Calibrate and adjust all items provided under this contract.
 - .3 Assist in the Commissioning Process as required. Refer to Specification Section 230805.
 - .4 Provide instructions to The Contract Administrator as required. Refer to Specification Section 210501.

END OF SECTION 233100