This document contains standards that are the minimum requirements for BCIT construction projects. The information in the document is organized using the MasterFormat® and SectionFormat® systems. It is not a specification; it is intended to supplement the Consultant's own documents. Do not use this information as a standalone specification.

SECTION 23 05 00
COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

.1 BCIT requires LEED Gold building design and operation standards to be met. Select and specify building HVAC systems to maximize LEED Energy Efficiency Credits, while maintaining low life cycle cost approach to the HVAC systems and components.

.2 BCIT Personnel may visit the project site at their discretion and will make arrangements for site access as required.

1.2 RELATED SECTIONS

.1 23 08 00 Commissioning of HVAC.

.2 22 05 53 Identification for Plumbing & Equipment.

.3 Division 26 Electrical.

1.3 REFERENCES

.1 ASHRAE 90.1-2013 Energy Standard for Buildings Except Low-Rise Residential Buildings (ANSI Approved; IES Co-sponsored)

.2 BCIT Technical Guidelines.

.3 British Columbia Building Code, 2012 edition.

.4 CSA B139 Series 15 Installation code for oil-burning equipment.

.5 CSA B149.1-15 Natural gas and propane installation code.

1.4 DESIGN REQUIREMENTS

.1 Refer to BCIT Technical Guidelines for HVAC Design for specification details and minimum standards of acceptance.

.2 Design HVAC systems and select equipment with end goal of maximizing LEED Energy Efficiency Credits within the project budget. BCIT requires new projects to attain LEED Gold standard of certification.

.3 The Consultant and BCIT Facilities Office reserves the right to reject any material, installation, or apparatus which does not conform to the requirements of the standards referenced in this Section, Design Drawings or Specifications.

.4 BCIT Facilities Office policy generally does not require space air-conditioning or relative humidity control for people comfort but only where is necessary for equipment operations.

.5 Controls specifications shall meet BCIT guidelines, based on ESC/Delta Controls. Overall responsibility of mechanical system design and necessary equipment controls shall be Mechanical Consultants' responsibility.

.6 Power wiring is defined as all single or three (3) phase wiring carrying the full current of the mechanical equipment, including wiring of full equipment current carrying line voltage controls and isolation disconnects in line between the power source and the mechanical equipment, and connection to the equipment.

.7 Power Wiring is defined as any wiring 110V and over, while Low Voltage Wiring is any wiring for less than 110V service.

.8 Control and interlock wiring is defined as all mechanical equipment wiring other than the power wiring outlined above.

.9 Interlock wiring may consist of a combination of low voltage and line voltage power wiring in some cases, and shall be the responsibility of the Mechanical Contractor to provide. Example: Remote mounted control panel for sump pump set, with equipment supplied and specified as a "package", will require "interlock wiring" between the remotely mounted panel and the pumps. This "interlock wiring" is the responsibility of the Mechanical Contractor to provide.

.10 Ensure BCIT Facilities Maintenance personnel are given access to review work at the site at key milestones and periodically through the work.

1.5 COORDINATION

.1 Coordinate with BCIT Building Operations - Technical Services.

.2 Coordinate with BCIT Utilities.

.3 Coordinate with BCIT Information Technology (IT).

.4 Coordinate with architectural discipline for specific framing, finishes and locations.

1.6 SUBMITTALS

.1 Shop Drawings:

.1 Drawings shall show Project Name and BCIT Project Reference number, name of Contractor submitting Shop Drawing, Title of Submittal (what it's for), labeling of components or items to match Equipment Schedule tagging, and indication on individual Shop Drawing Sheets of specific components and options being supplied.

.2 Where a piece of equipment is being supplied as a number of component parts, bind together Drawings and submittals that apply to the equipment as a single submission with clear references to system or equipment being submitted.

.3 Show sufficient detail of project specific installation details and installation-specific details and accessories on Drawings. Indicate project specific dimensions and coordination requirements required by other trades to accomplish a fully functioning installation.

.4 Include LEED documentation requirements towards energy credits, ratings, efficiencies and operating data to enable LEED Energy Modeling and documentation to be completed.

.5 Consultant shall review Shop Drawings and return as quickly as possible.

.6 Where Contractor installs equipment or systems for which shop drawings were required, and reviewed Shop Drawings were not submitted to the Consultant, Contractor shall rectify condemned equipment and systems at no cost to BCIT.

.7 Coordinate supports with structural and/or pre-engineered building Drawings and contractors. Submit Shop Drawing details of supports and bases to Consultant for approval.

.2 Record Drawings:

.1 Contractor shall produce a complete set of Record Drawings for Final Completion of Project. Include changes, revisions in routing, installation details and maintenance access points and devices in the as-constructed final configuration of the project. Provide additional set of floor plans showing control devices locations with their respective control tag/label.

.2 When requested, provide a set of white prints with changes and deviations from runs of piping, ductwork, conduit and other services from where shown on Drawings marked in coloured ink. Upon completion of work, ensure exact locations of services are indicated

as installed. Retain Record Drawings at site and update as work progresses. Submit completed record drawings before final certificate of job acceptance is issued.

.3 Mark in dimension locations of buried drains, access doors, pipes, duct, conduit, tanks, pads, manholes etc. to building column centres or other fixed reference points.

.4 Prepare and submit AutoCAD or Revit record drawings, with Contractor's logo/title in title block and a dated box indicating "Record Drawings, Dated _____". Provide Adobe versions for inclusion in Maintenance Manuals.

.3 Operation & Maintenance Manual:

.1 Bind within hard-covered, loose-leaf binders, maximum 3" (75mm) thick, three (3) complete sets of manufacturer's operating and maintenance instructions showing all major mechanical equipment and systems.

.1 Include Shop Drawings, detail Drawings and operating curves and complete instructions for installation, operation and maintenance. Include spare part suppliers, lists and addresses.

.2 Review instructions with operating personnel to ensure a thorough understanding of equipment and operation. Include a copy of the Valve Chart. Provide a complete Maintenance Manual in searchable electronic format using appropriate software (Excel, Word, Adobe), including the same required information in hard copy.

1.7 COMMISSIONING

.1 A complete list of equipment and systems to be commissioned are specified in Division 01 General Conditions, General Commissioning Requirements and in Section 23 08 00 Commissioning of HVAC.

.1 The Contractor is responsible to execute the commissioning process, which is defined in Division 01, General Commissioning Requirements.

.2 The Commissioning Agent (CxA) appointed by BCIT and/or Consultant shall manage the commissioning process, for selected projects.

PART 2 - PRODUCTS

2.1 MECHANICAL EQUIPMENT

.1 Clearly mark all exposed ducts, pipes, pullboxes, junction boxes, etc., to indicate the nature of the service. Provide Controls Contractor labels on all "controls" junction boxes and electrical devices.

.2 Identify mechanical equipment with black plastic laminated (Lamacoid) nameplates with white engraving, secured with screws.

.3 Where equipment is surface mounted, mount nameplates on exterior face of door or cover. Where equipment is flush mounted equipment, mount nameplates at top of the inside face of door or cover.

.4 Air terminals shall have a taped-on label noting system connection. For example, ceiling air diffuser shall have a taped-on label denoting "AHU-xx".

.5 Mechanical Contractor shall supply electrical motors, starters in/as part of packaged equipment, controls, relays, thermostats, float switches, pressure switches, flow switches, pilot lights, remote control stations, safety devices, aquastats, control transformers, disconnects for control circuits, and interlocks. Separate starters, as part of a motor control centre, or otherwise, are to be provided by Division 26 Electrical.

.6 Refer to Division 26 Electrical for supply and mount isolation disconnect switches where required for safe servicing of motors, and for disconnects at electrical panels of factory assembled package equipment, e.g. rooftop units, condensing units, air conditioning units.

.7 Refer to Division 26 Electrical for power wiring as defined herein.

.8 Where exhaust fans are roof mounted, factory mount safety isolation switches within the fan, complete with wiring from switch to motor.

.9 Mechanical Contractor shall provide all control and interlock wiring including connection to equipment and to source of supply.

2.2 IDENTIFICATION OF HVAC PIPING

.1 Provide painted colours and banding for HVAC piping systems as follows:

Service	Identification Lettering	Primary Colour	Secondary Colour
Boiler Blow Off Piping	-	yellow	black
Boiler Blowdown	-	yellow	black
Boiler Feed Water	B.F.W.	yellow	black
Chilled Water Return	CH.W.R.	green	-
Chilled Water Supply	CH.W.S	green	-
Cold Water Service	C.W.	green	-
Fire Combined Standpipes	SPR/S.P.	red	white
Compressed Air			
0 to 690 kPa	COMP.A.	green	-
690 kPa and higher	COMP.A.	yellow	black
Condensate - Medium Pressure	M.P.Cond.	yellow	black
Condensate - Low Pressure	L.P.Cond.	yellow	black
Condensate - Pumped	Pump.Cond.	yellow	black
Condenser Water Return	C.W.R	green	-
Condenser Water Supply	C.W.S.	green	-
Cooling Tower Sump Water Supply	C.T.W.S.	green	-
Cooling Tower Sump Water Return	C.T.W.R.	green	-
Non-Potable Cold Water	N.P.W.	purple	-
Exhaust Piping	-	yellow	black
Fire lines W.S.	W.S.	red	white
Fuel oil 2,3,4,5,6	F.O.#	yellow	orange
Glycol Heating Return	GLR - do not drain	yellow	black
Glycol Heating Supply	GLS - do not drain	yellow	black
Heat Pump Water return	H.P.W.R.	yellow	black
Heat Pump Water supply	H.P.W.S.	yellow	black
Heat Recovery (cool)	HRC - do not drain	yellow	black
Heat Recovery (warm)	HRW - do not drain	yellow	black
Hot Water Return	H.W.R.	yellow	black
Hot Water Supply	H.W.S.	yellow	black
Natural Gas	Gas	yellow	orange
Propane	LP GAS	yellow	orange

Service	Identification Lettering	Primary Colour	Secondary Colour
Safety Valve Blowdown	-	yellow	black
Fire Sprinkler lines	SPR	red	white
Fire Sprinkler lines (Dry)	SPR (DRY)	Red	white
Steam	kPa [psi]	yellow	black

.2 Locate colour banding on maximum 3M centers. Paint gas piping and fire protection piping in the primary colour for the full length of the pipe from source to terminal equipment.

2.3 PREFERRED SYSTEMS

.1 Use air systems in combination with perimeter heating/cooling elements. Perimeter elements shall be capable of being operated independent of the air system. Where radiant cooling panels are used, perimeter radiation or radiant ceiling panels shall be capable of supplying building skin loss and/or gain. Locate room return grilles near perimeter above low level heating elements to promote skin heating.

.2 Air handling units:

.1 Design all air handling units with minimum 15% spare volumetric and static pressure capacity.

.2 Locate air handling units of main air systems in mechanical rooms. Roof mounted packaged air units shall only be used for small dedicated systems. Roof mounted equipment locations shall be pre-approved and coordinated by BCIT Facilities Office.

.3 Air handling units shall have heating or preheat coils even if building load indicates that one is not required.

.4 Avoid “all air” systems.

.3 Use variable air volume air systems where applicable.

.4 Use constant volume airflow systems only for local make-up air services, rooms with high occupancy, and related high ventilation requirements and/or for areas requiring to maintain specific cross pressurization between individual rooms and/or zones. Incorporate demand-based ventilation air controls to efficiently use fresh air and provide energy efficiency.

.5 Mechanical Systems:

.1 Zone mechanical systems by intended occupancy, and provide separate interior and exterior zones.

.2 Divide each large air system into individually controlled thermal zones.

.1 Perimeter Zone: Maximum size 75 m^2

.2 Interior Zone: Maximum size 190 m^2.

.3 Where corner rooms have two (2) or more outside wall exposures, separate thermal zones.

.4 Rooms with high and variable occupancy, such as lecture rooms, classrooms, teaching labs etc. shall have a separate thermal control zone.

.5 Equipment rooms and research labs with 24 hour operation shall have small dedicated systems. Do not connect to large air systems.

.6 Fan Volume Control Schemes: Where based on building static pressure, obtain prior approval from BCIT Building Operations.

.1 Use variable frequency drives for fan speed control applications, complete with BACNET compatible interface for Building Automation controls.

.2 Use Room Occupancy sensors where they only have programmable standby mode operation.

.7 Air filters for use in HVAC systems: Adhere to the following nominal trade size:

.1 Pre Filters:

.1 24" x 24" x 2" MERV 8

.2 12" x 24" x 2" MERV 8

.2 Standard Cartridge Filters:

.1 24" x 24" x 2" MERV 13

.2 12" x 24" x 2" MERV 13

.3 Box Filters:

.1 24" x 24" x 12" MERV 13

.2 12" x 24" x 12" MERV 13

.4 Bag Filters will not be considered an acceptable system.

.8 Air filters provided for use in Fan Coil Units: Where practical, cartridge filters for use in Fan Coil Units shall be nominal trade size such as 12" x 24" x 1" and have efficiency rating of MERV 8.

.9 Buildings with no air conditioning: Cooling circulation air shall be increased by minimum of 25% or have sufficient air volume circulation to meet WorkSafe BC requirements with respect to maximum space operative temperature of 26C, whichever is greater. Consider additional costs of construction and compare to costs of adding and operating an air conditioning plant.

.10 Minimum ventilation air volumes: Maintain minimum and maximum space temperatures and space relative humidity at levels required by WCB and ASHRAE-55 standards and/or activity in research and special occupancy rooms.

.11 Classrooms: Do not specify high sidewall supply registers for classroom applications. Low level sidewall displacement ventilation diffusers with a durable face finish are acceptable.

.12 Laboratories: Provide minimum of 10 air changes per hour for laboratories, unless controlled and monitored as per ASHRAE 62.1 latest edition. Alternate proposals, including low flow fume cabinets, shall be approved by BCIT Risk Management Services/Health Safety and Environment and reviewed by BCIT Technical Services.

.13 Laboratory - Exhaust Systems:

.1 Systems shall provide airflows required by the equipment manufacturer and by WorkSafe BC standards for the work area.

.1 Provide exhaust systems for individual equipment and labs where required.

.2 Combine individual room and equipment exhausts into larger systems wherever allowed.

.3 Heights of fume exhaust stacks and/or equivalent exhaust fan airstreams: Minimum discharge height of 5.0 M, unless wind studies show otherwise. Shall meet WorkSafe BC Standards and Metro Vancouver Air Pollution Standard. Consult with and obtain approval by BCIT Facilities Office.

.4 Induced draft fans (Strobic) may use shorter discharge heights with prior acceptance with WorkSafe BC and BCIT.

.2 Evaluate system exhaust volumes in relation to system duty and as recommended by applicable standards, required area, room cross pressurization, lab equipment and good engineering practices. Select exhaust fans to handle required operation and duties and for highest possible efficiency.

.1 Fan motor sizes up to 0.5HP: Single phase 120V,

.2 Fan motor sizes 0.5HP and bigger: Three phase, voltage as required by Division 26.

.3 Provide separate dedicated point source exhaust to photocopier rooms or areas. Exhaust to outdoors. Where total fresh air minimum air quantities exceed 500 l/s, use heat recovery ventilator.

.4 Ensure sufficient air mixing within the occupied space on VAV systems under all operating conditions.

.5 VAV systems shall have reheat coils at all VAV boxes.

.6 Window and/or wall mounted air conditioners and exhaust fans are not acceptable, except for temporary buildings.

.7 Exhaust ductwork within the building shall be under negative pressure.

.8 Where fume hood exhaust systems are located in mechanical penthouses, place in separate self-contained area within the Mechanical Penthouse.

.9 Where fume hood fans are contained within mechanical penthouses, pressurize penthouse with supply air from the building from a safe outside source. This avoids the possibility of recirculating exhaust air into the service space and provides flushing of contaminants if a minor duct leak occurs.

.14 Mechanical Rooms: Specify separate ventilation system. Do not exhaust a mechanical room and create negative air pressure in the mechanical room.

.15 Zone within floor space or each floor: Provide CO_2 sensors connected to the building BMS. Design HVAC controls to allow general purge or flush routine after weekends and holidays.

.16 Return and supply fans requiring volumetric tracking shall have same type devices for volume control, i.e. inlet dampers must be only used with inlet dampers, VFD's with VFD's etc.

2.4 ACCESSORIES

.1 Air Intake Louvers - Outside:

.1 Locate outside air intake louvers as far away as practical from sources of contamination. Do not locate intakes at loading docks, fume hood exhausts, generator exhausts. Do not locate outside air intake louvers on roof tops where fume hood exhausts are located.

.2 Locate outside air intake louvers as high as possible above grade and not at grade level.

.3 Where below grade intakes are unavoidable install bird/debris screen on outside of louvers.

.2 Air Outlets and Inlets:

.1 Do not specify balancing dampers at face of air outlets and inlets. Locate balancing dampers at sufficient distance into ductwork to maintain acceptable sound level within the conditioned space. (NC 30 35 or less).

.2 Provide taped labels on air terminals denoting air unit or fan source. ie. exhaust grille in washroom shall have a taped-on label denoting "EF-xx", as it is connected fan system.

.3 Coupling And Belt Guards:

.1 Provide belt driven equipment with belt guards with tachometer openings at driven and drive shafts. Belt guards: Acceptable product: Open mesh expanded metal type.

.2 Provide coupling guards for pumps with exposed couplings.

.3 Fasten Belt guards and coupling guards by bolts or wing nuts, to ensure easy removal for servicing of equipment.

.4 Dissimilar Metals:

.1 Separate dissimilar metals from direct contact with each other.

.2 Install necessary gaskets and dielectric couplings. Metal screws, clamps, and fastenings shall be of same metal and finish as material supported.

.3 Provide di-electric couplings for “open” water systems; potable water, open cooling tower systems.

.5 Firestopping:

.1 Contractor shall include fire-stopping for mechanical systems and components, including controls wiring, ductwork, piping and other mechanical penetrations through rated fire separations. Equip with permanently applied label at fire-stop location indicating specific ULC Detail # confirming that fire-stop conforms to requirements. Provide summary list of ULC Fire-stop details, with references to specific installations within building, as part of Maintenance Manuals.

.1 Acceptable fire-stopping systems: Hilti Fire-stop Systems, or approved alternative for specific type of penetrations.

.2 Acceptable Firestopping Products: 3M, Tremco, or approved alternative.

.6 Inserts And Fastenings:

.1 Supply and install inserts and fastenings required for support of equipment and hangers provided under this Division. Use beam clamps attached onto structural steel and/or inserts set in concrete. Contractor shall ensure that hangers inserts are placed and coordinated prior to slab pouring.

.2 Where supports are required under roof slab and in other areas where structural bearings of sufficient strength do not exist, provide angle or channel iron supports, properly sized to support load from structural framework using beam clamps. Where wall, partition, floor or roof does not permit support of heavy equipment, carry suitable support to building structure.

.3 Percussion type fastenings of any kind for any service will not be permitted unless prior written acceptance is obtained from BCIT Facilities Office and Consultant.

.4 Brackets may be attached to masonry walls using expansion shields in shear. Do not punch through walls and before drilling is started. Obtain prior acceptance from BCIT Facilities Office and Consultant.

.7 Pipe Expansion And Anchors:

.1 Provide for expansion and contraction of pipe work. Erect pipe to ensure strain and weight does not bear upon cast connections or apparatus. Provide bends, loops, swing joints and expansion joints.

.2 Anchor piping at points shown and where required, using substantial structural steel angles, channels, or plates, well secured to building structure. Strength of anchor in shear and bending is to be approximately equal to strength of pipe being anchored.

.3 Provide pipe roll or structural steel guides, two (2) sets on each side of loop, joint or compensator, spaced at 14 pipe diameters or less and no more than four (4) pipe diameters to first guide. Provide required additional steel to span building structure for this purpose. Where anchor occurs within 10 M, guides may be omitted on one side.

.8 Sleeves:

.1 Contractor shall supply and set required sleeves at exact locations of sleeves.

.2 Steel pipe for piping passing through masonry walls and 1.3 mm galvanized iron for piping passing through concrete walls or floors.

.3 Line sleeves for bare copper piping with copper or lead. Size sleeves to permit insulation to pass through unbroken. Seal around pipes passing through sleeves with fire resistive non hardening mastic (concrete not acceptable) to control transmission of sound and noise, and to provide the full fire rating of the wall or floor. Unused sleeves shall be similarly sealed or filled with concrete. Use individual sleeves for each pipe.

.9 Starters And Controls:

.1 Unless modified in other sections of these specifications or by details or control diagrams, motor starters, control and disconnect switches shall comply with the following requirements. Refer also to Division 26 Electrical Specifications and standards.

.2 Provide each motor with a starter, specified and required protective devices of suitable type, and rating and adequate for condition of application. Comply with Canadian and BC Electric Codes and Local requirements.

.3 Starters shall be rated for safe making and interrupting of motor currents and equipped with overload relays to make or break simultaneously each ungrounded line to the motor.

.4 Use magnetic starters throughout project. Manual starters, with relays where required, may be used for single phase motors.

.5 All manual starters shall have red and green pilot lights.

.6 Equip magnetic starters with the following:

.1 Red and green pilot lights.

.2 Maintained contact on-off selector switch unless otherwise specified.

.3 Momentary contact start-stop pushbutton if starter is controlled by one or more remotely located start-stop stations.

.4 Test-Off-Auto selector switch where two wire automatic devices such as thermostats control starter, pressure switches, float switches, or others. On combination magnetic starters the 'test' position shall be spring return.

.5 Auxiliary contacts: Provide dry contacts connections as required for specified interlocks and control to allow DDC system to read status, alarms, and other outputs as required by BCIT Facilities Operations.

.6 Control Transformer: For remote control devices and stations of secondary voltage as required.

.7 Fused Control circuit.

.8 Overload relays.

.9 Reset Button.

.7 Magnetic starters shall be combination circuit breaker type.

.8 In all cases where magnetic starters are located in equipment manufacturer's cabinets or panels, each motor shall have separate disconnect and separate set of fuses. Panel shall have a main disconnect switch.

.9 Equip single phase 120V starters with one thermal overload device. Equip three (3) phase starters with three (3) thermal overload devices. Thermal overload devices shall be manual reset type. Overload device current ratings as recommended by motor manufacturer.

.10 Starter and control enclosures: Suitable for mounting in installation location. For dry and non-hazardous locations: Nema Type I. Provide required frames and supports required for proper installation, and as accepted by Consultant.

.11 Selector switches, pilot lights, stop-lock-off, start-stop, up-stop-down, and similar controls shall be oil tight heavy duty type.

.12 Selector switches, pushbutton stations, pilot lights, manual single phase starters, etc., located in finished areas or control panels shall be suitable for flush mounting and have brushed stainless steel cover plates.

.13 Motor Starters: Acceptable manufacturers: Canadian General Electric, Federal Pioneer, Westinghouse.

.14 Where motors are to be controlled by variable frequency drives, equip with load side reactors between the VFD and the motor.

.15 Speed control switches for small 120V fans: Lutron Nova NT series sliding bar speed controller, as required for specific load and numbers of fans being controlled, or approved alternative.

.10 Supports And Bases:

.1 Mechanical Contractor shall set out and coordinate with General Contractor/Construction Manager to provide concrete foundations and bases and steel supports, stands and platforms required for proper installation of equipment and work of this Division. Concrete shall be 20 MPa mix, with 10 m reinforcing steel bars on a 10” (250 mm) centered grid, dowelled into structural slab. Formwork shall be plywood finish, with chamfered edges, unless otherwise specified.

.2 Mechanical Contractor shall arrange for and include costs to fabricate miscellaneous metal supports, bases, hangers, wall supports, support frames, cradles, bracing, maintenance catwalks/platforms as shown on Drawings and as required for a complete installation of specific equipment.

.3 Supports and bases shall be as shown on Drawings, as recommended by manufacturer, and as required and accepted by Consultant. Ensure that no undue strain on equipment, piping or ducts is created by support equipment such as boilers, heat pumps, fans, tanks, pumps, softeners, heat exchangers, meters, compressors, transformers, switches, panels, on concrete bases/housekeeping pads, or from building structure, and independently from piping, conduits, and ducts.

.4 Bases: Supply required templates, anchor bolts, inserts and location Drawings for equipment supplied, and supervise Work of installation.

.1 Support bases above the floor shall be at least 50 mm larger all around than the base of the apparatus, with chamfered corners and finished to a smooth neat surface.

.2 Bases shall be 150 mm above the floor and doweled to the concrete floor with not less than four 13 mm dia. steel rods fastened to the reinforcing bars of the floor before pouring, unless shown otherwise on structural Drawings.

.5 Wherever equipment is required to be suspended above floor level and details are not shown on Drawings, mount on platform bracketed from wall.

.1 At locations where wall thickness is inadequate to permit such brackets, supports shall be carried to either ceiling or floor structure, or both.

.2 Coordinate supports with structural and/or pre-engineered building Drawings and contractors. Submit Shop Drawing details of supports and bases to Consultant for approval.

.6 Equipment stands: Constructed of structural steel members or steel pipe and fittings, braced and fastened with flanges bolted to floor. Where saddles are indicated or required, provide welded steel or cast iron saddles, of curvature to suit vessel being supported.

2.5 FINISHES

.1 Provide at least one coat of corrosion resistant primer paint to ferrous supports and site fabricated work.

.2 Provide painting of plumbing and mechanical equipment. Colour: pewter grey unless otherwise specified.

PART 3 - EXECUTION

3.1 ELECTRICAL WORK - MECHANICAL EQUIPMENT

.1 Mechanical Contractor shall mount electrical equipment, except for line voltage wall thermostats and starters, which will be under Division 26 Electrical.

.2 Mechanical Contractor shall provide detailed wiring diagrams for each motor and control where part of packaged equipment.

.3 To obtain line voltage supply for motorized dampers, motorized valves or other controls, provide wiring to the nearest lighting or power panel, including connection to same, unless shown otherwise on the Drawings.

.4 Where a low voltage supply source is required, obtain line voltage supply as described previously and provide control transformers of necessary voltage and wattage to suit low voltage equipment and controls.

.5 Mechanical Contractor, unless specifically indicated otherwise, shall provide wiring for damper motor power and control from nearest lighting panel except where Drawings indicate dedicated controls power outlets by Division 26 Electrical. For these instances Mechanical Contractor shall wire from power outlet to damper motor.

.6 Mechanical Controls Trade shall not run controls network cabling or other controls system wiring in Division 26 Electrical Cable Trays without prior written permission from Electrical Consultant and Division 26 Electrical Contractor. Run control cabling and wiring independently in conduits, and/or in separate raceways provided by the Mechanical Controls Trade for their own use.

3.2 INSTALLATION - STARTERS AND CONTROLS

.1 Controls, interlocks, start stop stations, and control wiring shall be 120V or lower, except if contained entirely within starter, unless otherwise notified. Obtain lower voltage from transformers of adequate rating mounted within the starter.

.1 Transformers shall be oversized where circuits carry external loads in addition to holding coil of starter. Where groups of motors are interlocked to function in a coordinated manner, such as air conditioning system, control circuit wiring shall be in accordance with manufacturer's recommendations.

.2 Starter containing wiring powered by another starter (or source) shall have double voltage relays, mylar covered interlocks, or other such provisions permitted by applicable codes and regulations.

.3 Each motor shall have a disconnecting means, consisting of a disconnect switch of suitable rating designed to break all ungrounded conductors of motor under full load. Locate within 5.0 M and within sight of motor and machinery driven by the motor.

.4 This Division shall provide detailed control wiring schematic diagrams for each motor.

.5 Where motor control centres are shown on the Drawing or where the number of starters grouped in one area warrants the use of motor control centres, specify under 'Motor Control Centres' in this Specification.

3.3 INSTALLATION - ACCESS DOORS

.1 Provide access doors to valves, cleanouts, electrical outlets, dampers, fire dampers, equipment, controls, plumbing devices and other apparatus requiring access where these are built in or concealed behind furring, walls or ceiling.

.2 Supply access doors under this Division, installed by trade providing wall or ceiling. Correct location of access doors is the responsibility of this Division.

.3 Frame and cover shall have a prime coat finish.

.4 Where required to have access doors installed in same area of a ceiling or wall, submit locations of these access doors for Consultant’s approval.

.5 Access doors provided in glazed tile walls shall suit the tile pattern. Refer to Architectural Drawings for Room Finish Schedules.

.6 Access doors in removable lay in T-bar acoustic tile ceilings are not required. Mark locations of removable ceiling tiles in four (4) corners of tiles with approved coloured marking devices. Colours shall indicate nature of item and later services as determined by Consultant.

.7 Provide two (2) sets of record Drawings showing locations of access panels with cross references to their function.

3.4 TESTS

.1 Insulate or conceal work only after testing and acceptance by BCIT Facilities Office and Consultant.

.2 Conduct tests in presence of BCIT Facilities Office representative and Consultant.

.3 Piping:

.1 General: Maintain test pressure without loss for 48 hours unless otherwise specified.

.2 Hydraulically test hydronic piping systems at 1-1/2 times system operating pressure or minimum 1300 kPa, whichever is greater.

.3 Test natural gas systems to latest edition of CAN-B149.1 and requirements of Authorities Having Jurisdiction.

.4 Test fuel oil systems to latest edition of CSA B139, CSA B139S1 and Authorities Having Jurisdiction.

.4 Ductwork: Pressure test 60% of the main runs to branches of main ducts from air units with more than 5,000 l/s of total airflow. Duct leakage shall be less than 1.5% of total airflow at 2x the design static pressure of the ducts.

3.5 PROTECTION

.1 Consultant and BCIT Facilities Office reserves the right to reject any material, installation, or apparatus which does not conform to the requirements of these Standards, the Design Drawings or Specifications.

END OF SECTION

This document contains standards that are the minimum requirements for BCIT construction projects. The information in the document is organized using the MasterFormat® and SectionFormat® systems. It is not a specification; it is intended to supplement the Consultant's own documents. Do not use this information as a standalone specification.

SECTION 23 05 93
TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

.1 Testing, adjustment, and balancing of air and hydronic heating and cooling systems.

.2 Testing, adjustment, and balancing of plumbing temperature balance and timers, infrared urinal flush valves setup and timers.

.3 Measurement of final operating condition of HVAC systems.

.4 Sound measurement of equipment operating conditions.

.5 Vibration measurement of equipment operating conditions.

.6 Post occupancy trim balancing for first year of warrantee as specified.

1.2 REFERENCES

.1 AABC National Standards for Total System Balance.

.2 ADC Test Code for Grilles, Registers, and Diffusers.

.3 ASHRAE 111-08 Testing, Adjusting, and Balancing of Building HVAC Systems (ANSI Approved).

.4 British Columbia Building Code, 2012 Edition.

.5 NEBB Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

.6 SMACNA HVAC Systems Testing, Adjusting, and Balancing.

1.3 PROJECT RECORD DOCUMENTS

.1 Record actual locations of flow measuring stations, balancing valves with final settings and flows, air valves and balancing dampers with final airflows, and complete summary of calibration settings used for devices and equipment.

.2 Include in the Balancing Report complete floor plans and system schematics indicating airflow measurements at terminals, and hydronic plans showing flows as set at heating and cooling terminals and balancing valves. Include system schematic record drawings as part of drawing packages.

.3 Include in the Balancing Report complete information on equipment tested. Pumps and fans information, rotation speed, HP, amperage, total head, and total static pressure, pulleys information where applicable.

1.4 QUALITY ASSURANCE

.1 Perform total system balance to AABC National Standards for Field Measurement and Instrumentation, Total System Balance, ASHRAE 111, NEBB Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems and SMACNA Standards for air systems.

.2 Provide list of equipment, certifications of equipment and personnel, and calibration history of air and water balancing equipment to the Consultant upon request.

1.5 QUALIFICATIONS

.1 Agency: Company specializing in testing, adjusting, and balancing of systems specified in this Section with minimum five (5) years documented experience.

1.6 PRE-BALANCING CONFERENCE

.1 Convene one (1) week prior to commencing work of this Section. Coordinate with BCIT Facilities Office, Contractor and Commissioning Agent for attendance and timing.

.2 At least one (1) pre-balancing site review and report shall be made by Balancing Agent to review general progress of work and note deficiencies that can affect Balancing of mechanical systems.

1.7 SEQUENCING

.1 Sequence work to commence after completion of systems and schedule completion of work before Substantial Completion of Project.

.2 This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned are specified in Division 01 General Conditions, General Commissioning Requirements. The commissioning process, which the Contractor is responsible to execute, is defined in Division 01, General Commissioning Requirements. A Commissioning Agent (CxA) appointed by BCIT and/or the Consultant will manage the commissioning process.

.3 The Contractor and Consultant shall engage BCIT Facilities Maintenance personnel and enable access at key milestones and periodically through the work for general installation reviews. BCIT Personnel may also visit the project site at their discretion and make arrangements for site access as required.

1.8 SCHEDULING

.1 Schedule and provide assistance in final adjustment and test of life safety, smoke evacuation, and smoke control systems with Fire Authority and BCIT Facilities Office.

.2 Site Reviews: Coordinate and schedule site reviews with Contractor, Commissioning Agent and Controls Trade. Ensure balancing devices are being installed correctly and in accessible locations, and final balancing occurs in sequence with Controls and Commissioning activities.

.3 Balancing Agent shall include for a minimum of three (3) eight (8) hour days' worth of on-site inspections during system installation stages for hydronic systems and air duct systems to verify and ascertain correct devices being installed along with accessibility review.

.1 Submit written reports to Consultant and Commissioning Agent through the Mechanical Contractor after every site visit.

.2 Provide written verification that duct protection, plastic covers, temporary filters and temporary transfer air protection has been removed and that transfer air and return air paths are free and clear.

.4 Balancing Agent shall include and allow for a total of eight (8) hour days' worth of post occupancy site visits for Balancing trim during seasonal variations and occupancy variations.

.1 Updated Balancing Reports shall be submitted after each post-occupancy site visit.

.2 Post-occupancy site visits shall be as follows:

.1 Two (2) days of Balancing checks during mid-spring conditions.

.2 Two (2) days during mid-summer conditions.

.3 Two (2) days during mid-fall conditions.

.4 Two (2) days during mid-winter conditions.

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 EXAMINATION

.1 Verify that systems are complete and operable before commencing work. Ensure the following conditions:

- .1 Systems are started and operate in a safe and normal condition. Start-up checklists from suppliers have been reviewed and circulated.
- .2 Temperature control systems are installed complete and operable.
- .3 Proper thermal overload protection is in place for electrical equipment.
- .4 Final filters are clean and in place. Where required, install temporary media in addition to final filters.
- .5 Duct systems are clean of debris.
- .6 Fans are rotating correctly.
- .7 Fire and volume dampers are in place and open.
- .8 Air coil fins are cleaned and combed.
- .9 Access doors are closed and duct end caps are in place.
- .10 Air outlets are installed and connected.
- .11 Duct system leakage is minimized.
- .12 Hydronic systems are flushed, filled, and vented.
- .13 Pumps are rotating correctly.
- .14 Proper strainer baskets are clean and in place.
- .15 Service and balance valves are open.

.2 Submit field reports:

- .1 Report defects and deficiencies that prevent system balance during performance of services to Contractor and Consultant.
- .2 Provide minimum of three (3) on-site pre-balancing reviews to ascertain access requirements for suitable balancing devices and dampers in correct locations, and general ductwork and piping installation with respect to fittings and potential system resistance problems.

.3 Beginning of work means acceptance of existing conditions.

3.2 PREPARATION

.1 Provide instruments required for testing, adjusting, and balancing operations. Ensure instruments are available to Consultant for spot checks during testing. Use two-way radios and digital photography to enhance the TAB process and ensure systems functionality for Commissioning Process.

.2 Provide additional balancing devices as required.

3.3 INSTALLATION TOLERANCES

.1 Air Handling Systems: Adjust to within plus or minus 10% of design for supply systems and plus or minus 10% of design for return and exhaust systems.

.2 Air Outlets and Inlets: Adjust total to within plus or minus 5% of design to space. Adjust outlets and inlets in space to within plus or minus 5% of design.

.3 Hydronic Systems: Adjust to within plus or minus 10% of design based on both flow and temperature difference at design points. Test and re-balance as required during system Commissioning to account for system flow variations due to controls dynamics and controls trend logging feedback.

3.4 ADJUSTING

.1 Ensure recorded data represents actual measured or observed conditions.

.2 Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops. Provide Balancing Company label with date of last adjustment.

.3 After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

.4 Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

.5 At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by BCIT.

.6 Check and adjust systems approximately six (6) months after final acceptance and submit report.

3.5 AIR SYSTEM PROCEDURE

.1 Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.

.2 Make air quantity measurements in ducts by pitot tube traverse of entire cross sectional area of duct.

.3 Measure air quantities at air inlets and outlets.

.4 Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

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

.6 Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

.7 Provide system schematic with required and actual air quantities recorded at outlet or inlet.

.8 Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50% loading of filters.

.9 Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

.10 Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

.11 Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rates, full cooling, and at minimum air flow rate, full heating. Note percent open to percent air flow.

.12 Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 12.5 Pa (0.05 inches) positive static pressure near the building entries [in clean rooms].

.13 Check multi-zone units for motorized damper leakage. Adjust air quantities with mixing dampers set first for cooling, then heating, then modulating.

.14 For variable air volume system powered units set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control. Coordinate and set up variable frequency drives for fans for airflow control.

.15 Adjust air flow switches for proper operation on fan powered VAV boxes.

.16 Check and test all fire dampers and at least 10% in the presence of Consultant.

.17 Provide and arrange smoke control testing for smoke control systems and fans. Verify emergency system operation and smoke evacuation operation. Coordinate with Commissioning Agent for proper attendance of Authorities.

3.6 WATER SYSTEM PROCEDURE

.1 Adjust water systems to provide required or design quantities.

.2 Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in system.

.3 Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

.4 Balance system with all automatic control valves fully open to heat transfer elements.

.5 Adjust water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

.6 Where available pump capacity is less than total flow requirements or individual system parts (diversity factor), full flow in one part may be simulated by temporary restriction of flow to other parts. Restriction of flow not to exceed diversity factor.

3.7 SCHEDULES

.1 Equipment requiring testing, adjusting and balancing:

.1 Fire Pumps

.2 Sprinkler Air Compressor

.3 Electric Water Coolers

.4 Plumbing Pumps

.5 HVAC Pumps

.6 Boilers

.7 Water Chillers

.8 Cooling Tower or Fluid Cooler

.9 Hydronic heating systems and terminals

.10 Hydronic cooling systems and terminals

.11 Air Cooled Refrigerant Condensers

.12 Packaged Roof Top Heating/Cooling Units

.13 Packaged Terminal Air Conditioning Units

.14 Unit Air Conditioners

.15 Computer Room Air Conditioning Units

.16 Air Coils

.17 Evaporative Humidifier

.18 Sprayed Coil Dehumidifier

.19 Terminal Heat Transfer Units

.20 Air Handling Units

.21 Fans

.22 Air Filters

.23 Air Terminal Units

.24 Air Inlets and Outlets

.25 Side stream filters

.26 Domestic hot water recirculation branches.

.2 Provide floor plans with air and hydronic system schematics indicating air flows and fluid flows at all balanced/controlled points, including as-constructed changes and modifications. Use Consultants CAD plans as a basis, including system air and hydronic flow schematics. Coordinate and confirm controls sequence of operation and include air balancing data and protocol on how positive building air pressure is to be maintained.

.3 Report Forms:

.1 Title Page:

.1 Name of Testing, Adjusting, and Balancing Agency

.2 Address of Testing, Adjusting, and Balancing Agency

.3 Telephone number of Testing, Adjusting, and Balancing Agency

.4 Project name

.5 Project location and BCIT Project Number/Building Number

.6 Project Architect

.7 Project Engineers/Consultants

.8 Project Contractors

.9 Project altitude

.10 Report date

.2 Summary Comments:

.1 Design versus final performance

.2 Notable characteristics of system

.3 Description of systems operation sequence

.4 Summary of outdoor and exhaust flows to indicate amount of building pressurization

.5 Nomenclature used throughout report

.6 Test conditions

.3 Instrument List:

.1 Instrument

.2 Manufacturer

.3 Model number

.4 Serial number

.5 Range

.6 Calibration date

.4 Electric Motors:

.1 Manufacturer

.2 Model/Frame

.3 HP/BHP

.4 Phase, voltage, amperage; nameplate, actual, no load

.5 RPM

.6 Service factor

.7 Starter size, rating, heater elements

.8 Sheave Make/Size/Bore

.5 V-Belt Drive:

.1 Identification/location

.2 Required driven RPM

.3 Driven sheave, diameter and RPM

.4 Belt, size and quantity

.5 Motor sheave diameter and RPM

.6 Centre to centre distance, maximum, minimum, and actual

.6 Pump Data:

.1 Identification/number

.2 Manufacturer

.3 Size/model

.4 Impeller

.5 Service

.6 Design flow rate, pressure drop, BHP

.7 Actual flow rate, pressure drop, BHP

.8 Discharge pressure

.9 Suction pressure

.10 Total operating head pressure

.11 Shut off, discharge and suction pressures

.12 Shut off, total head pressure

.13 Systems curve applied to pump curve data

.14 RPM

.7 Combustion Test:

.1 Boiler manufacturer

.2 Model number

.3 Serial number

.4 Firing rate

.5 Overfire draft

.6 Gas meter timing dial size

.7 Gas meter time per revolution

.8 Gas pressure at meter outlet

.9 Gas flow rate

.10 Heat input

.11 Burner manifold gas pressure

.12 Percent carbon monoxide (CO)

.13 Percent carbon dioxide (CO2)

.14 Percent oxygen (O2)

.15 PPM of NOx

.16 Percent excess air

.17 Flue gas temperature at outlet

.18 Ambient temperature

.19 Net stack temperature

.20 Percent stack loss

.21 Percent combustion efficiency

.22 Heat output

.8 Air Cooled Refrigerant Condenser:

.1 Identification/number

.2 Location

.3 Manufacturer

.4 Model number

.5 Serial number

.6 Entering DB air temperature, design and actual

.7 Leaving DB air temperature, design and actual

.8 Number of compressors

.9 Chillers:

.1 Identification/number

.2 Manufacturer

.3 Capacity

.4 Model number

.5 Serial number

.6 Evaporator entering water temperature, design and actual

.7 Evaporator leaving water temperature, design and actual

.8 Evaporator pressure drop, design and actual

.9 Evaporator water flow rate, design and actual

.10 Condenser entering water temperature, design and actual

.11 Condenser pressure drop, design and actual

.12 Condenser water flow rate, design and actual

.10 Cooling Tower / Fluid Cooler:

.1 Tower identification/number

.2 Manufacturer

.3 Model number

.4 Serial number

.5 Rated capacity

.6 Entering air WB temperature, specified and actual

.7 Leaving air WB temperature, specified and actual

.8 Ambient air DB temperature

.9 Condenser water entering temperature

.10 Condenser water leaving temperature

.11 Condenser water flow rate

.12 Fan RPM

.11 Heat Exchanger:

.1 Identification/number

.2 Location

.3 Service

.4 Manufacturer

.5 Model number

.6 Serial number

.7 Primary water entering temperature, design and actual

.8 Primary water leaving temperature, design and actual

.9 Primary water flow, design and actual

.10 Primary water pressure drop, design and actual

.11 Secondary water leaving temperature, design and actual

.12 Secondary water leaving temperature, design and actual

.13 Secondary water flow, design and actual

.14 Secondary water pressure drop, design and actual

.12 Cooling Coil Data:

- .1 Identification/number
- .2 Location
- .3 Service
- .4 Manufacturer
- .5 Air flow, design and actual
- .6 Entering air DB temperature, design and actual
- .7 Entering air WB temperature, design and actual
- .8 Leaving air DB temperature, design and actual
- .9 Leaving air WB temperature, design and actual
- .10 Water flow, design and actual
- .11 Water pressure drop, design and actual
- .12 Entering water temperature, design and actual
- .13 Leaving water temperature, design and actual
- .14 Saturated suction temperature, design and actual
- .15 Air pressure drop, design and actual

.13 Heating Coil Data:

- .1 Identification/number
- .2 Location
- .3 Service
- .4 Manufacturer
- .5 Air flow, design and actual
- .6 Water flow, design and actual
- .7 Water pressure drop, design and actual
- .8 Entering water temperature, design and actual
- .9 Leaving water temperature, design and actual
- .10 Entering air temperature, design and actual
- .11 Leaving air temperature, design and actual
- .12 Air pressure drop, design and actual

.14 Electric Duct Heater:

- .1 Manufacturer
- .2 Identification/number
- .3 Location
- .4 Model number
- .5 Design kW
- .6 Number of stages
- .7 Phase, voltage, amperage

.8 Test voltage (each phase)

.9 Test amperage (each phase)

.10 Air flow, specified and actual

.11 Temperature rise, specified and actual

.15 Air Moving Equipment

.1 Location

.2 Manufacturer

.3 Model number

.4 Serial number

.5 Arrangement/Class/Discharge

.6 Air flow, specified and actual

.7 Return air flow, specified and actual

.8 Outside air flow, specified and actual

.9 Total static pressure (total external), specified and actual

.10 Inlet pressure

.11 Discharge pressure

.12 Sheave Make/Size/Bore

.13 Number of Belts/Make/Size

.14 Fan RPM

.16 Return Air/Outside Air Data:

.1 Identification/location

.2 Design air flow

.3 Actual air flow

.4 Design return air flow

.5 Actual return air flow

.6 Design outside air flow

.7 Actual outside air flow

.8 Return air temperature

.9 Outside air temperature

.10 Required mixed air temperature

.11 Actual mixed air temperature

.12 Design outside/return air ratio

.13 Actual outside/return air ratio

.17 Exhaust Fan Data:

.1 Location

.2 Manufacturer

.3 Model number

.4 Serial number

.5 Air flow, specified and actual

.6 Total static pressure (total external), specified and actual

.7 Inlet pressure

.8 Discharge pressure

.9 Sheave Make/Size/Bore

.10 Number of Belts/Make/Size

.11 Fan RPM

.18 Duct Traverse:

.1 System zone/branch

.2 Duct size

.3 Area

.4 Design velocity

.5 Design air flow

.6 Test velocity

.7 Test air flow

.8 Duct static pressure

.9 Air temperature

.10 Air correction factor

.19 Duct Leak Test:

.1 Description of ductwork under test

.2 Duct design operating pressure

.3 Duct design test static pressure

.4 Duct capacity, air flow

.5 Maximum allowable leakage duct capacity times leak factor

.6 Test apparatus

.1 Blower

.2 Orifice, tube size

.3 Orifice size

.4 Calibrated

.7 Test static pressure

.8 Test orifice differential pressure

.9 Leakage

.20 Air Monitoring Station Data:

.1 Identification/location

.2 System

.3 Size

.4 Area
.5 Design velocity
.6 Design air flow
.7 Test velocity
.8 Test air flow

.21 Flow Measuring Station:
.1 Identification/number
.2 Location
.3 Size
.4 Manufacturer
.5 Model number
.6 Serial number
.7 Design Flow rate
.8 Design pressure drop
.9 Actual/final pressure drop
.10 Actual/final flow rate
.11 Station calibrated setting

.22 Terminal Unit Data:
.1 Manufacturer
.2 Type, constant, variable, single, dual duct
.3 Identification/number
.4 Location
.5 Model number
.6 Size
.7 Minimum static pressure
.8 Minimum design air flow
.9 Maximum design air flow
.10 Maximum actual air flow
.11 Inlet static pressure

.23 Air Distribution Test Sheet:
.1 Air terminal number
.2 Room number/location
.3 Terminal type
.4 Terminal size
.5 Area factor
.6 Design velocity
.7 Design air flow

.8 Test (final) velocity

.9 Test (final) air flow

.10 Percent of design air flow

.24 Sound Level Report:

.1 Location and distance from equipment

.2 Octave bands - equipment off

.3 Octave bands - equipment on

.25 Vibration Testing:

.1 Equipment to be tested:

.1 Main AHU's

.2 Chiller

.3 Cooling Tower/Fluid Cooler

.4 Pumps over 5 hp (3.73KW)

.5 Any/all fans over 10 hp (7.5 KW)

.2 Location of points:

.1 Fan bearing, drive end

.2 Fan bearing, opposite end

.3 Motor bearing, centre (if applicable)

.4 Motor bearing, drive end

.5 Motor bearing, opposite end

.6 Casing (bottom or top)

.7 Casing (side)

.8 Duct after flexible connection (discharge)

.9 Duct after flexible connection (suction)

.3 Test readings:

.1 Horizontal, velocity and displacement

.2 Vertical, velocity and displacement

.3 Axial, velocity and displacement

.4 Normally acceptable readings, velocity and acceleration

.5 Unusual conditions at time of test

.6 Vibration source (if non-complying)

END OF SECTION

This document contains standards that are the minimum requirements for BCIT construction projects. The information in the document is organized using the MasterFormat® and SectionFormat® systems. It is not a specification; it is intended to supplement the Consultant's own documents. Do not use this information as a standalone specification.

SECTION 23 08 00
COMMISSIONING OF HVAC

PART 1 - GENERAL

1.2 DESCRIPTION

.1 The purpose of this Section is to specify responsibilities in the commissioning (CX) process. Contractor shall engage an independent Commissioning Agent (CA) to oversee, direct and perform Commissioning Tasks and Commissioning Plan.

.1 BCIT shall directly engage independent Commissioning Agent to oversee, direct and perform Commissioning Tasks and Commissioning Plan for selected projects having a Construction Project value of over $500,000.00.

.2 For smaller projects, General Contractor/Construction Manager shall engage a Commissioning Agent/Authority to perform building systems and building automation controls commissioning.

.2 Nominated Controls vendor will perform Controls system commissioning and Functional Performance testing of Building Automation System as required in Section 25 08 00 Commissioning of Integrated Automation

.3 Commissioning requires participation of Mechanical Trades and Electrical Trades to ensure systems are operating in a manner consistent with Contract Documents.

.1 Electrical Fire Alarm systems will be commissioned by Electrical forces; however Commissioning Agent shall participate in, and report on Fire Alarm system commissioning and verify proper operation of mechanical equipment and systems with fire alarm interlocks.

.2 Ensure Commissioning of Building Systems and Life Safety Systems are in accordance with requirements of National Standard of Canada for commissioning of building life safety systems -CAN/ULCS575, Building/Facility Commissioning. Ensure General Commissioning Scope is in accordance with ASHRAE Guideline 1.1, HVAC&R Technical Requirements for the Commissioning Process.

.4 Contractor is responsible for satisfactory completion of building systems and to demonstrate that requirements of building systems performance and commissioning are satisfied. Contractor will employ and pay for specialist supervision, inspection and testing as required to complete the Work described.

.5 Commissioning of building components and systems is of utmost importance to ensure the successful operation of this building. The building will not be considered complete until systems have been demonstrated to work in accordance with Contract requirements.

.6 Contractor is responsible for satisfactory completion of building and to demonstrate that requirements of commissioning are satisfied. Contractor will employ and pay for specialist supervision, inspection, and testing as required to complete the Work described.

.7 Scope of Commissioning:

.1 Review of Architectural/Engineering Field Review Reports and changes through CCN to date, pre-commissioning site inspection to verify status of previous field review deficiencies and systems status. Provide written pre-commissioning report with installation deficiencies noted and systems status report.

.2 HVAC systems, central heating and cooling equipment, and related controls, infrastructure and accessories.

.3 Plumbing systems including fixtures, infrastructure, and accessories. Verify dual flush tank type toilets field with respect to water fill level in tanks, flush button setup to linkage and test flushing. Test infra-red activated faucets and flush valves and set up with respect to sensitivity, run-time/flush activation.

.4 Fire protection system equipment and accessories. Verify full documentation, and materials and test observations.

.5 Emergency smoke control systems, emergency pressurization equipment, and accessories. Include smoke bomb test for timed smoke evacuation, under direction of local Fire Department Authority.

.6 Complete HVAC systems emergency shutdown and re-start sequences for power failures, fire alarms, and localized equipment alarm shutdowns.

.7 Where design performance is not being met, complete trouble-shooting and detailed testing of mechanical systems to ascertain departures from design conditions and performance once Balancing has been completed, and as determined during the Commissioning Process. Include written confirmation of BCIT's Training acceptance.

.8 Other systems as follows: [**SPEC NOTE***: Consultant and BCIT add other systems here- smoke removal smoke tests, HVAC smoke/balancing tests, security, audio-visual, specialty systems, etc.]*

1.3 RESPONSIBILITIES

.8 Commissioning Agent (CA):

.1 Prior to writing test procedures, CA shall obtain requested documentation and current list of change orders affecting equipment or systems, including updated points list, control sequences and setpoints. CA shall develop specific test procedures to verify proper operation of each piece of equipment and system, using testing requirements in Specifications. CA shall obtain clarification, as needed, from contractors, suppliers, and Consultant regarding sequences and operation to develop these tests. Prior to execution, CA shall provide a copy of primary equipment tests to installing Sub (via the GC/CM) who shall review tests for feasibility, safety, warranty and equipment protection. Blank copies of procedures are input into O&M manuals for later use by Building Operations Staff.

.2 Functional testing and verification may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring performance and analyzing results using control system's trend log capabilities or by stand-alone data-loggers. CA shall follow Specifications, and determine appropriate method. According to Specifications, not all pieces of identical equipment receive in-depth testing. CA to review contracted, factory or required acceptance tests and determine further testing requirements to comply with Specifications. Redundancy is minimized.

.3 CA shall provide schedule and plan format to assist construction team and CM/GC with scheduling of functional testing, issues preventing the start of testing, contractors required for each test and expected time requirements. Formulate schedule after most equipment has been started up, and when functional testing dates are near.

.9 Mechanical, Controls and TAB Contractors: Commissioning responsibilities applicable to mechanical, controls, and TAB contractors are as follows:

.1 Construction and Acceptance Phases:

.1 Include and itemize cost of commissioning in contract price.

.2 Include requirements for submittal data, commissioning documentation, O&M data and training in each purchase order or subcontract.

.3 Attend a commissioning scoping meeting and other meetings necessary to facilitate the CX process.

.4 Contractors shall provide CA with normal cut sheets and shop drawing submittals of commissioned equipment.

.5 Prior to normal O&M manual submittals, provide additional requested documentation to CA for development of start-up and functional testing procedures.

.1 Include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, details of contracted tests, fan and pump curves, factory testing reports, and warranty information, including BCIT's responsibility to clearly identify warranty in force. Submit to Commissioning Agent installation, start-up and checkout materials shipped inside the equipment and actual field checkout sheet forms for use by factory or field technician.

.2 Commissioning Agent may request further documentation necessary for the commissioning process.

.3 This data request may be made prior to normal submittals.

.6 Provide copy of O&M manuals and submittals of commissioned equipment, through normal channels, to CA for review.

.7 Contractors and design engineers shall assist in clarifying operation and control of commissioned equipment in areas where specifications, control drawings or equipment documentation are not sufficient for writing detailed testing procedures.

.8 Provide limited assistance to CA in preparing the specific functional performance test procedures as specified in Commissioning Plan. Sub-Trades shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.

.9 Develop full start-up and initial checkout plan using manufacturer's start-up procedures and CA's pre-functional checklists for commissioned equipment. Submit to CA for review and approval prior to startup.

.10 During startup and initial checkout process, execute mechanical-related portions of pre-functional checklists for all commissioned equipment.

.11 Perform and clearly document completed startup and system operational checkout procedures, providing a copy to CA.

.12 Address current A/E punch list items prior to functional testing. Complete air and water TAB. Remedy discrepancies and problems prior to functional testing of respective air- or water-related systems.

.13 Obtain services of factory qualified personnel from primary equipment supplier for major equipment start-up tests. Ensure personnel is available and present during the agreed upon schedules and for sufficient duration to complete necessary tests, adjustments and problem-solving.

.14 Correct deficiencies (differences between specified and observed performance) as interpreted by CA, CM and Consultant and retest the equipment.

.15 Prepare O&M manuals according to Contract Documents. Clarify and update original sequences of operation to as-built conditions.

.16 During construction, maintain as-built red-line drawings for drawings and final CAD Record Drawings for contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing).

.17 Provide training of BCIT's operating staff using expert qualified personnel, as specified. Consultant will be available as a resource for these sessions.

.18 Coordinate with equipment manufacturers to determine specific requirements to maintain validity of the warranty.

.2 Warranty Period:

.1 CA to witness the execution of seasonal or deferred functional performance testing in accordance with specifications.

.2 Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

.3 Provide minimum of twenty (20) eight (8) hour work days in parallel with Balancing Agent to perform seasonal tests over the first year of operation.

.10 Mechanical Contractor: The responsibilities of the mechanical Contractor, during construction and acceptance phases in addition to those listed are:

.1 Provide startup for mechanical equipment, including building automation control system.

.2 Assist and cooperate with TAB contractor and CA by:

.1 Operating HVAC equipment and systems and continue 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.

.5 Ensuring all access panels open and equipment is accessible including change of filters, replacement of control valves and isolating valves.

.3 Install a P/T plug at each water sensor which is an input point to control system.

.4 Verify that drain pans operate.

.5 Check noise levels in rooms under extreme operating conditions.

.6 List and clearly identify on as-built drawings locations of air-flow stations.

.7 Prepare preliminary schedule for Mechanical pipe and duct system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by CA. Update schedule as appropriate.

.8 Notify CM or CA, when pipe and duct system testing, flushing, cleaning, startup of equipment and TAB will occur. Notify CM or CA in advance of when commissioning activities not yet performed or scheduled will delay construction. Ensure that commissioning processes are executed and that CA has scheduling information required to efficiently execute the commissioning process.

.11 Controls Contractor: Commissioning responsibilities of controls contractor, during construction and acceptance phases in addition to those listed in (A) are:

.1 Sequences of Operation Submittals: Controls Contractor's submittals of control Drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of completeness and clarity of sequences in specifications. They shall include:

.1 An overview narrative of system (one or two paragraphs) generally describing its purpose, components and function.

.2 All interactions and interlocks with other systems.

.3 Detailed delineation of control between packaged controls and building automation system, listing 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 Normal operating mode sequences.

.7 Unoccupied mode sequences.

.8 Shutdown sequences.

.9 Emergency shut-down and start-up after Emergency for all systems.

.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 alarms and emergency shut downs.

.15 Seasonal operational differences and recommendations.

.16 Initial and recommended values for adjustable settings, setpoints and parameters typically set or adjusted by operating staff; and other control settings or fixed values, delays, etc. that will be useful during testing and operating equipment.

.17 Operating Schedules, if known.

.18 To facilitate referencing in testing procedures, write sequences in small statements, with a number for reference. For a given system, numbers will not repeat for different sequence sections, unless sections are numbered.

.19 Monitor and review trend logs for equipment and systems, including review of and trending energy metering and total building energy use over the first year of operation.

.2 Control Drawings Submittal:

.1 Control drawings shall have a key to abbreviations.

.2 Control drawings shall contain graphic schematic depictions of systems and each component.

.3 Schematics will include system and component layout of equipment that control system monitors, enables or controls, even if equipment is primarily controlled by packaged or integral controls.

.4 Provide a 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:

.1 Point Description: DB temp, airflow, etc.

.2 Control or Setpoint: Point that controls equipment and can have its setpoint changed (OSA, SAT, etc.).

.3 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).

.4 Monitoring Point: Point that does not control or contribute to control of equipment, but is used for operation, maintenance, or performance verification.

.5 Calculated Point: “Virtual” point generated from calculations of other point values.

.5 Controls Contractor shall keep CA informed of all changes to this list during programming and setup.

.6 Updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.

.7 Assist and cooperate with TAB contractor in the following manner:

.1 Meet with TAB contractor prior to beginning TAB and review TAB plan to determine capabilities of the control system toward completing TAB. Provide TAB with required unique instruments for setting terminal unit boxes and instruct TAB in their use (handheld control system interface for use around the building during TAB, etc.).

.2 For a given area, ensure required prefunctional checklists, calibrations, startup and selected functional tests of system are completed and approved by CA prior to TAB.

.3 Provide qualified technician to operate controls to assist TAB contractor in performing TAB, or provide sufficient training for TAB to operate system without assistance.

.8 Assist and cooperate with CA in the following manner:

.1 Using skilled technician familiar with the building, execute functional testing of controls system as specified. Assist in functional testing of equipment. Provide two-way radios during the testing.

.2 Execute control system trend logs.

.9 Controls contractor shall prepare a written plan indicating step-by-step, procedures to test, checkout and adjust control system prior to functional performance testing. At minimum, plan shall include 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 sensors.

.5 Description of expected field adjustments for transmitters, controllers and control actuators in cases where control responses fall outside of expected values.

.6 Copy of log and field checkout sheets that will document the process. Log shall 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 contract parameters.

.7 Description of instrumentation required for testing.

.8 Indicate the tests on systems required for completion prior to TAB using the control system for TAB work. Coordinate with CA and TAB contractor for this determination.

.10 Provide signed and dated certification to CA and CM upon completion of checkout of controlled devices, equipment and systems prior to functional testing for each piece of equipment or system. Ensure system programming is complete and in accordance with Contract Documents, with the exception of functional testing requirements.

.11 Beyond control points necessary to execute documented control sequences, provide monitoring, control and virtual points as specified.

.12 List and clearly identify on as-built duct and piping Drawings locations of static and differential pressure sensors (air, water and building pressure).

.12 TAB Contractor: The duties of the TAB contractor, in addition to those listed in (A) are:

.1 Six (6) weeks prior to starting TAB, submit to CM the qualifications of the site technician for project, including names of contractors and facility managers of recent projects the technician was the lead of. BCIT will approve the site technician’s qualifications for this project.

.2 Submit outline of TAB plan and approach for each system and component to CA, CM and the controls contractor six weeks prior to starting TAB. Develop plan after TAB has some familiarity with control system.

.3 Submitted plan will include:

.1 Certification that TAB contractor has reviewed construction documents and systems with design engineers and contractors to sufficiently understand the design intent for each system.

.2 Explanation of intended use of building control system. Controls contractor will comment on feasibility of plan.

.3 Use field checkout sheets and logs that list each piece of equipment to be tested, adjusted and balanced with data cells to be gathered for each.

.4 Discussion of notations and markings to be made on 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 / sub-main proportioning, total flow calculations, rechecking, diversity issues, expected problems and solutions, etc. Discuss criteria for using air flow straighteners or relocating flow stations and sensors. Provide analogous explanations for water side.

.7 List of air flow, water flow, sound level, system capacity and efficiency measurements to be performed and 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) pitot traverse, SA or RA flow stations. Water: pump curves, circuit setter, flow station, ultrasonic, etc.).

.9 Identification and types of measurement instruments to be used and their most recent calibration date.

.10 Specific procedures that will ensure air and water side are operating at lowest possible pressures and provide methods to verify this.

.11 Confirmation that TAB understands 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).

.4 Running log of events and issues shall be kept by TAB field technicians. Submit hand-written reports of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests to CA and CM at least once a week.

.5 Communicate in writing, setpoint and parameter changes made or problems and discrepancies identified during TAB which affect control system setup and operation to Controls Contractor.

.6 Provide draft TAB report within two (2) weeks of completion. Provide copy to CA. Include full explanation of methodology, assumptions and results in a clear format with designations of uncommon abbreviations and column headings. Report shall follow latest and most rigorous reporting recommendations by AABC, NEBB or ASHRAE 0-2005 "*The Commissioning Process*".

.7 Provide CA with requested data, gathered, but not shown on draft reports.

.8 Provide final TAB report for CA with details, as in draft.

.9 Conduct functional performance tests and checks on the original TAB.

1.1 QUALITY ASSURANCE

1. Commissioning shall be executed in accordance with intent of ASHRAE Standard "Guideline for Commissioning of HVAC Systems".

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

.1 Mechanical Contractor shall provide conventional test equipment necessary to fulfill testing requirements of this Division.

.2 Where specialized testing and measurement equipment is required to fully commission a system or device, CA shall procure and use such equipment to prove operation. Testing and measurement equipment required for accurate trouble-shooting of mechanical systems shall be provided by CA unless procured from Mechanical Trade.

.3 CA shall coordinate with and obtain test instruments and devices from Controls Trade that are compatible with Controls Devices and operational standards specified in Controls Specifications. Confirm calibration and accuracy of testing instruments prior to use.

PART 3 - EXECUTION

3.1 SUBMITTALS

.1 Contractor shall provide submittal documentation relative to Commissioning as required in this Section and Division 01.

.2 The Contractor shall turn over component and system verification progress and sign-off sheets to Commissioning Agent and Consultant, organized in labelled binders by discipline. Where CA has own standard checklist forms, submit for review prior to use.

.4 Project Schedule Format:

TASK / ACTIVITY	ESTIMATED START DATE	ESTIMATED END DATE
Initial scoping meeting and final Cx plan		
Submittals obtained and reviewed		
Begin construction site visits/inspections		
Pre-functional forms developed and distributed		
Startup and initial checkout plans		
Startup and initial checkout executed		
TAB Water Air		
Functional performance tests		
O&M documentation review and verification		
Facilities Operator Training and training verification		
Final commissioning report		
Seasonal testing -Two Months after Occupancy -Six Months After Occupancy -One month before Warrantee period expires.		

3.2 STARTUP

.1 HVAC Mechanical and Controls Contractors shall follow start-up and initial checkout procedures outlined in responsibilities list in this Section. Mechanical Contractor has start-up responsibility and is required to complete systems and sub-systems, meeting design objectives of Contract Documents. Commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility to commissioning agent or BCIT.

.2 CA shall schedule functional tests through CM, GC and affected Subs.

.1 For any given system, prior to performing functional testing, CA shall wait until pre-functional checklist has been submitted with necessary signatures, sign-offs and supplier/manufacturer start-up test results, confirming that the system is ready for functional testing.

.2 CA shall oversee, witness and document functional testing of equipment and systems according to Specifications and Commissioning Plan. Contractors execute the tests.

.3 Test control system before it is used to verify performance of other components or systems.

.4 Air balancing and water balancing shall be completed and debugged before functional testing of air-related or water-related equipment or systems.

.5 Testing proceeds from components to subsystems to systems and finally to interlocks and connections between systems.

.3 Functional testing shall begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at discretion of CA and CM. Beginning system testing before completion does not relieve Contractor from fully completing the system, including all pre-functional checklist.

.4 Ensure reported results of testing and procedures are checked and verified within stated tolerances. Where inconsistencies appear between reported results and demonstrated values, repeat relevant testing procedures and adjust until satisfactory results are obtained.

3.3 FUNCTIONAL PERFORMANCE TESTS

.1 Commission mechanical systems, including plumbing devices, fixtures and components within scope of work. Refer to Controls Specifications for sequences of operations for building climate control systems operation.

.2 Prior to conducting defined system Performance Verification Tests, Contractor and Manufacturers startup and proving tests are to be completed and reviewed by Consultant and Commissioning Agent.

.3 Prior to conducting defined system Performance Verification Tests, component verifications related to a given system shall be completed by Contractor and reviewed by Consultant and Commissioning Agent.

Prior to notifying Consultant and Commissioning Agent that system is ready for verification, Contractor will complete the “Contractor Verification” portion of the System Performance Verification Test forms.

.4 Each system listed on system test ledger will require a similar level of testing by the Contractor. Consultant and/or Commissioning Agent will provide Contractor with clarification of test procedure and provide technical assistance prior to test being performed.

.5 Coordinate System Performance Verification tests with Building Automation System Trend data and graphs to provide additional documentation of system performance. Attach hard copy of data to System Performance Verification test document. Note requirements for two (2) week trending of systems once Commissioning and verification is complete.

.6 System Performance Verification Testing: Schedule and conduct by Contractor, and overseen by Commissioning Agent, with TAB Trade in attendance.

.7 System Performance Verification Tests as per verification forms will be conducted in presence of Commissioning Agent, and reviewed by Consultant.

3.4 OPERATION AND MAINTENANCE (O&M) MANUALS

.1 The following specific O&M manual requirements are in addition to O&M manual documentation requirements elsewhere.

.2 Prior to training of BCIT personnel, Mechanical Contractor shall compile and prepare documentation for equipment and systems covered in Mechanical Contract and deliver documentation to Construction Manager/ General Contractor for inclusion in O&M manuals, in accordance with requirements of this Section.

.3 Provide copy of Draft O&M manuals for review to Commissioning Agent and Consultant.

.4 Special Control System O&M Manual Requirements: In addition to documentation specified elsewhere, Controls contractor shall compile and organize at minimum the following data on control system in labeled three-ring binders with indexed tabs.

.1 Three copies of controls training manuals in separate manual from O&M manuals.

.2 Operation and Maintenance Manuals containing:

.1 Specific step-by-step instructions of performance and application functions, features, and modes mentioned in controls training sections of this specification and other features of this system. Include indexes, clear tables of contents, detailed technical manual for programming and customizing control loops and algorithms.

.2 Full as-built set of control drawings (refer to Submittal section above for details).

.3 Full as-built sequence of operations for each piece of equipment.

.4 Full points list, in addition to updated points list required in original submittals (Part 1 of this section), provide listing of all rooms with following information for each room:

.1 Building

.2 Floor

.3 Room number

.4 Room name

.5 Air handler unit ID

.6 Reference drawing number

.7 Air terminal unit tag ID

.8 Heating and/or cooling valve tag ID

.9 Minimum cfm

.10 Maximum cfm

.11 Radiant slab loop data, flow, temperatures, pressure drops.

.5 Full print out of schedules and set points after testing and acceptance of the system.

.6 Full as-built print out of software program.

.7 Electronic copy on disk of the entire program for this facility.

.8 Marking of system sensors and thermostats on as-built floor plan and mechanical drawings with their control system designations.

.9 Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.

.10 Control equipment component submittals, parts lists, etc.

.11 Warranty requirements.

.12 Copies of checkout tests and calibrations performed by the Contractor (not commissioning tests).

.3 Organize and subdivide manual with permanently labeled tabs for each of the following data in the given order:

.1 Sequences of operation

.2 Control drawings

.3 Points lists

.4 Controller / module data

.5 Thermostats and timers

.6 Sensors and DP switches

.7 Valves and valve actuators

.8 Dampers and damper actuators

.9 Program setups (software program printouts)

.4 Provide field checkout sheets and trend logs to CA for inclusion in the Commissioning Record Book.

.5 Special TAB Documentation Requirements: TAB will compile and submit the following with other documentation that may be specified elsewhere in Specifications.

.1 Final report containing explanation of methodology, assumptions, test conditions and results in clear format with designations of uncommon abbreviations and column headings.

.2 TAB shall mark on Drawings where traverse and other critical measurements were taken and cross reference location in TAB report.

.6 Reviews: Consultant and CA shall review commissioning related sections of the O&M manuals.

3.5 TRAINING OF BCIT FACILITIES OPERATIONS PERSONNEL

.1 Commissioning Contractor is responsible for training coordination and scheduling and ultimately ensure that training is completed.

.2 CA shall oversee and review content and adequacy of training of BCIT personnel for commissioned equipment.

.3 Mechanical Contractor. Mechanical Contractor shall have following training responsibilities:

.1 Provide CA with training plan two (2) weeks before planned training according to outline described in General Requirements.

.2 Provide designated BCIT personnel with comprehensive orientation and training in understanding of systems, 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 normally starts with classroom sessions followed by hands-on training on each piece of equipment, and illustrates 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 requirements of O&M manual or sequence of operations, repair system or adjust as necessary and repeat the demonstration.

.5 Trade or manufacturer's representative shall provide instructions on each major piece of equipment. The representative 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 modes of operation of specific piece of equipment are required. More than one party may be required to execute the training.

.6 Controls Contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of controls system relating to equipment being discussed.

.7 Training sessions shall follow outline in Table of Contents of Operation and Maintenance Manual and illustrate whenever possible the use of O&M manuals for reference.

.8 Training shall include:

.1 Use of printed installation, operation and maintenance instruction material included in O&M manuals.

.2 Review of written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. Training includes 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 Common troubleshooting problems and solutions.

.6 Include explanatory information in O&M manuals and location of plans and manuals in facility.

.7 Discuss peculiarities of equipment installation or operation.

.8 The format and training agenda in HVAC Commissioning Process, ASHRAE Guideline 0-2005 is recommended.

.9 Classroom sessions include the use of overhead projections, slides, video/audio-taped material as might be appropriate.

.10 Hands-on training includes start-up, operation in all modes possible, including manual, shut-down and emergency procedures and preventative maintenance for all pieces of equipment.

.11 Mechanical contractor shall explain and demonstrate operation, function and overrides of local packaged controls, not controlled by central control system.

.12 Training occurs after functional testing is complete, unless approved otherwise by Project Manager.

.4 Controls Contractor: Controls contractor shall have the following training responsibilities:

.1 Provide CA with training plan four weeks before the planned training.

.2 Controls Contractor shall provide designated BCIT personnel training on control system in this facility. Clearly and completely instruct personnel on the capabilities of the control system.

.3 Training manuals: Provide each trainee with standard operating manual for system and special training manuals, three extra copies for O&M manuals. Copies of system technical manual will be demonstrated during training and three copies submitted with the O&M manuals. Manuals shall include detailed description of subject matter for each session, control sequences, and definitions section describing relevant words used in manuals and software displays. Tailor to needs and skill-level of trainees.

.4 Trainers will be knowledgeable on the system and its use in buildings. The most qualified trainer(s) will be used for the on-site sessions. BCIT shall approve the instructor prior to scheduling the training.

.5 During any demonstration, should the system fail to perform in accordance with requirements of O&M manual or sequence of operations, repair or adjust system as necessary and repeat the demonstration.

.6 Controls Contractor shall attend sessions other than the controls training, as requested, to discuss interaction of controls system relating to equipment being discussed.

.7 Conduct three training sessions:

.1 Training I Control System: On-site or in supplier's facility. Where held off-site, training may occur prior to final completion of system installation. Upon completion, students shall be able to perform elementary operations and describe general hardware architecture and functionality of system, using appropriate documentation.

.2 Training II Building Systems: On-site hands-on training after completion of system commissioning. Session shall include instruction on:

.1 Specific hardware configuration of installed systems in this building and specific instruction for operating installed system, including HVAC systems, lighting controls and interfaces with security and communication systems.

.2 Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.

.3 Trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing tabular, graphical and printing trends. Trainees will set-up trends in presence of trainer.

.4 Every screen shall be completely discussed, allowing time for questions.

.5 Use of keypad or plug-in laptop computer at the zone level.

.6 Use of remote access to the system via phone lines or networks.

.7 Setting up and changing an air terminal unit controller.

.8 Graphics generation

.9 Point database entry and modifications

.10 Understanding DDC field panel operating programming (when applicable)

.3 Training III: On-site six months after occupancy. Session structured to address specific topics that trainees need to discuss and answer questions concerning operation of the system.

.5 TAB contractor shall have the following training responsibilities:

.1 TAB shall meet with facility staff after completion of TAB and instruct them on the following:

.1 Review final TAB report, explaining layout and meanings of each data type.

.2 Discuss outstanding deficient items in control, ducting or design that may affect proper delivery of air or water.

.3 Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.

.4 Discuss any temporary settings and steps to finalize them for any areas that are not finished.

.5 Other salient information that may be useful for facility operations, relative to TAB.

3.6 WRITTEN WORK PRODUCTS

.1 Written work products of the Commissioning Contractor shall consist of start-up and initial checkout plans and filled out start-up, initial checkout and pre-functional checklists for systems and equipment. Provide reports at each stage of the Commissioning Process as follows:

.1 Provide Commissioning Report by Phase at each stage of the Commissioning Process:

.2 Stage 1: Equipment checks, safeties, end to end checks, electrical readiness, system readiness;

.3 Stage 2: Operational testing/start-ups of major equipment and systems, at rough balancing stage;

.4 Stage 3: Final balancing stage and beginning of Controls calibration and trend logging;

.5 Stage 4: Final Completion report with operating systems trend logs, system final balancing configuration and shut-down/start-up tests completed. Include all Emergency Standard Operating Procedures for systems and equipment. Include Standard Operating

Procedures for power failure recovery, fire alarm conditions, failure of major equipment and systems.

.6 Post-Occupancy Report: Include within scope of work for minimum of four (4) work days of post-occupancy site review three to four months after occupancy to survey, record, troubleshoot and correct operational deficiencies. Check HVAC and Controls systems randomly over and above any reported issues to ensure systems operations, setpoints, and maintenance are in compliance with system design intent and occupant/Facility Maintenance requirements.

END OF SECTION

This document contains standards that are the minimum requirements for BCIT construction projects. The information in the document is organized using the MasterFormat® and SectionFormat® systems. It is not a specification; it is intended to supplement the Consultant's own documents. Do not use this information as a standalone specification.

SECTION 23 09 00
INSTRUMENTATION AND CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

.1 Provide air supply systems.

.2 Provide automatic dampers and damper operators.

.3 Provide Carbon Dioxide sensors (CO_2).

.4 Provide control valves.

.5 Provide hydronic systems.

.6 Provide humidistats.

.7 Provide isolation (two position) dampers of parallel blade construction.

.8 Provide miscellaneous accessories.

.9 Provide mixing dampers of parallel blade construction arranged to mix streams.

.10 Provide pilot positioners on mixed air damper motors.

.11 Provide pilot positioners on pneumatic damper operators sequenced with other controls.

.12 Provide protective guards on thermostats in entrances and other public areas and where indicated.

.13 Provide separable sockets for liquids and flanges for air bulb elements.

.14 Provide thermostats in aspirating boxes in front entrances gymnasiums, high security areas, and where indicated by Consultant and BCIT Facilities Office.

.15 Provide thermostats.

.16 Provide time clocks.

.17 Provide valves with position indicators and with pilot positioners where sequenced with other controls.

1.2 REFERENCES

.1 AMCA 500-D-12 Laboratory Methods of Testing Dampers for Rating.

.2 ASME B16.22-2013 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

.3 ASTM B32-08(2014) Standard Specification for Solder Metal.

.4 ASTM B280-16 Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.

.5 ASTM D1693-15 Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics.

.6 British Columbia Building Code, 2012 Edition (BCBC).

.7 NEMA DC 3-2008 Residential Controls - Electric Wall-Mounted Thermostats.

.8 NFPA (Fire) 70 National Electrical Code (NEC), 2014 Edition.

.9 NFPA (Fire) 90A Installation of Air Conditioning and Ventilating Systems, 2015 Edition.

1.3 REQUIREMENTS

.1 Pre-installation Meeting: Convene one (1) week before starting work of this section. Coordinate with Commissioning Agent for start-up meetings and system readiness meeting.

.2 Ensure new control system is Bac-Net compatible and has compatibility to expand to incorporate into existing BCIT system.

.3 Sequencing: Revise Shop Drawings to reflect actual installation and operating sequences.

1.4 SUBMITTALS

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

.2 Product Data: Provide description and engineering data for each control system component. Include sizing as requested. Provide data for each system component and software module.

.3 Shop Drawings:

.1 Indicate complete operating data, system drawings, wiring diagrams, and written detailed operational description of sequences.

.2 Submit schedule of valves indicating size, flow, and pressure drop for each valve.

.3 For automatic dampers indicate arrangement, velocities, and static pressure drops for each system.

.4 Design Data: Provide design data for control devices, sensors, damper and valve operators.

.5 Manufacturer's Instructions: Provide for manufactured components, and each device listed in Part 2 Products of this Specification that are being used for the specific Project.

.6 Operation and Maintenance Data: Include inspection period, cleaning methods, recommended cleaning materials, and calibration tolerances.

.7 Warranty: Submit manufacturer’s warranty and ensure forms have been filled out in Owners name and registered with manufacturer.

.8 Extra Materials: Provide two (2) of each type of thermostat, exposed temperature sensor, and pipeline pressure sensor.

.9 Building Systems: Base building automation DDC systems on ESC/Delta systems, software and equipment. Refer to Integrated Building Automation sections for additional details and requirements.

1.5 QUALITY ASSURANCE

.1 Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum five (5) years documented experience. All products shall be compatible with and able to be used with ESC/Delta DDC Controls system.

.2 Installer Qualifications: Company specializing in performing the work of this section with minimum five (5) years documented experience approved by manufacturer.

.3 Design system: Under direct supervision of a Professional Engineer experienced in design of this Work and licensed at the place where the Project is located in the Province of British Columbia.

.4 Regulatory Requirements: Products Requiring Electrical Connection: Listed and classified by ULC and CSA or a testing firm acceptable to authority having jurisdiction as suitable for purpose specified and indicated.

1.6 PROJECT CONDITIONS

.1 Project Record Documents: Record actual locations of control components, including panels, thermostats, and sensors. Accurately record actual location of control components, including panels, thermostats, and sensors.

.2 Weather Data: Import current weather and forecast data through BCIT Web software EntelliWeb to DDC System to enable control strategies.

1.7 WARRANTY

.1 Correct defective Work within a one (1) year period after Substantial Completion. Provide a complete parts and labour Warranty for the Warranty period.

.2 Provide five (5) year manufacturer's warranty for Control Panels, Control Damper Actuators, and Control Valves.

.3 Provide service and maintenance of control system for one (1) Year from Date of Substantial Completion.

.4 Provide complete service of controls systems, including call backs. Make minimum of four (4) complete normal inspections of approximately seven (7) hours duration in addition to normal service calls to inspect, calibrate, and adjust controls, and submit written reports, during Warrantee period.

PRODUCTS

1.8 CONTROL PANELS

.1 Unitize cabinet type for each system under automatic control with relays and controls mounted in cabinet and temperature indicators, pressure gauges, pilot lights, push buttons and switches flush on cabinet panel face.

.2 NEMA 250, general purpose utility enclosures with enamelled finished face panel.

.3 Each piece of equipment shall be controlled by its own controller to enable independent control in case of communication failure. All I/O points specified associated with particular equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network such as outdoor air conditions, air or water temperatures coming from source equipment.

.4 Provide common keying for all panels.

1.9 CONTROL VALVES

.1 Belimo Ball valves:

.1 Up to 50 mm Bronze body, bronze trim, renewable composition disc, screwed ends with backseating capacity repackable under pressure.

.2 Over 50 mm Iron body, bronze trim, flanged ends, renewable seat and disc.

.3 Hydronic Systems:

.1 Rate for service pressure of 860 kPa at 121°C.

.2 Size for 20 kPa maximum pressure drop at design flow rate.

.3 Two-way valves with equal percentage characteristics, three-way valves with linear characteristics. Size two-way valve operators to close valves against pump shut off head.

.2 Butterfly Pattern:

.1 Iron body, stainless steel disc, resilient replaceable seat for service to 121°C wafer or lug ends, extended neck.

.2 Hydronic Systems:

.1 Rate for service pressure of 860 kPa at 121°C.

.2 Size for 7 kPa maximum pressure drop at design flow rate.

.3 Electronic Operators:

.1 Valves: spring return to normal position as indicated on freeze, fire, or temperature protection.

.2 Select operator for full shut off at maximum pump differential pressure.

.4 Radiation Valves:

.1 Bronze body, bronze trim, two (2) or three (3) port as indicated, replaceable plugs and seats, union and threaded ends.

.2 Rate for service pressure of 860 kPa at 121°C.

.3 Size for 20 kPa maximum pressure drop at design flow rate.

.4 Two-way valves with equal percentage characteristics, three way valves with linear characteristics. Size two-way valve operators to close valves against pump shut off head.

.5 Operators (Two Position): Synchronous motor with enclosed gear train, dual return springs, valve position indicator; 24 v DC, 0.4 amp. Valves: Spring return to normal position for temperature protection.

.6 Operators (Modulating): Self-contained, linear motorized actuator with approximately 19 mm stroke, 60 second full travel with transformer and SPDT contacts: 24 v DC, 6 watt maximum input.

1.10 DAMPERS

.1 Standard of Acceptance: Tamco 9000 series.

.2 Performance: Test to AMCA 500.

.3 Frames: Galvanized steel welded or riveted with corner reinforcement, minimum 2.7 mm (12 gauge).

.4 Blades: Extruded aluminum, maximum blade size 150 mm wide, 1200 mm long, minimum 0.85 mm (22 gauge) attached to minimum 13 mm shafts with set screws. Exposed shaft ends shall be saw-cut with black paint in saw-cut, aligned with damper blade for positive position indication.

.5 Blade Seals: Neoprene inflatable, mechanically attached, field replaceable.

.6 Jamb Seals: Spring stainless steel.

.7 Shaft Bearings: Graphite impregnated nylon sleeve, with thrust washers at bearings.

.8 Linkage Bearings: Graphite impregnated nylon.

.9 Leakage: Less than 1/2% based on approach velocity of 10 m/sec and 1.0 kPa.

.10 Maximum Pressure Differential: 1.5 kPa.

.11 Temperature Limits: -40 to 93°C.

1.11 DAMPER OPERATORS

.1 General: Provide smooth proportional control throughout its entire range with sufficient power for air velocities 20% greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return for two (2) position control and for fail safe operation. Provide Belimo brand actuators, or approved alternative.

.2 Electric Operators: Spring return, adjustable stroke motor having oil immersed gear train, with auxiliary end switch, minimum position potentiometer, and 24 V dc, 24 va transformer, as required.

.3 Number: Sufficient to achieve unrestricted movement throughout damper range. Provide one (1) damper operator for maximum 3.34 m^2 damper section.

1.12 INPUT/OUTPUT SENSORS

.1 Temperature:

.1 Resistance temperature detectors with resistance tolerance of plus or minus 0.1% at 21°C interchangeability less than plus or minus 0.2%, time constant of 13 seconds maximum for fluids and 200 seconds maximum for air.

.2 Measuring current maximum 5 mA with maximum self-heat of 0.017°C/mW (0.031°F/mW) in fluids and 0.008°C/mW (0.014°F/mW) in air.

.3 Provide two wire 10k thermistor type and shield for input bridge circuit.

.4 Use insertion elements in ducts not affected by temperature stratification or smaller than 1 m^2. Use averaging elements where larger or prone to stratification sensor length 2.5 m (8 feet) or 5 m (16 feet) as required.

.5 Insertion elements for liquids: with brass socket, minimum insertion length of 60 mm.

.6 Room sensors: Locking cover.

.7 Outside air sensors: Watertight inlet fitting, shielded from direct rays of sun.

.8 Room security sensors: Stainless steel cover plate with insulated back and security screws.

.2 Humidity Sensors:

.1 Elements: Accurate within 5% full range with linear output.

.2 Room Sensors: With locking cover [matching pneumatic thermostats used], span of 10 to 80% relative humidity.

.3 Duct and Outside Air Sensors: With element guard and mounting plate, range of 0 – 100% relative humidity.

.3 Static Pressure Sensors:

.1 Unidirectional with ranges not exceeding 150% of maximum expected input.

.2 Temperature compensate with typical thermal error or 0.06% of full scale in temperature range of 5 to 40°C.

.3 Accuracy: 1% of full scale with repeatability 0.3%.

.4 Output: 0 - 5 vdc with power at 12 to 28 vdc.

.4 Equipment Operation Sensors:

.1 Status Inputs for Fans: Differential pressure switch with adjustable range of 0 to 1250 Pa

.2 Status Inputs for Pumps: Differential pressure switch piped across pump with adjustable pressure differential range of 50 to 400 kPa

.3 Status Inputs for Electric Motors: Current sensing relay with current transformers, adjustable and set to 175% of rated motor current.

.5 Damper Position Indication: provide feedback from damper actuator to indicate actual damper position on DDC Controls Graphics.

.6 Carbon Dioxide Detectors/Sensors:

.1 Manufacturer: AirSense™ Elite Beam Model 310e, or equal, no digital indication required.

.2 Technical data: For analogue output to DDC System.

Operating principle	Non-dispersive infrared (NDIR)
Gas sampling method	Diffusion or available duct kit
Measurement range	0-2000 ppm
Repeatability	± 20 ppm
Measurement accuracy	± 5% of reading or 75 ppm, whichever is greater
Recommended calibration interval	5 years
Warm up time	Less than 1 minute
Power requirements	18 - 30 VDC or 18 - 28 VRMS AC
Power consumption	Less than 1 watt
Operating temperature range	0 - 50° Celsius
Operating humidity range	5 - 95% RH, non-condensing.
Optional relay contact rating	3 Amps @ 24 VAC
Voltage output (linear)	V 0 - 10 VDC full scale standard. Range field adjustable from 1-10 VDC
Current output (linear)	4-20 mA (RLOOP : 400 □ maximum)
Optional relay setpoint range	0 to full scale

.7 Carbon Monoxide Detectors:

.1 Single or multichannel dual level detectors, using solid state sensors with three (3) year minimum life. Sensor replacement time: maximum 15 minutes. Suitable over temperature range of -5 to 55°C.

.2 Individual indicators and contractors for each level, initially calibrated for 50 ppm and 100 ppm for Warning and Alarm condition respectively.

.3 Maximum response time to 100 ppm CO calibration gas: Two (2) minutes.

1.13 THERMOSTATS

.1 Electric Room Thermostats:

.1 Type: NEMA DC 3, 24 volts, with setback/setup temperature control.

.2 Service: Cooling and heating.

.3 Covers: Locking, with set point adjustment, set point indication, and digital space temperature readout.

.2 Line Voltage Thermostats:

.1 Integral manual On/Off/Auto selector switch, single or two pole as required.

.2 Dead band: Maximum 1°C.

.3 Cover: Locking with set point adjustment, set point indication, and digital space temperature indication.

.4 Rating: Motor load.

.3 Room Thermostat Accessories:

.1 Thermostat Protective Covers: Cast Brushed aluminum.

.2 Insulating Bases: For thermostats located on exterior walls.

.3 Thermostat Guards: Cast metal mounted on separate base.

.4 Adjusting Key: As required for device.

.5 Aspirating Boxes: Where indicated for thermostats requiring flush installation.

.4 Outdoor Reset Thermostat:

.1 Remote bulb or bimetal rod and tube type, proportioning action with adjustable throttling range, adjustable set point.

.2 Scale range: 2 to 35°C.

.5 Immersion Thermostat:

.1 Remote bulb or bimetallic rod and tube type, proportional action with adjustable set point and adjustable throttling range.

.6 Airstream Thermostats:

.1 Remote bulb or bimetallic rod and tube type, proportional action with adjustable set-point in middle of range and adjustable throttling range.

.2 Averaging service remote bulb element: 6 m.

.7 Electric Low Limit Duct Thermostat:

.1 Snap acting, single pole, single throw, manual reset switch which trips if temperature sensed across any 300 mm of bulb length is equal to or below set point.

.2 Bulb length: Minimum 6 m.

.3 Provide one (1) thermostat for every 1.86 m^2 of coil surface.

.8 Electric High Limit Duct Thermostat:

.1 Snap acting, single pole, single throw, manual reset switch which trips if temperature sensed across any 300 mm of bulb length is equal to or above set point.

.2 Bulb length: Minimum 6 m.

.3 Provide one (1) thermostat for every 1.86 m^2 of coil surface.

1.14 TRANSMITTERS

.1 Building Static Pressure Transmitter:

.1 One (1) pipe, [direct acting, double bell] [differential type with temperature compensation, scale range 2.5 to 1500 kPa positive or negative, and sensitivity of 0.125 kPa Transmit electronic signal to receiver with matching scale range.

.2 Pressure Transmitters:

.1 One (1) pipe direct acting indicating type for gas, liquid, or steam service, range suitable for system, proportional electronic output.

.3 Temperature Transmitters:

.1 One (1) pipe, directly proportional output signal to measured variable, linearity within plus or minus 1/2% of range for 93°C span and plus or minus 1% for 10°C span, with 93°C temperature range, compensated bulb, averaging capillary, or rod and tube operation on 138 kPa (20 psig) input pressure and 20 to 100 kPa output.

.4 Humidity Transmitters:

.1 One (1) pipe, directly proportioned output signal to measured variable, linearity within plus or minus 1% for 70% relative humidity span, capable of withstanding 95% relative humidity without loss of calibration.

PART 2 - EXECUTION

2.1 EXAMINATION

.1 Verify that systems are ready to receive work.

.2 Beginning of installation means installer accepts existing conditions.

.3 Sequence work to ensure installation of components is complementary to installation of similar components in other systems.

.4 Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

.5 Ensure installation component is complementary to installation of similar components.

.6 Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

.7 Under no circumstances shall the Controls Trade run controls network cabling or other controls system wiring in the Electrical Cable Trays without prior written permission from the Electrical Consultant and the Electrical Contractor.

.8 Control cabling and wiring shall be run independently in conduits, and/or in separate raceways provided by the Controls Trade for their own use unless otherwise agreed or directed.

2.2 INSTALLATION

.1 Install to manufacturer's instructions.

.2 Check and verify location of thermostats, humidistats and other exposed control sensors with plans and room details before installation.

.1 Locate 1200 mm above floor, unless otherwise noted on Architectural wall elevations.

.2 Align with lighting switches and humidistats.

.3 Do not install thermostats/room temperature sensors over top of, beside, or near dimmer switches or other lighting control switch banks. Do not install in middle of wall.

.3 Mount freeze protection thermostats using flanges and element holders.

.4 Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors with sun shield, as necessary.

.5 Install damper motors on outside of duct in warm areas. Do not install motors in locations at outdoor temperatures.

.6 Mount control panels serving specific main air handling units or other large packaged pieces of equipment adjacent to associated equipment on vibration free walls or free standing angle iron supports.

.1 One (1) cabinet may accommodate more than one (1) system in same equipment room.

.2 Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.

.3 Install general control panels for services in main Mechanical Room unless noted otherwise.

.4 Route controls services back to main Mechanical Room, unless noted otherwise.

.7 Install "hand/off/auto" selector switches to override automatic interlock controls when switch is in "hand" position.

.8 Provide conduit and electrical wiring to Division 26 Electrical standards. Electrical material and installation to appropriate requirements of Division 26.

.1 Do not place controls wiring in Division 26 Electrical cable Trays unless prior written acceptance is obtained.

.2 Clearly label control wiring on maximum 3M centres that it is Controls Wiring and it's service.

END OF SECTION

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SECTION 23 31 00
HVAC DUCTWORK AND CASINGS

PART 1 - GENERAL

1.1 SECTION INCLUDES

.1 Provide metal duct work.

.2 Provide non-metal duct work.

.3 Provide casing and plenums.

.4 Provide buried duct work.

.5 Provide kitchen hood duct work.

.6 Provide duct cleaning.

.7 Provide Food Service Equipment: Supply of kitchen range hoods for placement by this Section.

.8 Provide laboratory fume exhaust ductwork and accessories.

1.2 REFERENCES

.1 ASTM A36/A36M-14 Standard Specification for Carbon Structural Steel.

.2 ASTM A90/A90M-13 Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.

.3 ASTM A480/A480M-16 Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.

.4 ASTM A568/A568M-15 Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.

.5 ASTM A653/A653M-15e1 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

.6 ASTM A1008/A1008M-15 Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.

.7 ASTM A1011/A1011M-15 Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.

.8 ASTM C14-15a Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe.

.9 ASTM C443-12 Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.

.10 AWS D9.1M/D9.1-2012 Sheet Metal Welding Code.

.11 British Columbia Building Code, 2012 Edition (BCBC).

.12 NBS PS 15 Voluntary Product Standard for Custom Contact-Moulded Reinforced-Polyestor Chemical Resistant Process Equipment.

.13 NFPA (Fire) 90A Installation of Air Conditioning and Ventilating Systems, 2015 Edition.

.14 NFPA (Fire) 90B Standard for the Installation of Warm Air Heating and Air-Conditioning Systems, 2015 Edition.

.15 NFPA (Fire) 91 Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids, 2015 Edition.

.16 NFPA (Fire) 96 Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations, 2014 Edition.

.17 SMACNA HVAC Air Duct Leakage Test Manual.

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

.19 UL 181-13 Factory-Made Air Ducts and Connectors.

1.3 SUBMITTALS

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

.2 Shop Drawings:

.1 Where a proprietary rated duct system is being used for kitchen exhaust systems, provide complete Shop Drawings of the duct material, accessories, layout, and installation data.

.2 Construct kitchen hood exhaust ductwork to NFPA 96 latest standards and requirements. Where proprietary duct systems are used, provide complete Shop Drawings showing system installation details, layouts and installation requirements.

.3 Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA HVAC Air Duct Leakage Test Manual.

.4 Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.4 QUALITY ASSURANCE

.1 Perform Work to SMACNA HVAC Duct Construction Standards Metal and Flexible.

.2 Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum five (5) years documented experience.

.3 Installer: Company specializing in performing the work of this Section with minimum five (5) years documented experience.

1.5 PROJECT CONDITIONS

.1 During construction provide temporary closures of metal or taped polyethylene on open duct work to prevent construction dust from entering duct work system.

.2 Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.

.3 Maintain temperatures during and after installation of duct sealants.

.4 Protect open ends of ductwork during construction to minimize the ingress of dust and debris.

.5 Store internally insulated ducts that have been shop prepared in a clean dry location and seal and repair damaged and cut ends of the insulation prior to duct installation.

PART 2 - PRODUCTS

2.1 MATERIALS

.1 Galvanized Steel Ducts: ASTM A653 galvanized steel sheet, lock-forming quality, having G60 zinc coating to ASTM A90.

.2 Steel Ducts: ASTM A1008, A1011, A568.

.3 Duct Sizes: Inside clear dimensions. For lined ducts, maintain sizes inside lining.

.4 Flexible Non-Insulated Ducts:

.1 UL 181, Class 0, interlocking spiral of aluminum foil.

.2 Pressure Rating: 2.0 kPa positive or negative.

.3 Maximum Velocity: 25.4 m/sec

.4 Temperature Range: -73 to 224°C.

.5 Insulated Flexible Ducts:

.1 UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound spring steel wire; fibreglass insulation; aluminized vapour barrier film.

.2 Pressure Rating: 2.50 kPa positive and 250 Pa negative.

.3 Maximum Velocity: 20.3 m/sec

.4 Temperature Range: -28 to 99°C.

.6 Stainless Steel Ducts: ASTM A167, Type 304, or as required for the specific application and vapour composition for Laboratory fume exhaust requirements.

.7 Glass Fibre Reinforced Plastic Ducts: Glass Fibre reinforced plastic to NBS PS 15, with minimum 5 mm wall thickness.

.8 HDPE (high density polyethylene) direct buried ductwork (non-pressure pipe): Formulate with minimum of 2% carbon black for maximum protection against UV rays, PE 3408 HDPE. Conform to ASTM D3350 with cell classification of 345464C/E.

.9 Buried Underground Ducts: Buried ducts may be fibre glass reinforced plastic, HDPE, PVC as indicated.

2.2 MANUFACTURED DUCTWORK AND FITTINGS

.1 Manufacture to SMACNA HVAC Duct Construction Standards Metal and Flexible, and as indicated. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.

.2 Flat Oval Ducts:

.1 Machine manufactured from round spiral lockseam duct with light reinforcing corrugations; fittings of at least two (2) gauges heavier metal than duct.

.3 Double Wall Insulated Flat Oval Ducts:

.1 Machine manufactured from round spiral lockseam duct with light reinforcing corrugations, galvanized steel outer wall, 25 mm (1 inch) thick fibreglass insulation, perforated galvanized steel inner wall; fittings with solid inner wall.

.4 Slab Duct Ventilation System:

.1 ASTM A653 galvanized steel, corrugated, in standard sizes with support brackets, connecting couplings, elbows, end caps, spin-in-collar, wall discharge head, and soffit discharge head.

.2 Designed for installation in cast-in-place concrete floor assemblies. Equal to EccoDuct,

.5 Double Wall Insulated Round Ducts:

.1 Round spiral lockseam duct with galvanized steel outer wall, 25 mm thick fibreglass insulation, perforated galvanized steel inner wall; fittings with solid inner wall.

.6 Transverse Duct Connection System:

.1 SMACNA "E" rated, SMACNA "F" rated, or SMACNA "J" rigid class connections to suit size of ducts, interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips.

2.3 ACCESSORIES

.1 Fasteners: Rivets, bolts, or sheet metal screws.

.2 Sealant:

.1 Non-hardening, water resistant, fire resistive, compatible with mating materials; liquid used alone or with tape, or heavy mastic.

.2 Robson Thermal Duct-Seal-WB

.3 Hanger Rod: ASTM A36 steel, galvanized; threaded both ends, threaded one (1) end, or continuously threaded.

2.4 FABRICATION

.1 Duct Work Fabrication - General:

.1 Fabricate and support to SMACNA HVAC Duct Construction Standards Metal and Flexible, and as indicated. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.

.2 Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centreline.

.1 Where not possible and where rectangular elbows are used, provide air foil turning vanes.

.2 Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fibre insulation.

.3 Increase duct sizes gradually, not exceeding 15° divergence wherever possible; maximum 30° divergence upstream of equipment and 45° convergence downstream.

.4 Fabricate continuously welded round and oval duct fittings two (2) gauges heavier than duct gauges indicated in SMACNA Standard.

.1 Joints: Minimum 100 mm cemented slip joint, brazed or electric welded. Prime coat welded joints.

.5 Provide standard 45° lateral wye takeoffs. Where otherwise indicated use 90° conical tee connections.

.6 Completely weld kitchen grease exhaust ductwork, kitchen dishwasher exhaust ductwork and laboratory fume exhaust at all seams and joints.

.2 Kitchen Hood Exhaust Duct Work:

.1 Fabricate to SMACNA HVAC Duct Construction Standards Metal and Flexible and NFPA 96 Standard, latest edition.

.2 Construct of 1.37 mm (16 gauge) 316 type stainless steel, using continuous external welded joints.

.3 Provide gasketted removable cleanout access panels in accordance with NFPA-96 Standard, latest edition.

.3 Kitchen Dishwasher Exhaust Duct Work:

.1 Fabricate to SMACNA HVAC Duct Construction Standards Metal and Flexible.

.2 Construct of 1.37 mm (16 gauge) 316 type stainless steel, using continuous external welded joints.

.4 Laboratory Exhaust Ductwork:

.1 Fabricate to SMACNA HVAC Duct Construction Standards Metal and Flexible.

.2 Use appropriate duct material suitable for the fumes being exhausted. Utilize necessary scrubbers to remove corrosive material from the exhaust fumes.

.3 Construct of 1.37 mm (16 gauge) 316 type stainless steel, using continuous external welded joints.

.4 Casings and Plenums:

.1 Fabricate casings to SMACNA HVAC Duct Construction Standards - Metal and Flexible and construct for operating pressures indicated.

.2 Fabricate acoustic casings with reinforcing turned inward.

.3 Provide 1.50 mm (16 gauge) back facing and 0.80 mm (22 gauge) perforated front facing with 2.4 mm diameter holes on 4 mm centers.

.4 Construct panels 75 mm thick packed with 72 kg/cu m minimum glass fibre media, on inverted channels of 1.50 mm (16 gauge).

PART 3 - EXECUTION

3.1 INSTALLATION

.1 Install to manufacturer's instructions.

.2 Ducts - General:

.1 Install and seal ducts to SMACNA HVAC Duct Construction Standards Metal and Flexible, latest edition.

.2 Install fibrous glass ducts to SMACNA Fibrous Glass Duct Construction Standards. Obtain manufacturer's inspection and acceptance of fabrication and installation at beginning of installation.

.3 Provide openings in duct work where required to accommodate thermometers and controllers.

.4 Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage.

.5 Where openings are provided in insulated duct work, install insulation material inside a metal ring.

.6 Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

.7 Use crimp joints with or without bead for joining round duct sizes 200 mm and smaller with crimp in direction of air flow.

.8 Seal seams, joints, and connections with two coats of duct sealer, regardless of pressure and construction class. Do not use duct tape as a joint sealing method.

.9 Use double nuts and lock washers on threaded rod supports.

.10 Connect terminal units to supply ducts with 300 mm maximum length of flexible duct. Do not use flexible duct to change direction.

.3 Underground Ducts:

.1 Slope underground ducts to plenums or low pump out points. Provide access doors for inspection.

.2 Insulate buried supply duct runs over 10 m long with 25 mm thick rigid board insulation covered with plastic vapour barrier.

.3 Join plastic HDPE and PVC underground ductwork by electrofusion, socket fusion, butt fusion, sidewall fusion, saddle fusion as required for a completely sealed installation.

.4 Connect Tee-bar ceiling diffusers or light troffer boots to low pressure ducts with 1.5 m maximum length of flexible duct held in place with strap or clamp.

.5 Connect flexible ducts to metal ducts with liquid adhesive plus tape or draw bands/screw clamps.

.6 Set plenum doors 150 to 300 mm above floor. Arrange door swings so that fan static pressure holds door in closed position.

.7 Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for clean out. Use stainless steel for duct work exposed to view and stainless steel or carbon steel for ducts where concealed.

.8 Laboratory Exhaust System Installation:

.1 Hood exhausts shall be manifolded together except for:

.1 Perchloric/hot acid hoods.

.2 Hoods with wash-down equipment.

.3 Hoods that could deposit highly hazardous residues on the ductwork.

.4 Exhaust requiring HEPA filtration or other special air cleaning.

.5 Situations where the mixing of exhausted materials may result in a fire, explosion, or chemical reaction hazard in the duct system.

.6 Termination of exhaust duct shall be such that the exhaust duct is safely discharged and is not recirculated back into the building.

.2 Join manifolded fume hood exhaust ducts inside a fire rated shaft or mechanical room, or outside of building at the roofline.

.3 Slope horizontal fume exhaust ducts at least 1 inch per 10 feet downward in direction of airflow to suitable drain or sump.

.4 Do not use automatic fire dampers in laboratory hood exhaust systems.

.5 Do not interlock fire detection and alarm systems to automatically shut down laboratory hood exhaust fans.

.9 Casings and Plenums:

.1 Mount floor mounted casings on 100 mm high concrete curbs.

.1 Rivet panels on 200 mm centers to angles at floor.

.2 Where floors are acoustically insulated, provide liner of 1.20 mm (18 gauge) galvanized expanded metal mesh supported at 300 mm centers, turned up 300 mm at sides with sheet metal shields.

.2 Reinforce door frames with steel angles tied to horizontal and vertical plenum supporting angles.

.3 Install hinged access doors where indicated or required for access to equipment for cleaning and inspection.

.4 Provide clear wire glass observation ports, minimum 150 X 150 mm size.

3.2 DUCT WORK MATERIAL SCHEDULE

AIR SYSTEM	MATERIAL
Low Pressure Supply (Heating Systems)	Steel
Low Pressure Supply (System with Cooling Coils)	Steel
Buried Supply or Return	Glass Fibre Reinforced Plastic, non-pressure HDPE, non-pressure PVC
Medium and High Pressure Supply	Steel
Return and Relief	Steel
General Exhaust	Steel
Kitchen Hood Exhaust	16 ga.Stainless Type 316 Steel
Dishwasher Exhaust	16 ga.Stainless Type 316 Steel
Shower rooms/wet areas	20 gauge Type 316 Stainless Steel for minimum 10M (30 ft.) downstream from terminal
Fume Hood Exhaust	18 ga type 316 Stainless Steel, Glass Fibre Reinforced Plastic, Polypropylene rigid duct
Outside Air Intake	Steel
Combustion Air	Steel
Evaporative Condenser Intake and Exhaust	Steel
Emergency Generation Ventilation	Steel

3.3 DUCT WORK PRESSURE CLASS SCHEDULE

AIR SYSTEM	PRESSURE CLASS
Supply (Heating Systems)	250 Pa
Supply (System with Cooling Coils)	500 Pa
Buried Supply or Return	500 Pa
Return and Relief	250 Pa
General Exhaust	250 Pa
Dishwasher Exhaust	500 Pa
Fume Hood Exhaust	750 Pa
Outside Air Intake	500 Pa
Combustion Air	125 Pa
Evaporative Condenser	250 Pa
Intake and Exhaust	500 Pa
Emergency Generator Ventilation	500 Pa

3.4 ADJUSTING, CLEANING AND PROTECTION

.1 Duct System:

.1 Clean duct system and force air at high velocity through duct to remove accumulated dust.

.2 Clean half the system at a time to obtain sufficient air.

.3 Protect equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning.

.4 Clean duct systems with high power vacuum machines.

.5 Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning.

.6 Provide adequate access into duct work for cleaning purposes.

.7 Use white glove test on accessible points in the ductwork to ascertain cleaning standard.

END OF SECTION

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SECTION 23 33 00
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

.1 Air turning devices/extractors.

.2 Backdraft dampers.

.3 Combination fire and smoke dampers.

.4 Duct access doors.

.5 Duct test holes.

.6 Fire dampers.

.7 Flexible duct connections.

.8 Volume control dampers.

1.2 RELATED SECTIONS

.1 23 31 00 HVAC Ductwork and Casings.

1.3 REFERENCES

.1 British Columbia Building Code, 2012 Edition (BCBC).

.2 NFPA (Fire) 70 National Electrical Code (NEC), 2014 Edition.

.3 NFPA (Fire) 90A Installation of Air Conditioning and Ventilating Systems, 2015 Edition.

.4 NFPA (Fire) 92A Standard for Smoke Control Systems, 2015 Edition.

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

.6 UL 33 Standard for Heat Responsive Links for Fire-Protection Service.

.7 UL 555 Fire Dampers.

.8 UL 555S Smoke Dampers.

1.4 SUBMITTALS

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

.2 Product Data:

.1 Provide for shop and factory fabricated assemblies including volume control dampers, duct access doors, and hardware used, fire dampers, combination smoke and fire dampers, backdraft dampers.

.2 Include electrical characteristics and connection requirements.

.3 Manufacturer's Installation Instructions: Indicate for fire dampers and combination fire and smoke dampers.

1.5 QUALITY ASSURANCE

.1 Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum five (5) years documented experience.

.2 Project Record Documents:

.1 Record actual locations of access doors, test holes, fire dampers and all in-duct accessories.

.2 Provide ULC Installation diagrams and specific fire damper standards with fire damper shop drawings to be part of the mechanical maintenance manuals.

.3 Regulatory Requirements:

.1 Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories of Canada Inc., or a testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

PART 2 - PRODUCTS

2.1 AIR TURNING DEVICES/EXTRACTORS

.1 Multi-blade device with radius blades attached to pivoting frame and bracket, steel construction, with push-pull operator rod and locking collar, or ceiling mounted rotary operator knob, with worm drive mechanism with 450 mm long removable key operator.

2.2 BACKDRAFT DAMPERS.

.1 Single-Blade - Gravity Backdraft Dampers: Size 450 x 450 mm or smaller, provide with air moving equipment. Air moving equipment to manufacturer’s standard construction.

.2 Multi-Blade - Parallel Action Gravity Balanced Backdraft Dampers: For applications bigger than 450 x 450 mm provide 1.5 mm (16 gauge) thick galvanized steel, with centre pivoted blades of maximum 150 mm width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90° stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

2.3 SMOKE DAMPERS

.1 Fabricate to NFPA 90A and UL 5555.

.2 UL Class 1 curtain and multiple blade type fire damper, specify and select normally open or closed automatically operated by electric actuator as required for application.

.3 Electro Thermal Link: Fusible link melting at 74°C 120 volts, single phase, 60 Hz; ULC listed and labeled.

2.4 COMBINATION FIRE AND SMOKE DAMPERS

.1 Fabricate to NFPA 90A, UL 555, UL 555S.

.2 Provide factory sleeve and collar for each damper.

.3 Multiple Blade Dampers: Fabricate with 1.5 mm (16 gauge) galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, stainless steel jamb seals, 3.2 x 12.7 mm plated steel concealed linkage, stainless steel closure spring, blade stops, and lock, and 12.7 mm actuator shaft.

.4 Operators: ULC listed and labelled spring return electric type suitable for 120V, single phase, 60 Hz. Provide end switches to indicate damper position. Locate damper operator on exterior of duct and link to damper operating shaft.

.5 Normally Closed Smoke Responsive Fire Dampers: Curtain type, opening by gravity upon actuation of electro thermal link, flexible stainless steel blade edge seals to provide constant sealing pressure.

.6 Normally Open Smoke Responsive Fire Dampers: Curtain type, closing upon actuation of electro thermal link, flexible stainless steel blade edge seals to provide constant sealing pressure, stainless steel springs with locking devices [to ensure positive closure for units mounted horizontally].

.7 Electro Thermal Link: Fusible link melting at 74°C (165°F); 120V, single phase, 60 Hz; ULC listed and labeled.

2.5 DUCT TEST HOLES

.1 Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

.2 Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation. Acceptable product: Duro-Dyne model IP-1 or IP-4 or approved alternative.

2.6 FIRE DAMPERS

.1 Fabricate to NFPA 90A and UL 555, and shall be ULC Labelled.

.2 Ceiling Dampers: Galvanized steel, 0.76 mm (22 gauge) frame and 1.5 mm (16 gauge) flap, two (2) layers 3.2 mm ceramic fibre on top side , and one (1) layer on bottom side for round flaps, with locking clip.

.3 Horizontal Dampers: Galvanized steel, 0.76 mm (22 gauge) frame, stainless steel closure spring, and lightweight, heat retardant non-asbestos fabric blanket.

.4 Vertical Dampers: Galvanized steel. 0.76 (22 gauge) frame, galvanized interlocking blades. Replaceable fusible link, 165 deg. F standard. Drop curtain out of the air stream.

.5 Multiple Blade Dampers: 1.5 mm (16 gauge) galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, 3.2 x 12.7 mm plated steel concealed linkage, stainless steel closure spring, blade stops, and lock.

.6 Fusible Links: UL 33, separate at 74°C (165°F) with adjustable link straps for combination fire/balancing dampers.

.7 Fire dampers:

.1 Static, for HVAC systems that shut down automatically in a fire or smoke emergency.

.2 Dynamic, for HVAC systems that remain operational during a fire or smoke emergency.

2.7 FLEXIBLE DUCT CONNECTIONS

.1 Fabricate to SMACNA HVAC Duct Construction Standards Metal and Flexible.

.2 Connector: Fabric crimped into metal edging strip.

.1 Fabric: ULC listed fire-retardant neoprene coated woven glass fibre fabric to NFPA 90A, minimum density 1.0 kg/m^2.

.2 Net Fabric Width: Approximately 75 mm wide.

.3 Metal: 75 mm wide, 0.6 mm thick (24 gauge) galvanized steel.

.3 Leaded Vinyl Sheet: Minimum 14 mm (0.55 inch) thick, 4.2 kg/m^2 10 dB attenuation in 10 to 10,000 Hz range.

2.8 VOLUME CONTROL DAMPERS

.1 Fabricate to SMACNA HVAC Duct Construction Standards Metal and Flexible.

.2 Hardware: Acceptable product: Duro-Dyne K series lockable quadrant type with sealed end bearings or approved alternative. Complete with minimum 25 mm standoff bridge for externally insulated ducts. Blade to be one gauge heavier than duct into which it is installed.

.3 Splitter Dampers:

.1 Material: Same gauge as duct to 600 mm size in either direction, and two gauges heavier for sizes over 600 mm

.2 Blade: Fabricate of double thickness sheet metal to streamline shape, secured with continuous hinge or rod.

.3 Operator: Minimum 6 mm diameter rod in self-aligning, universal joint action, flanged bushing with set screw.

.4 Single-Blade Dampers: For duct sizes up to 150 x 760 mm hardware provide as per volume balance dampers.

.5 Multi-Blade Damper: For opposed blade patterns with maximum blade sizes 200 x 1825 mm, construct centre and edge crimped blades of prime coated or galvanized channel frame with suitable hardware. Acceptable product: Duro-Dyne Opax series opposed blade damper kit or approved alternative.

.6 End Bearings:

.1 Provide sealed end bearings, except in round duct work 300 mm and smaller.

.2 Provide oil-impregnated nylon or sintered bronze bearings on multiple blade dampers.

.7 Quadrants:

.1 Provide locking, indicating quadrant regulators on single and multi-blade dampers.

.2 On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

.3 Where rod lengths exceed 750 mm (30 inches) provide regulator at both ends.

2.9 DUCT ACCESS DOORS

.1 Fabricate to SMACNA HVAC Duct Construction Standards Metal and Flexible.

.2 Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices.

.3 For insulated ductwork, install minimum 25 mm thick (or thickness to match specified insulation thickness) insulation covered with 26 gauge perforated sheet metal cover.

.1 Less than 300 mm Square: Secure with sash locks and retainer chain bolted to duct.

.2 Up to 450 mm Square: Provide two (2) hinges and two (2) sash locks.

.3 Alternate acceptable access: Provide oval gasketted door with retaining chain bolted to duct, for sizes up to 450 x 300mm.

.4 Up to 600 x 1200 mm: Provide three (3) hinges and two (2) compression latches with outside and inside blade/lever handles.

.5 Larger Sizes: Provide an additional hinge.

.6 Sash Lock: Equal to Duro-Dyne Model SL-1.

.7 Compression Latch: Equal to Duro-Dyne Model SP-20 lever handle or approved alternative.

.8 Hinge: Equal to Duro-Dyne Model HB-3 butt hinges, or Duro-Dyne HPH612 plated steel piano hinge.

.4 Access doors with sheet metal screw fasteners are not acceptable.

PART 3 - EXECUTION

3.1 PREPARATION

.1 Verify that electric power is available and of the correct characteristics.

3.2 INSTALLATION

.1 Install accessories to manufacturer's instructions, NFPA 90A, and follow SMACNA HVAC Duct Construction Standards Metal and Flexible. Refer to Section 23 31 00 Ductwork for duct construction and pressure class.

.2 Provide saw-cut on the ends of all damper shafts, aligned with the balancing damper blade, with black paint or marker in saw cut for visual indication of damper position.

.3 Provide gasketted backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated. Provide access panel at all backdraft damper locations.

.4 Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated.

- .1 Provide minimum 200 x 200 mm size for hand access, for shoulder access.
- .2 Provide minimum 200 x 200 mm for all fire dampers for all ducts up to 600 mm wide.
- .3 Provide minimum 450 x 450 mm size for all larger ducts.
- .4 Review locations prior to fabrication.
- .5 Provide gasketted bolted access doors for cleaning kitchen exhaust duct work to NFPA 96.

.5 Provide duct test holes where indicated and required for testing and balancing purposes.

.6 Provide fire dampers, combination fire and smoke dampers, and smoke dampers at locations required, where ducts and outlets pass through fire rated components.

- .1 Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges. Affix permanent labels at each fire damper location on wall or duct surface with Fire Damper model and ULC Installation detail reference.

.7 Install smoke dampers and combination smoke and fire dampers to NFPA 92A.

.8 Demonstrate re-setting of fire dampers to Consultant and BCIT Facilities Office representative.

.9 Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment, and supported by vibration isolators. For fans developing static pressures of 1250 Pa and over, cover connections with leaded or barium impregnated vinyl sheet, held in place with metal straps. Provide thrust limiting guide rods and stops at flexible connections on axial fans.

.10 Use splitter dampers only where absolutely required to provide airflow control.

.11 Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly. Provide main duct to main branch line volume balancing dampers as indicated on the drawings.

END OF SECTION

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SECTION 23 74 13

PART 1 - GENERAL

1.1 SUMMARY

.1 Provide copper tube aluminum fin evaporator coil assembly with galvanized drain pan and minimum 25 mm tail piece connection.

.2 Provide maintenance service.

.3 Provide packaged Roof mounted HVAC units having high efficiency natural gas heating section and electric refrigeration direct expansion (DX) cooling section or electric direct expansion air source heat pump heating/cooling section.

.4 Provide remote panel.

.5 Provide roof mounting curb and base.

.6 Provide unit controls.

.7 Provide vibration isolation curb with seismic anchors.

.8 This Section includes different air unit components and accessories and are to be reviewed for the specific project to match the intended HVAC capacity, design, and operation.

1.2 REFERENCES

.1 ARI 210/240-2008 Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment with Addenda 1 and 2 (AHRI).

.2 ARI 270-2008 Sound Rating of Outdoor Unitary Equipment.

.3 British Columbia Building Code, 2012 Edition (BCBC).

.4 NFPA (Fire) 70 National Electrical Code (NEC), 2014 Edition.

.5 NFPA (Fire) 90A Installation of Air Conditioning and Ventilating Systems, 2015 Edition.

1.3 SUBMITTALS FOR REVIEW

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

.2 Product Data:

.1 Provide capacity and dimensions of manufactured products and assemblies required for this project, including full selection sheet.

.2 Indicate electrical service with electrical characteristics and connection requirements, and duct connections.

.3 Provide data on recycled content of components and assembly and recyclable content for post life disposal.

.4 Provide refrigerant data for global warming and ozone layer depletion impact. Include energy efficiency and seasonal efficiencies for LEED Documentation.

.3 Shop Drawings:

.1 Indicate overall performance parameters, including capacity and dimensions of manufactured products and assemblies required for this project.

.2 Indicate electrical service with electrical characteristics and connection requirements, and duct connections.

.3 Indicate complete controls interface for ESC/Delta DDC connection and review.

.4 Manufacturer Data: Submit manufacturer's installation instructions. Indicate assembly, support details, connection requirements, and include start up instructions.

.5 Operation and Maintenance Data: Include manufacturer's descriptive literature, sound power levels both radiated and discharge, operating instructions, installation instructions, maintenance and repair data, wiring diagram and controls wiring diagrams, and parts listing.

1.4 QUALITY ASSURANCE

.1 Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience.

.2 Ensure that all packaged controls are compatible with the ESC/Delta controls system including BacNet or compatible connections for complete control interface.

.3 Regulatory Requirements:

.1 Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories of Canada Inc., or testing firm acceptable to Authority Having Jurisdiction as suitable for the purpose specified and indicated.

.4 BCIT requires all new projects and HVAC systems to meet LEED Gold standard. Select equipment to maximize LEED Energy Efficiency credits, while meeting project budget.

1.5 DELIVERY, STORAGE, AND PROTECTION

.1 Protect units from physical damage by storing off site until roof mounting curbs are in place, ready for immediate installation of units.

1.6 WARRANTY

.1 Provide a one (1) year parts and labour warranty to include coverage for refrigeration compressors, heat exchangers, condenser fans and on-board controls.

.2 Provide separate price for 5 year compressor extended warranty.

1.7 MAINTENANCE

.1 Provide service and maintenance of packaged roof top units for one year from Date of Substantial Completion.

.2 Provide maintenance service with a two month interval as maximum time period between calls. Provide 24 hour emergency service on breakdowns and malfunctions.

.3 Include maintenance items as outlined in manufacturer's operating and maintenance data, including minimum of six filter replacements, minimum of one fan belt replacement, and controls check out, adjustments, and recalibration.

.4 Submit copy of service call, work order or report, and include description of work performed.

PART 2 - PRODUCTS

2.1 AIR CONDITIONING UNITS

.1 Self-contained, packaged, factory assembled and prewired. Components include:

.1 Cabinet and frame.

.2 Supply fan.

.3 Return fan (if required for air systems over 2,000 l/s).

.4 Relief/exhaust fan.

.5 Heat exchanger and burner.

.6 Heat recovery section where the total minimum fresh airflow is over 2,000 l/s.

.7 Controls.

.8 Air filters.

.9 Refrigerant cooling coil and compressor.

.10 Condenser coil and condenser fan.

.2 Disconnect Switch: Factory mounted weatherproof disconnect switch on equipment.

2.2 GAS BURNER SECTION

.1 Induced draft or Forced draft type burner with adjustable combustion air supply, pressure regulator, gas valves, manual shut off, intermittent spark or glow coil ignition, flame sensing device, and automatic 100 percent shut off pilot.

.2 Turndown capability: Minimum 14:1.

.3 Safety Controls: Energize ignition, limit time for establishment of flame, prevent opening of gas valve until pilot flame is proven, stop gas flow on ignition failure, energize blower motor, and after air flow proven and slight delay, allow gas valve to open.

.4 High Limit Control: Temperature sensor with fixed stop at maximum permissible setting.

.1 De-energize burner: On excessive bonnet temperature.

.2 Energize burner: When temperature drops to lower safe value.

.5 Supply Fan Control: Temperature sensor sensing bonnet temperatures and independent of burner controls, with provisions for continuous fan operation.

.6 Evaporator Coil: Provide capillary tubes or thermostatic expansion valves for units of 21 kW capacity and less, and thermostatic expansion valves and alternate row circuiting for units 26 kW cooling capacity and larger.

.7 Compressor: Provide hermetic or semi hermetic compressors, 3600 rpm maximum, resiliently mounted with positive lubrication, crankcase heater, high and low pressure safety controls, motor overload protection, suction and discharge service valves and gauge ports, and filter drier.

.1 Five minute timed off circuit to delay compressor start.

.2 Outdoor thermostat to energize compressor above 14 degrees C ambient.

.3 Provide step capacity control by cycling compressors, cylinder unloading, or cycling multi speed compressors.

.8 Heat pump units: Provide reversing valve, suction line accumulator, discharge muffler, flow control check valve, and solid state defrost control utilizing thermistors.

.9 Condenser Coil:

.1 Provide copper tube aluminum fin coil assembly with sub-cooling rows and coil guard.

.2 Provide direct drive propeller fans, resiliently mounted with fan guard, motor overload protection, wired to operate with compressor.

.3 Provide high efficiency fan motors.

.4 Provide refrigerant pressure switches to cycle condenser fans.

.10 Mixed Air Casing:

.1 Dampers: Provide outside, return, and relief dampers with damper operator and control package to automatically vary outside air quantity. Outside air damper to fail to closed position. Relief dampers may be gravity balanced.

.2 Gaskets: Provide tight fitting dampers with edge gaskets maximum leakage 3 percent at 500 Pa (2 inches) pressure differential.

.3 Damper Operator: 24 volt with gear train sealed in oil with spring return on units 26 kW cooling capacity and larger.

.4 Mixed Air Controls: Maintain fresh air dampers to minimum position when in active heating or mechanical cooling mode. Maximize free cooling using enthalpy based economizer controls.

.11 Operating Controls:

.1 Provide low voltage, adjustable supply air duct thermostat to control to maintain supply air temperature setting.

.2 Provide complete controls interface to the ESC/Delta DDC system.

.3 Provide low limit thermostat in supply air to close outside air damper and stop supply fan and annunciate and alarm to the control system.

2.3 ACCESSORIES

.1 Cabinet: Galvanized steel with baked enamel finish, access doors or removable access panels with quick fasteners locking door handle type with piano hinges. Structural members minimum 1.20 mm (18 gauge), with access doors or removable panels of minimum 0.90 mm (20 gauge).

.2 Casing Insulation: Minimum 75 mm thick neoprene coated glass fibre with edges protected from erosion.

.3 Gas-fired Heat Exchangers: Stainless steel, of welded construction.

.4 Supply, Return, and Exhaust Fan: Forward curved centrifugal type, resiliently mounted with V belt drive, adjustable variable pitch motor pulley, and rubber isolated hinge mounted high efficiency motor. Isolate complete fan assembly with seismically snubbed spring isolators.

.5 Air Filters: 100 mm thick pleated glass fibre disposable media in metal frames, minimum final efficiency of MERV-13

.6 Roof Mounting Curb: 350mm high galvanized steel, channel frame with gaskets, nailer strips.

2.4 OPERATING CONTROLS - SINGLE ZONE UNITS - NOT CONNECTED TO DDC

.1 Electric solid state microcomputer based room thermostat, located as indicated.

.2 Room thermostat:

.1 Automatic switching from heating to cooling.

.2 Preferential rate control to minimize overshoot and deviation from set point.

.3 Set up for four separate temperatures per day.

.4 Instant override of set point for continuous or timed period from one hour to 31 days.

.5 Short cycle protection.

.6 Programming based on weekdays, Saturday and Sunday.

.7 Switch selection features including imperial or metric display, 12 or 24 hour clock, keyboard disable, remote sensor, fan on auto.

.3 Room thermostat display:

.1 Time of day.

.2 Actual room temperature.

.3 Programmed temperature.

.4 Programmed time.

.5 Duration of timed override.

.6 Day of week.

.7 System model indication: heating, cooling, auto, off, fan auto, fan on.

.8 Stage (heating or cooling) operation.

.4 Provide low limit thermostat in supply air to close outside air dampers and stop supply fan.

2.5 OPERATING CONTROLS - VARIABLE VOLUME UNITS

.1 Temperature transmitter located in supply air to signal electronic logic panel to control mixing dampers and cooling in sequence.

.2 Operate mixing section as first stage of cooling and revert to minimum outside air above approximately 24˚C (75˚F), adjustable, as determined by enthalpy of return and outdoor air.

.3 Control cooling by cycling compressors, cylinder unloading, and variable speed compressors as required.

.4 Allow supply air reset under low load or airflow conditions.

.5 Packaged Units of less than 2,500 l/s total airflow capacity:

.1 Provide within roof curb, by pass dampers, bypassing air from supply fan discharge to return fan inlet to control duct static pressures.

.2 Control operation by sensing current to supply fan motor.

.6 Packaged units with a total airflow capacity over 2,500 l/s:

.1 Provide variable frequency speed drives on the supply fan, return fan and exhaust/relief fan (if used).

.2 Provide building air pressure monitoring to control exhaust/relief air to avoid over-pressurizing the building and to avoid negative air pressure inside the building.

2.6 HEAT RECOVERY SECTION

.1 Provide heat recovery section to recover exhaust/relief air heat for air units with total minimum fresh airflow over 2,000 l/s.

.2 Cross-flow plate type, counterflow plate type, or heat-pipe coil type.

.3 Where additional maintenance and crossover contamination of airstreams is not critical, use energy recovery wheels only upon prior approval from BCIT.

PART 3 - EXECUTION

3.1 EXAMINATION

.1 Verify that roof is ready to receive work and opening dimensions are as indicated on Shop Drawings and as illustrated by the manufacturer.

.2 Verify that proper power supply is available.

3.2 INSTALLATION

.1 Install to manufacturer's instructions and to requirements of NFPA 90A.

.2 Mount units on factory built roof mounting curb providing watertight enclosure to protect ductwork and utility services.

.3 Install roof mounting curb level.

.4 Locate remote panels where indicated.

3.3 FIELD QUALITY CONTROL

.1 Provide initial start-up and shut down during first year of operation, including routine servicing and check out.

.2 Coordinate with Testing, Start-up and Commissioning requirements.

END OF SECTION

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SECTION 23 81 00
DECENTRALIZED UNITARY HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

.1 Provide packaged terminal air conditioning units.

.2 Provide packaged terminal heat pump units.

.3 Provide wall sleeves and louvres.

.4 Provide controls.

.5 This equipment shall only be used for small or temporary building projects where stand-alone air conditioning is required. Consult BCIT for location and use of this type of equipment.

1.2 REFERENCES

.1 ARI 210/240-2008 Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment with Addenda 1 and 2 (AHRI).

.2 ARI 270-2008 Sound Rating of Outdoor Unitary Equipment (AHRI).

.3 British Columbia Building Code, 2012 Edition (BCBC).

.4 NFPA (Fire) 70 National Electrical Code (NEC), 2014 Edition.

1.3 SUBMITTALS FOR REVIEW

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

.2 Product performance: Provide selection sheet noting all operational parameters and equipment performance.

.3 Product Data: Provide drawings indicating dimensions, rough-in connections, and electrical characteristics and connection requirements. Include controls wiring diagram and internal controls descriptions.

.4 Submit manufacturer's installation instructions. Indicate assembly, support details, connection requirements, and include start-up instructions.

.5 Manufacturer’s Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, and maintenance and repair data.

1.4 QUALITY ASSURANCE

.1 Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five (5) years documented experience.

.2 Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories of Canada, Inc., CSA, or a testing firm acceptable to the Authority Having Jurisdiction as suitable for the purpose specified and indicated.

1.5 WARRANTY

.1 Provide a one (1) year parts and labour warranty to include coverage for refrigeration compressors.

.2 Provide separate price for compressor(s) extended five (5) year warranty.

.3 Provide complete warranty terms & conditions with equipment shop drawing submittal.

PART 2 - PRODUCTS

2.1 PACKAGED TERMINAL AIR CONDITIONING UNITS

.1 Description: Packaged, self-contained, through-the-wall air or water cooled terminal heat pump units, with wall sleeve, room cabinet, electric refrigeration system, outside air louvres, remote temperature controls; fully charged with refrigerant and filled with oil.

.2 Electrical Characteristics:

.1 Disconnect Switch: Factory mounted disconnect switch on equipment or pigtail plugged to wall outlet at unit.

.3 Cabinet:

.1 Wall mounted or floor mounted of 1.20 mm (18 gauge) galvanized steel with baked enamel finish, removable front panel with concealed latches, colour as selected.

.2 Discharge Grille and Access Door: Removable punched louvre or extruded aluminum discharge grilles, allowing 4-way discharge air pattern, with hinged door in top of cabinet for access to controls.

.3 Wall Cabinet: Matching cabinet in construction and finish, allowing diversion of 40% of unit air flow to adjoining room, with grille.

.4 Chassis:

~~.1~~ Air System: Centrifugal forward curved evaporator indoor fans with two electrically commutated motor, permanent washable filters. ~~–~~ Full economizer, with power exhaust.

.2 Heating Coil: Hot water.

.3 Refrigeration System:

.1 Direct expansion indoor coil.

.2 Hermetically sealed compressor with crankcase heater, internal spring isolation, external isolation, permanent split capacitor motor and overload protection.

.3 Accumulator.

.4 Condenser, Outdoor coil and fan.

.5 Coaxial condenser with head pressure water regulating valve.

.6 Capillary tube or thermal expansion valve with remote bulb and equalizing port.

.7 Reversing valve.

.5 Condensate Drain: Drain pan to direct condensate to condenser or outdoor coil for re-evaporation.

.6 Condenser or Outdoor Fan: Centrifugal, forward curved, or axial type with separate permanent split capacitor or electrically commutated motor.

.7 Controls:

.1 Control Module: Remote mounted 7-day programmable thermostat with heat anticipator, off-heat-auto-cool switch, auto-on fan switch.

.2 Low Ambient Kit: Unit shall be capable to operate in cooling / heating modes with ambient temperature down to minus 18°C (0°F)

.8 Wall Sleeves and Louvres:

.1 Wall Sleeves: 1.50 mm (16 gauge) galvanized steel with protective mastic coating or polyester finish.

.2 Louvres: Flush or Companion flanged anodized aluminum with enamel finish, colour as selected.

.9 Electric Re-heat

.1 Integral electric re-heat coil suitable for supplementary heat and for defrost cycle.

2.2 SPLIT-SYSTEM AIR CONDITIONERS

.1 Description: Factory assembled and tested, floor-mounted, wall-mounted, ceiling mounted unit, with air or water-cooled remote heat-pump type condensing unit, and field-installed refrigeration piping.

.2 Air-Cooled, Compressor-Condenser Components:

.1 Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Service valves, fittings, and gage ports shall be brass and located outside of the casing.

.2 Compressor: Hermetically sealed scroll with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

.3 Compressor motor with manual-reset, high-pressure switch and automatic-reset, low-pressure switch.

.4 Fan: Aluminum, propeller type, directly connected to motor.

.5 Low Ambient Kit: Permit operation down to minus 18 deg C.

.6 Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1 Latest Edition, "Energy Standard for Buildings except Low-Rise Residential Buildings."

.7 Motor: Permanently lubricated, with integral thermal-overload protection.(electrically commutated)

.8 Mounting Base: Polyethylene.

.9 Refrigerant: R-407C or R-410A.

.10 Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with liquid sub-cooler.

.3 Concealed Evaporator Components:

.1 Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

.2 Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.

.3 Disposable Filters: 25 mm (1 inch) thick, in fiberboard frames with MERV rating of 8 or higher according to ASHRAE 52.2.

.4 Drain Pans: Stainless steel, or polypropylene with connection for drain; insulated and complying with ASHRAE 62.1. Insulated condensate drain pan complete with 25mm diameter condensate drain connection to connect to local drain system.

.5 Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.

.6 Fan Motors: Comply with requirements for multi-tapped, multi-speed motors with internal thermal protection and permanent lubrication. Or electrically commutated motor.

.7 Insulation: Factory-applied duct liner.

.8 Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with thermal-expansion valve.

.9 Electric reheat: Integral electric re-heat coil suitable for suitable for supplementary heat and for defrost cycle.

.10 Water Coil:

.1 Co-axial condenser, leak tested to 2770 kPa underwater; and having a head pressure regulating control valve.

.2 Provide shut-off valve on supply line and flow control and shut-off valve on return line. Provide manual or float operated automatic air vents at high points complete with stop valve.

.11 Wiring Terminations: Connect motor to chassis wiring with quick-connect plug connection.

PART 3 - EXECUTION

3.1 INSTALLATION

.1 Install to manufacturer's instructions.

.2 Coordinate installation of units with architectural, mechanical, and electrical work.

END OF SECTION