

**SECTION 15060
PIPING SUPPORT SYSTEMS**

1 GENERAL

1.01 SUMMARY

A. Comply with Division 1, General Requirements

1. The NEWPCC facility is a major wastewater treatment plant with limitations and restrictions to access and service disruptions. Work within this Division must be planned and coordinated as further described in Division 1, Section 01040.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this Section:

1. Building Officials and Code Administrators (BOCA): Basic Building Code.
2. International Conference of Building Officials (ICBO): Uniform Building Code.
3. National Building Code of Canada (NBC)
4. Manufacturers' Standardization Society (MSS):
 - a. SP 58, Pipe Hangers and Supports - Materials, Design and Manufacture.
 - b. SP 69, Pipe Hangers and Supports - Selection and Application.
 - c. SP 89, Pipe Hangers and Supports - Fabrication and Installation Practices.

1.03 SUBMITTALS

A. Shop Drawings:

1. Drawings of piping support system, locating each support, brace, hanger, guide, component, and anchor. Identify support, hanger, guide, and anchor type by catalog number and Shop Drawing detail number.
2. Revisions to support systems resulting from changes in related piping system layout or addition of flexible joints.

1.04 QUALIFICATIONS

- A. Piping support systems shall be designed and Shop Drawings prepared and sealed by a Professional Engineer registered in the Province of Manitoba.

1.05 DESIGN REQUIREMENTS

A. General:

1. Design, size, and locate piping support systems throughout facility, whether shown or not.
2. Supports are shown only where specific types and locations are required; additional pipe supports may be required.
3. Meet requirements of MSS SP 58, MSS SP 69, and MSS SP 89, or as modified by this Section.

B. Pipe Support Systems:

1. Support Load: Dead loads imposed by weight of pipes filled with intended service commodity except air and gas pipes.
2. Maximum Support Spacing and Minimum Rod Size:
 - a. Mild Steel or Ductile Iron Piping:

Pipe Size	Maximum Support/ Hanger Spacing	Minimum Rod Size Single Rod Hangers
25 mm & smaller	1.8 m	6.25 mm
32.5 mm through 62.5 mm	2.4 m	6.25 mm
75 mm & 100 mm	3.0 m	9.5 mm
150 mm	3.6 m	9.5 mm
200 mm	3.6 m	12.5 mm
250 mm & 300mm	4.3 m	15.9 mm
350 mm	4.8 m	19.1 mm

b. Plastic and Fiberglass Piping:

- 1) Maximum support spacing: As recommended by Manufacturer for flow temperature in pipe.
- 2) Minimum Hanger Rod Sizing: Same as listed for steel pipe.

c. Stainless Steel Piping:

SST Pipe Size	Maximum Support/ Hanger Spacing	Minimum Rod Size Single Rod Hangers
25 mm through 100 mm	2.4 m	6.25 mm
150 mm	2.4 m	9.5 mm
200 mm & 250 mm	3.0 m	12.5 mm
300 mm	3.0 m	12.5 mm
350 mm & 400 mm	3.6 m	15.9 mm

- C. Anchoring Devices: Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor support, to withstand shear and pullout loads imposed by loading and spacing on each particular support.
- D. Existing Support Systems: Use existing supports systems to support new piping only if Contractor can show that they are adequate for additional load, or if they are strengthened to support additional load.

2 PRODUCTS

2.01 GENERAL

- A. When specified items are not available, fabricate pipe supports of correct material and to general configuration indicated by catalogs.
- B. Special support and hanger details are shown for cases where standard catalog supports are inapplicable.
- C. Materials: Stainless Steel (316) unless approved by Contract Administrator

2.02 HANGERS

- A. Clevis Type: MSS SP 58 and SP 69, Type 1 or 6.
 - 1. Anvil; Figure 104 or 260.
 - 2. B-Line; Figure B3198 or B3100.
- B. Equal leg angle for trapeze assembly.
 - 1. Anvil; Figure 50.
- C. Hanger Rods, Clevises, Nuts, Sockets, and Turnbuckles: In accordance with MSS SP 58.

2.03 WALL BRACKETS

- A. Welded Stainless Steel Bracket: MSS SP 58 and SP 69, Type 32 (Medium-duty).
 - 1. Anvil; Figure 195.
 - 2. B-Line; Figure B3067.

2.04 PIPE CLAMPS

- A. Riser Clamp: MSS SP 58 and SP 69, Type 8.
 - 1. Anvil; Figure 261.
 - 2. B-Line; Figure B3373.
- B. Offset pipe Clamp
 - 1. Anvil; Figure 103

3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install support systems in accordance with MSS SP 69 and MSS SP 89, unless shown otherwise.
2. Support piping connections to equipment by pipe support and not by equipment.
3. Support large or heavy valves, fittings, and appurtenances independently of connected piping.
4. Support no pipe from pipe above it.
5. Support pipe at changes in direction or in elevation, adjacent to flexible joints and couplings, and where shown.
6. Do not install pipe supports and hangers in equipment access areas.
7. Repair mounting surfaces to original condition after attachments are made.

B. Standard Pipe Supports:

1. Horizontal Suspended Piping:
 - a. Single Pipes: Adjustable swivel-ring, split-ring, or clevis hangers.
 - b. Grouped Pipes: Trapeze hanger systems.
2. Horizontal Piping Supported From Walls:
 - a. Single Pipes: Wall brackets or wall clips attached to wall with anchors. Clips attached to wall mounted framing also acceptable.
 - b. Stacked Piping:
 - 1) Wall mounted framing system and clips acceptable for piping smaller than 75 mm minimal diameter.
 - 2) Piping clamps that resist axial movement of pipe through support not acceptable.
3. Vertical Pipe: Support with wall brackets and base elbow or riser clamps on floor penetrations or offset clamp.

C. Accessories:

1. Dielectric Barrier:
 - a. Install between carbon steel members and copper or stainless steel pipe.
 - b. Install between stainless steel supports and nonstainless steel ferrous metal piping.
2. Electrical Isolation: Install 6.4 mm by 75 mm neoprene rubber wrap between submerged metal pipe and oversized clamps.

3.02 MATERIALS

- A. Supports, brackets, and hanger rods, clevises, nuts, washers, and turnbuckles to be 316 stainless steel unless otherwise is shown.

END OF SECTION

SECTION 15100
PLUMBING PIPING AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

1. Comply with the latest edition of the following statutes codes and standards and all amendments thereto. American National Standards Institute (ANSI):
 - a. B2.1.001, Standard Welding Procedure Specification for Shielded Metal Arc Welding of Carbon Steel.
 - b. B16.5, Pipe Flanges and Flanged Fittings.
 - c. B16.9, Factory-Made Wrought Steel Buttwelding Fittings.
2. American Society for Testing and Materials (ASTM):
 - a. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - b. A105/A105M, Standard Specification for Forgings, Carbon Steel, for Piping Components.
 - c. A181/A181M, Standard Specification for Forgings, Carbon Steel, for General-Purpose Piping.
 - d. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.
 - e. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
 - f. A563, Standard Specification for Carbon and Alloy Steel Nuts.
3. Conform with the Plumbing Code and the requirements of Provincial and local authorities having jurisdiction.

1.02 SUBMITTALS

- A. Action Submittals:
 1. Product data sheets.
 2. Drawings showing changes in location of fixtures or equipment that are advisable in the opinion of Contractor.
 3. Isometric riser diagrams.
- B. Informational Submittals:
 1. Changes in location of equipment or piping that affect connecting or adjacent work, before proceeding with the work.
 2. Complete list of products proposed for installation.

3. Test records produced during testing.

PART 2 PRODUCTS

2.01 PIPING

- A. Piping Schedule: Refer to Section 15200, Process Piping—General
- B. Piping Material: Refer to Piping Data Sheet(s), Article—Supplements and Section 15200, Process Piping—General.

2.02 PIPE HANGERS AND SUPPORTS

- A. As specified in Section 15060

2.03 VALVES

- A. Lubricated Plug Valve for Natural gas service:
 1. 25mm to 300mm
 - a. Short pattern, regular straightway port, pressure lubricated plug, button head fitting, ASRM A1 26 Class B semi steel body and plug, flanged ANSI B16.1 on 100mm and larger, threaded on 75 mm and smaller, ANSI Class 125 rating, enclosed worm gear operator on 100mm and larger, lever on 75mm and smaller.
 - b. Manufacturers and Products:
 - 1) Neo PR, AS40114C
 - 2) Milliken
 - 3) Rockwell

PART 3 EXECUTION

3.01 GENERAL

- A. Install plumbing systems to meet the applicable Plumbing Code.
- B. Field Obstructions:
 1. Drawings do not attempt to show exact details of piping. Provide offsets around obstructions.
 2. Do not modify structural components, unless approved by Contract Administrator.
- C. Sleeves:
 1. Pipe sizes shown are nominal sizes, unless shown or specified otherwise.

2. Provide piping passing through walls, floors, or ceilings with standard-weight pipe sleeves.
 3. Provide pipes passing through finished walls with chrome-plated canopy flanges.
 4. Dry pack sleeves in existing work in-place and provide finished appearance.
 5. Pack holes left by removal of existing piping with grout and finish to match adjacent surface.
- D. Provide unions in piping systems at connections to equipment.
- E. Provide insulating dielectric unions and flanges between ferrous and nonferrous piping and where otherwise required for electrically insulated connection.

3.02 INSTALLATION

- A. Steel Pipe:
1. Ream, clean, and remove burrs and mill scale from piping before making up.
 2. Seal joint with pipe joint sealer or Teflon tape.
- B. Valves: Install in accordance with manufacturer's recommendations.
- C. Miscellaneous Piping Specialties: Install in accordance with manufacturer's recommendations.
- D. Metering and Measuring Devices: Install in accordance with manufacturer's recommendations.

3.03 GAS PIPING

- A. Slope piping 2 percent downward in direction of flow toward respective drip traps.
- B. Install drip traps at end of runs and where pipe changes elevation.
- C. Provide union adjacent to each flexible connector hose.
- D. Installation shall comply with applicable local gas code.
- E. Label "GAS" at intervals not to exceed 1.5 m.

3.04 INTERIM CLEANING

- A. Prevent accumulation of weld rod, weld spatter, pipe cuttings and filings, gravel, cleaning rags, and other foreign material within piping during fabrication and assembly.
- B. Examine piping to assure removal of foreign objects prior to assembly.
- C. Shop cleaning may employ conventional commercial cleaning method if it does not corrode, deform, swell, or otherwise alter physical properties of material being cleaned.

3.05 TESTING

- A. General:
 - 1. Conduct pressure and leakage tests on newly installed pipelines.
 - 2. Provide necessary equipment and material and make taps in pipe, as required.
 - 3. Contract Administrator will monitor the tests. Provide 24 hours advance notice of start of testing.
 - 4. Test Pressures: As specified herein and in Piping Schedule.
 - 5. Test Records: Make records of each piping system installation during the test to document the following:
 - a. Date of test.
 - b. Description and identification of piping tested.
 - c. Test fluid.
 - d. Test pressure.
 - e. Remarks, including:
 - 1) Leaks (type, location).
 - 2) Repairs made on leaks.
 - f. Certification by Contractor and signed acknowledgment by Contract Administrator that tests have been satisfactorily completed.
- B. Testing New Pipe Connected to Existing Pipe: Isolate new pipe with grooved end pipe caps, spectacle blinds, or blind flanges.
- C. Preparation and Execution:
 - 1. Buried Pressure Piping:
 - a. An initial service leak test may be conducted with a partially backfilled trench and the joints left open for inspection, if field conditions permit, as determined by the Contract Administrator.
 - b. Expose joints for the acceptance test on buried pressure piping to be pneumatically tested or subjected to an initial service leak test.
 - c. Conduct final hydrostatic acceptance tests after trench has been completely backfilled.

2. Exposed Piping: Conduct tests after piping has been completely installed including supports, hangers, and anchors, but prior to insulation.

D. Pneumatic Leak Tests:

1. Perform on natural gas piping.
2. Equipment: Provide the following:

Amount	Description
1	Pneumatic compressor separator-dryer system capable of providing oil-free dry air and equipped with one or more full capacity safety relief valves set at a pressure of not more than 105 percent of the required primary test pressure
1	Calibrated test gauge

3. Procedure:
 - a. Perform pneumatic testing using accurately calibrated instruments and oil-free, dry air.
 - b. Perform tests only on exposed piping, after piping has been completely installed, including supports, hangers and anchors, and inspected for proper installation.
 - c. Test piping system at the test pressure specified in the Piping Schedule.
 - d. Take necessary precautions to protect test personnel and Owner's operating personnel from hazards associated with air testing.
 - e. Secure piping to be tested to prevent damage to adjacent piping and equipment in event of a joint failure.
 - f. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by test.
 - g. Apply maximum 172 kPa preliminary pneumatic test to piping system prior to final leak testing, to locate major leaks.
 - h. Examine joints and connections for leakage with soap bubbles.
 - i. Correct visible leaks and retest to satisfaction of Contract Administrator.
 - j. Gradually increase pressure in the system to not more than one-half of test pressure.
 - k. Thereafter increase pressure in steps of approximately 1/10 of maximum test pressure until required test pressure is reached.
 - l. Maintain pneumatic test pressure continuously for minimum 10 minutes and for such additional time as necessary to conduct a soap bubble examination for leakage.
 - m. The piping system, exclusive of possible localized instances at pump or valve packing, shall show no evidence of leakage.
 - n. Correct visible leakage retest to satisfaction of Contract Administrator.

- o. Following pneumatic testing, thoroughly purge, with nitrogen, lines that are to carry flammable gases to assure no explosive mixtures will be present in the system during the filling process.

3.06 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are part of this Specification.

- 1. Plumbing Piping Data Sheets.

Section Number	Title
-01	Carbon Steel pipe and fittings – special services

END OF SECTION

**SECTION 15100-01
CARBON STEEL PIPE AND FITTINGS-SPECIAL SERVICE**

Item	Size	Description
Pipe	40 mm & smaller	Black carbon steel, ASTM A106, Grade B seamless or ASTM A53, Grade B seamless or ERW. Threaded, butt-welded, and flanged joints: Schedule 80.
	50 mm thru 250 mm	Schedule 40, except 100 mm and smaller in chlorine service; Schedule 80.
	300 mm thru 400 mm	Schedule 30.
	450 mm thru 600 mm	Schedule 20.
Joints	50 mm & smaller	Threaded or socket-welded; flanged at equipment as required or shown.
	60 mm & larger	Butt-welded or flanged at valves and equipment.
Fittings	50 mm & smaller	Threaded or socket-weld, forged carbon steel, ASTM A105/A105M, 900 kg- or 1365 kg WOG (1365 kg chlorine service), conforming to ANSI B16.11; bore to match pipe inside diameter.
	60 mm & larger	Wrought carbon steel butt-welding, ASTM A234/A234M, Grade WPB meeting the requirements of ANSI B16.9; fitting wall thickness to match adjoining pipe; long radius elbows unless shown otherwise.
Branch Connections	50 mm & smaller	Threadolet or socket in conformance with Fittings above.
	60 mm & larger	Butt-welding tee in accordance with Fittings above.
Flanges	50 mm & smaller	Forged carbon steel, ASTM A105/A105M, ANSI B16.5 Class 150 or Class 300 socket-weld or threaded, 1.50 mm raised face.
	60 mm & larger	Forged carbon steel, ASTM A105/A105M, ANSI B16.5 Class 150 or Class 300 slip-on or welding neck, 1.50mm raised face; weld neck bore to match pipe internal diameter. Use weld neck flanges when abutting butt-weld fittings.

**SECTION 15100-01
CARBON STEEL PIPE AND FITTINGS-SPECIAL SERVICE**

Item	Size	Description
Unions	50 mm & smaller	<p>Threaded or socket-weld, forged carbon steel, ASTM A105/A105M, 13800- or 20700 kpag WOG, integral ground steel-to-steel seats, AAR design meeting the requirements of ANSI B16.11, bore to match pipe.</p> <p>Chlorine Service: Threaded or socket-weld end ammonia type tongue-and-groove flange union, ASTM A105/A105M forged carbon steel, 10350 kpag two-bolt oval type.</p>
Bolting	All	<p>Carbon steel ASTM A193/A193M, Grade B7 studs and ASTM A194/A194M, Grade 2H hex head nuts. Quench and temper for chlorine service.</p> <p>When mating flange on equipment is cast iron and gasket is flat ring, provide ASTM A307, Grade B hex head bolts and ASTM A563, Grade A heavy hex nuts.</p>
Gaskets	All flanges	<p>General Service and Oil/Gas: 1.5 mm thick compressed nonasbestos composition flat ring type. Garlock, Style 3000; Manville, Style 978.</p> <p>Steam Service: Spiral wound, Type 304 stainless steel with nonasbestos filler, integral 3 mm thick carbon steel centering ring. Garlock, Guardian Style 555; Flexitalic, Style CGP.</p> <p>Chlorine Unions: Chemical lead, 2 to 4 percent antimony, 3 mm thick.</p>
Thread Lubricant		<p>General Service: Teflon tape.</p> <p>Chlorine Service: White lead paste or litharge and glycerine.</p>

END OF SECTION

**SECTION 15200-00
PROCESS PIPING**

1 GENERAL

1.01 SUMMARY

A. Comply with Division 1, General Requirements

1. The NEWPCC facility is a major wastewater treatment plant with limitations and restrictions to access and service disruptions. Work within this Division must be planned and coordinated as further described in Division 1, Section 01040.

1.02 SCOPE

- A. This Section covers the supply, installation, testing, cleaning and placing into operation of all process piping systems including fittings, mentioned in the piping schedule.

1.03 REFERENCES

- A. The following is a list of standards which may be referenced in this Section and any supplemental Data Sheets:

1. American National Standards Institute (ANSI): B16.21, Nonmetallic Flat Gaskets for Pipe Flanges
2. American Society for Testing and Materials (ASTM):
 - a. A276, Standard Specification for Stainless Steel Bars and Shapes
 - b. A312/A312M, Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes
 - c. D1330, Standard Specification for Rubber Sheet Gaskets
 - d. D1785, Standard Specification for PVC Plastic Pipe, Schedules 40, 80, and 120
 - e. D2464, Standard Specification for Threaded PVC Plastic Pipe Fittings, Schedule 80
 - f. D2467, Standard Specification for PVC Plastic Pipe Fittings, Schedule 80

3. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS): SP43, Wrought Stainless Steel Butt-Welding Fittings Including Reference to Other Corrosion Resistant Materials

1.04 DESIGN REQUIREMENTS

- A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:
 1. Process Piping: ASME B31.3
 2. Building Service Piping: ASME B31.9, as applicable
 3. Standard Specification for PVC Plastic Pipe, Schedules 40, 80, and 120: ASTM D1785
 4. Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes: ASTM A312/A312M.
 5. Provincial Regulations

1.05 SUBMITTALS

- A. Shop Drawings:
 1. Shop Fabricated Piping:
 - a. For stainless steel piping, sizes 50 mm and larger, provide detailed pipe fabrication or spool drawings showing fittings and bends, dimensions, field weld locations, and other pertinent information.
 - b. For shop fabricated piping that connects to existing piping, measure and show on the shop drawings the as-built information for the existing pipes. Adjust design of new piping accordingly so that new piping accurately mates with existing piping.
 2. For connection to the existing pipes: details including materials, sizes, and pipe attachment methods.
 3. Dissimilar Buried Pipe Joints: joint types and assembly drawings.
- B. As-built drawings

1.06 QUALITY CONTROL

- A. Welding materials, fabrication standards and labour qualifications shall conform to ANSI/ASME B31.1, ANSI/ASME B31.3, ANSI B16.25, and the Provincial Board of Labour Regulations.

- B. Use welders fully qualified and licensed by provincial authorities in accordance with CSA W59.

1.07 DELIVERY, STORAGE, AND HANDLING

A. General:

1. Flanges: securely attach metal, hardboard, or wood protectors over entire gasket surface.
2. Threaded or Socket Welding Ends: fit with metal, wood, or plastic plugs or caps.
3. Cold Weather Storage: locate Products to prevent coating from freezing to ground.
4. Handling: use heavy canvas or nylon slings to lift pipe and fittings.

2 PRODUCTS

2.01 PIPING

A. Diameters Shown:

1. Standardized Products: nominal size.
2. Fabricated Stainless Steel Piping: outside diameter, ASME B36.10M.

2.02 JOINTS

A. Grip Connection Couplings:

1. Stainless steel, ASTM A276, Type 316 SS.
2. Manufacturers:
 - a. Staub.
 - b. YNI
 - c. Approved equal.

2.03 WELDING

- A. Welding materials shall be in accordance with CSA W48.

2.04 GASKET LUBRICANT

- A. Lubricant shall be supplied by pipe manufacturer and no substitute or “or-equal” will be allowed.

2.05 FABRICATION

- A. Mark each pipe length on outside:
 - 1. Size or diameter and class
 - 2. Manufacturer's identification and pipe serial number
 - 3. Location number on laying drawing
 - 4. Date of manufacture
- B. Flanged pipe shall be fabricated in the shop, not in the field, and delivered to the Site with flanges in place and properly faced. Threaded flanges shall be individually fitted and machine tightened on matching threaded pipe by the Manufacturer.

3 EXECUTION

3.01 PIPING MATERIAL SELECTION

- A. As specified on Piping Schedule located at the drawings (See drawing P0002).

3.02 EXAMINATION

- A. Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipelines to be connected to new pipelines or new equipment.
- B. When connecting to existing flanges and pipeline, accurately measure pipe/flange locations and any angular misalignment and make appropriate adjustments so that new piping will mate up properly.
- C. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.
- D. Welding Electrodes: verify proper grade and type, free of moisture and dampness, and coating is undamaged.

3.03 PREPARATION

- A. Notify Contract Administrator at least one (1) week prior to field fabrication of pipe or fittings.

- B. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.

3.04 WELDING

- A. Perform in accordance with ASME B31.1, B31.3 and B31.9 for Pressure Piping, as may be specified on Piping Data Sheets, and if recommended by piping or fitting Manufacturer.
- B. Pipe End Preparation:
 - 1. Machine Shaping: preferred
 - 2. Oxygen or Arc Cutting: smooth to touch, true, and slag removal by chipping or grinding
- C. Surfaces:
 - 1. Clean and free of paint, oil, rust, scale, slag, or other material detrimental to welding.
 - 2. Clean stainless steel joints with stainless steel wire brushes or stainless steel wool prior to welding.
 - 3. Thoroughly clean each layer of deposited weld metal, including final pass, prior to deposition of each additional layer of weld metal with a power-driven wire brush.
- D. Alignment and Spacing:
 - 1. Align ends to be joined within existing commercial tolerances on diameters, wall thicknesses, and out-of-roundness.
 - 2. Minimum Spacing of Circumferential Butt Welds: minimum four times pipe wall thickness or 25mm, whichever is greater.
- E. Climatic Conditions:
 - 1. Do not perform welding if there is impingement of any rain, snow, sleet, or high wind on the weld area, or if the ambient temperature is below 0°C.
 - 2. Stainless Steel and Alloy Piping: If the ambient is less than 0°C, local preheating to a temperature warm to the hand is required.
- F. Surface Defects: chip or grind out those affecting soundness of weld.
- G. Weld Passes: as required in welding procedure.

- H. Weld Quality: free of cracks, incomplete penetration, weld undercutting, excessive weld reinforcement, porosity slag inclusions, and other defects in excess of limits shown in applicable piping code.

3.05 INSTALLATION-GENERAL

- A. Join pipe and fittings in accordance with Manufacturer's instructions, unless otherwise shown or specified.
- B. Remove foreign objects prior to assembly and installation.
- C. Flanged Joints:
 - 1. Install perpendicular to pipe centreline.
 - 2. Bolt Holes: straddle vertical centrelines, aligned with connecting equipment flanges or as shown.
 - 3. Raised-Face Flanges: use flat-face flange when joining with flat-faced ductile or cast iron flange.
 - 4. Threaded flanged joints must be shop fabricated and delivered to Site with flanges in-place and properly faced.
 - 5. Manufacturer:
 - a. Same as pipe Manufacturer.
- D. PVC and CPVC Piping:
 - 1. Provide Schedule 80 threaded nipple where necessary to connect to threaded valve or fitting.
 - 2. Use strap wrench for tightening threaded plastic joints. Do not over tighten fittings.

3.06 INSTALLATION-EXPOSED PIPING

- A. Piping Runs:
 - 1. Parallel to building or column lines and perpendicular to floor, unless shown otherwise.
- B. Install piping so that no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.
- C. PVC Placement:

1. Do not lay pipe when temperature is below 5°C, or above 32°C when exposed to direct sunlight.

D. Tolerances:

1. Deflection from Horizontal Line, Except PVC, CPVC, or HDPE: maximum 2 mm.
2. Deflection From Vertical Grade: maximum 6 mm.
3. Joint Deflection: maximum of 75% of Manufacturer's recommendation.

3.07 INTERIM CLEANING

- A. Prevent accumulation of weld rod, weld spatter, pipe cuttings and filings, gravel, cleaning rags, and other foreign material within piping during fabrication and assembly.
- B. Examine piping to assure removal of foreign objects prior to assembly.
- C. Shop cleaning may employ conventional commercial cleaning method if it does not corrode, deform, swell, or otherwise alter physical properties of material being cleaned.

3.08 FIELD FINISHING

- A. Repair any damage to coating and lining on embedded pipes and sleeves.

END OF SECTION

SECTION 15202
PROCESS VALVES AND OPERATORS

PART 1 GENERAL

1.01 SCOPE

- A. The work of this section includes supplying, installing, and commissioning the 200mm gate valve belong to the siphon pipe-line (pipe A-12 in the piping schedule).

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. American National Standards Institute (ANSI):
 - a. B16.1, Cast Iron Pipe Flanges and Flanged Fittings.
 - b. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - 2. American Water Works Association (AWWA):
 - a. C500, Metal-Seated Gate Valves for Water Supply Service.
 - b. C509, Resilient-Seated Gate Valves for Water Supply Service.
 - c. C550, Protective Epoxy Interior Coatings for Valves and Hydrants.
 - d. C606, Grooved and Shouldered Joints.
 - 3. Manufacturers Standardization Society (MSS):
 - a. SP-81, Stainless Steel, Bonnetless, Flanged Knife Gate Valves.

1.03 SUBMITTALS

- A. Shop Drawings:
 - 1. Product data sheets for make and model.
 - 2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
- B. Information Submittals:
 - 1. Tests and inspection data.
 - 2. Operation and Maintenance Manual.

PART 2 PRODUCTS

2.01 GENERAL

- A. The valve to include handwheel, and accessories for a complete operation.

- B. Valve to be suitable for wastewater service.
- C. Valve same size as adjoining pipe (200 mm).
- D. Valve to open by turning counterclockwise.
- E. Factory mount operator, and accessories.

2.02 FACTORY FINISHING

- A. Epoxy Lining and Coating:
 - 1. Use where specified for individual valves described herein.
 - 2. In accordance with AWWA C550.
 - 3. Minimum 0.18 mm dry film thickness except where limited by valve operating tolerances.

2.03 VALVES

- A. Gate Valve:
 - 1. Gate Valve, 200 mm, cast iron body, flanged ends, rated 125 psi.
 - 2. Manufacturers
 - a. Crane (Type 461)
 - b. Jenkins (452J)
 - c. Or approved equal

2.04 OPERATORS

- A. Manual Operator:
 - 1. General:
 - a. Operator force not to exceed 18 kilograms under any operating condition, including initial breakaway. Gear reduction operator when force exceeds 18 kilograms.
 - 2. Exposed Operator:
 - a. Galvanized or painted handwheels.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Flange Ends:
 - 1. Flanged valve boltholes shall straddle vertical centerline of pipe.
 - 2. Clean flanged faces, insert gasket and bolts, and tighten nuts progressively and uniformly.

3.02 TESTS AND INSPECTION

- A. Test that valves open and close smoothly under operating pressure conditions.
- B. Count and record number of turns to open and close valve; account for any discrepancies with manufacturer's data.

SECTION 15500 HEAT GENERATION

PART 1 GENERAL

1.01 REFERENCES

1. Comply with the latest edition of the following statutes codes and standards and all amendments thereto. Canadian Gas Association (CGA): CAN/CGA B149.1 Natural Gas Installation Code.
2. ARI 300 Standard for central station Air Handling Units
3. Air Moving and Conditioning Association (AMCA): Bulletin 300.
4. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):
 - a. 52, Method of Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
 - b. 90, Energy Conservation in New Building Design.
5. American Society of Mechanical Engineers (ASME): Code for Pressure Vessels.
6. Factory Mutual (FM).
7. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
8. Industrial Risk Insurers (IRI).
9. National Electrical Manufacturers' Association (NEMA):
 - a. MG 1-12.53a, Motors and Generators.
 - b. 250 Enclosures for Electrical Equipment.
10. National Fire Protection Association (NFPA):
 - a. 54, National Fuel Gas Code.
 - b. 70, National Electric Code (NEC).
11. Occupational Safety and Health Act (OSHA).
12. Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA): Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems.
13. Underwriters Laboratories Inc. (UL).
 - a. Gas and Oil Equipment Directory.
 - b. Electric Heating and Air-Conditioning Directory.
14. Underwriters Laboratories of Canada (ULC).
15. National Fire Code of Canada.

1.02 SUBMITTALS

- A. Action Submittals: Shop Drawings:
 - a. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature that include make, model, dimensions,

weight of equipment, and electrical schematics , for products specified.

2. Recommended procedures for protection and handling of equipment and materials prior to installation.
3. When Located in a Seismic Zone 3 or Greater Region: Design and drawings for support, expansion, drainage, and guy anchor rods required to support the boiler stack in a 161 km/hr wind.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance for the energy efficient motor
2. Operation and Maintenance Data.
3. Manufacturer's Certificate of Proper Installation.

1.03 STRUCTURAL ANALYSIS

- A. All equipment and equipment anchoring systems shall be designed in accordance with the latest edition of the Building Code, Seismic requirements.

1.04 QUALITY ASSURANCE

- A. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the authority having jurisdiction (local), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the authority having jurisdiction (local) in order to provide a basis for approval under the NEC.
- B. Products manufactured within scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.
- C. Certify air volume, static pressure, fan speed, break horsepower and selection procedures in accordance with ARI 430

PART 2 PRODUCTS

2.01 GENERAL

- A. Heating equipment shall have minimum operating efficiencies as specified in Chapter 6 of ASHRAE 90
- B. Unit must be specifically designed for outdoor installation
- C. Fans: Sound power level (ref. 10 to 12 watts) at design operating point; ratings based on AMCA Bulletin 300, Setup No. 1.
- D. The unit shall be able to withstand up to 1.5 time design static pressure

2.02 INDIRECT GAS-FIRED AIR HANDLING UNIT

A. UNIT BASE

1. The unit base design shall allow unit to rest on top of platform when field installed. .

B. CASING

1. All panels shall be double wall construction. Interior and exterior panels shall be constructed of galvanized steel. Panel insulation system shall provide a minimum R value of 12. Insulation shall conform to NFPA 90 requirements.
2. Panels shall be fully removable to allow for a proper way to thoroughly clean panels and to access internal parts. If panels are not removable, then manufacturer shall provide access sections with doors between all internal components to ensure access and cleanability of the air handler.
3. Access doors shall be constructed with a lockable double-wall of solid G90 galvanized steel interior panel. Gasketing around the full perimeter of the access door shall be used to prevent air and water leakage. Preferred door handle shall not penetrate door casing with single-handle latch.
4. External surface of unit casing shall be prepared and factory coated with a minimum 1.5 mil enamel finish or equal. Unit casing exterior with factory coating shall be able to withstand a salt spray test in accordance with ASTM B117 for a minimum of 500 consecutive hours. Unit casing will be provided with standard paint finish.
5. Unit roof shall be sloped a minimum 2% either from one side of unit to other or from center to sides of the unit. Roof assembly shall overhang all walls of units by 50mm minimum.
6. For units with outside air requirements, manufacturer shall provide inlet hood with high performance sine wave moisture eliminator to prevent water carryover into unit casing from outside air. Hoods shall be sized for 100% outside air.

C. FANS SECTIONS

1. Provide supply fan fan section(s) with air foil double width, double inlet centrifugal fan designed and suitable for class of service indicated in the unit schedule. Fan shaft to be properly sized and protectively coated with lubricating oil. Fan shafts shall be solid and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. Fans shall be statically and dynamically tested as an assembly at the required RPM to meet design specifications. Key fan wheels to fan shaft to prevent slipping.
2. Provide self-aligning, grease lubricated pillow-block ball bearings selected for L-50 200,000 hour average life per ANSI/AFBMA 9.

- Extend both grease lubrication fittings to drive side of unit with plastic tubes and zerk fittings rigidly attached to drive side bearing support.
3. Mount fans on isolation bases. Internally mount motors on same isolation bases and internally isolate fans and motors with spring isolators. Install flexible canvas ducts between fan and casings to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A.
 4. Fan sections shall have full height, double wall, hinged lockable doors on one side for inspection and maintenance of internal components.
 5. Weigh fan and motor assembly at AHU manufacturer's factory for isolator selection. Statically and dynamically balance fan section assemblies. Fan section assemblies include fan wheels, shafts, bearings, drives, belts, isolation bases and isolators. Allow isolators to free float when performing fan balance. Measure vibration at each fan shaft bearing in horizontal, vertical and axial directions. Balance at design RPM as scheduled on drawings.
 6. For fan sections controlled by variable frequency drives, balance at speeds between 25% and 100% of design RPM.

D. MOTORS AND DRIVES

1. Factory install all motors on slide base to permit adjustment of belt tension.
2. Fan Motors shall be Inverter duty motor, TEFC Premium Efficiency, operable at 575/60/3.
3. V-Belt Drive shall be fixed pitch rated at 1.5 times the motor nameplate.

E. FILTERS

1. Provide 50mm Pleated Media filter sections with MERV 7 filters. Filters shall be removable from one side(s) of filter sections.

F. REMOTE VARIABLE FREQUENCY DRIVE / LINE BREAK SWITCH FOR MAKE UP AIR UNIT AND EXHAUST FAN

1. Combination VFD / line break switches shall include the VFD, a circuit breaker disconnect, an H-O-A switch, a manual speed control dial, and a control transformer.
2. VARIABLE FREQUENCY DRIVES: The VFD shall be a high performance pulse width modulated (PWM) AC drive that generates a sine-code, variable voltage/frequency, three phase output for optimum speed control. The inverter section shall utilize only intelligent power modules (IPM's) to generate an 8kHz PWM output to ensure a low audible magnetic motor noise (@ 60 Hz) of less than 2 dB (@ 1 meter) above across the line operation. Power electronics shall provide at least 96% efficiency. The VFD shall be digitally based using a common

microprocessor control logic circuit board for the horsepower ratings. All programming shall be maintained in non-volatile RAM memory so the program will be maintained when power is removed. A digital operator keypad and display shall provide local control and readout for: run/stop, speed, reset, volts, amps, kilowatts, and diagnostics. Output current overload should be rated at 110% of motor FLA for one minute. The VFD shall have the following minimal protective features: current limited stall prevention, auto restart after momentary power loss, speed search for starting into rotating motor, anti-windmill w/DC injection before start, phase-to-phase short circuit protection, and ground fault protection. Ambient service temperature rating of -10 to 50 degrees C, and humidity rating to 95% non-condensing. The VFD shall be UL508C listed and CSA certified and shall conform to applicable NEMA, ICS, NFPA, IEC, AND ISO 9001 standards.

3. AC Line Reactors on both the input line and output load of the VFD. Both reactors to be 3% impedance each to protect the VFD and limit harmonics
4. An output LC filter to deliver sine wave voltage to the motor. This reduces audible motor noise, allows the use of longer motor leads and reduces insulation stress
5. ENCLOSURE: VFD / Line Break Switch shall have full metal enclosures. Enclosures shall be NEMA 12 suitable for wall mounting

G. INTERFACE CONTROL PANEL (HCP)

1. The programmable DDC controller and a majority of the control components shall be selected, mounted, wired, and tested by the AHU manufacturer. HCP shall be covered by the AHU manufacturer's standard warranty of one year from AHU startup or 18 months from shipment, whichever comes first. Field-installed systems are acceptable with the Contract Administrator's approval of actuators, valves, sensors, and control drawings prior to bid day.
2. A dedicated stand-alone programmable DDC controller shall be provided to control make up air unit, exhaust fan and all associated equipment.
3. All programming required for operation shall be retained in permanent memory. Battery backup (for a minimum of 72 hours) is also permissible. Include a lifetime battery replacement (parts and labor) warranty in the bid.
4. Each controller shall have a LCD screen and keypad for user interface. System passwords are required to prevent unauthorized use. Local access to AHU status, set points, and alarms is critical. No exceptions will be permitted.
5. Manual reset low limit switches will shut down the fan, close the outside air damper, and open the heating valve to protect the unit. The low limit switches shall be factory mounted to maximize coil coverage.

Field installation will be acceptable if the proper capillary clips are used and all four corners of the coil and the coil face are uniformly protected.

Units with greater than 2 square meter of coil shall have at least two low limits. Averaging sensors must be installed with the same quality procedures across the coil face.

6. Refer to sections 15900 and 15901 for more control details

H. GAS HEATING SECTION

1. General

- a. The gas heat section shall be natural gas, indirect fired and shall be completely factory assembled, wired and tested to form an integral part of the unit. It shall bear an ETL or UL label for Commercial and Industrial Gas Heating Equipment (ANSI / UL Standard 795) and for Industrial Gas Fired Packaged Units (CGA Standard 3.2-1976).

2. Heat Exchanger

- a. The heat exchanger shall be a two or four-pass design. The primary surface shall be one or two passes, constructed of welded 409 stainless steel. The secondary heat exchanger shall consist of multiple tubes of 409 stainless steel in a single- or two pass arrangement. Tubes shall be fitted with multi-plane metal turbulators, and both primary and secondary surfaces shall be minimum 14-gauge thickness. Lighter metal gauges will not be acceptable. The heat exchanger shall be fitted with a cleanout plate to facilitate cleaning and inspection of tubes and turbulators as well as a condensate drain connection that is piped to an accessible shutoff valve.

3. Burner Assembly

- a. The burner shall be forced draft, industrial type capable of efficient firing over its operating range without producing excessive CO, CO₂ or NO_X. It shall be fitted with a combustion air damper assembly for control of fuel-air ratio through its modulating range. The burner uses a modulating gas valve design, not a step-controlled gas valve, to provide precise capacity control with minimum 10:1 turn down ratio. Two-speed fan motors will not be acceptable for this application. The burner modulation range (i.e., turndown) shall be as specified on the equipment schedule. The combustion air damper and modulating gas valve shall be linked either internally or through a control linkage that is factory preset. The burner shall have a low fire start interlock and shall be manufactured by Maxon, Power Flame or Eclipse only.

4. Combustion Assembly

- a. The combustion blower shall be centrifugal type, direct drive, capable of delivering the proper amount of combustion air to the burner nozzle. The blower motor shall have an internal thermal

overload protection, and an air proving switch shall be mounted on the scroll, interlocking burner operation with the gas train controls to prevent burner operation when the combustion air fan is shut down. Induced draft fan shall be employed for positive venting of combustion products. An induced draft (ID) fan shall be centrifugal type, capable of withstanding high temperatures associated with flue gas. The unit shall be equipped with a stainless steel flue stack that rises above the roof level with rain hood.

5. Gas Train

- a. The gas train shall meet FM approval and shall include the following:
 - 1) A modulating gas valve
 - 2) Automatic gas valve with gas
 - 3) Pressure regulator
 - 4) Redundant automatic gas valve (above 117 kW)
 - 5) Main gas shutoff valve with pressure tap and second ball shutoff cock
 - 6) Pilot solenoid
 - 7) Pilot gas pressure regulator
 - 8) Pilot solenoid valve
 - 9)

6. Controls

- a. The gas safety controls shall include the following:
 - 1) Electronic flame relay with UV flame sensor
 - 2) High limit control
 - 3) Combustion air flow
 - 4) Primary air flow interlocks
- b. The unit shall be programmed to start in low-fire mode, and the flame relay shall be Honeywell Model 7895A or equal and shall be equipped with annunciation lights indicating pilot on, safeties satisfied, combustion airflow and flame failure. The unit shall have a purge cycle that provides a minimum of four air changes of the heat exchanger interior. The purge time shall not exceed four minutes.
- c. The heating system shall have an intermittent spark ignition to establish the pilot flame. The ignition transformer shall be factory wired into the control system. All control components shall be factory pre-wired to numbered terminal strips in the burner control panel. All wiring shall be run in conduit. The control circuit shall have a circuit breaker as a disconnecting device and for overcurrent protection. Field connections shall require only main power (120 Vac or line voltage), a heat start contact closure and a modulating 0 to 10 Vdc (4 to 20 Ma optional) signal. Avoid using a zone sensor to control leaving air temperature from the gas heat section. This could cause excessive discharge air temperature due to over-firing of the burner. A discharge air

sensor is the preferred method of control. For VAV applications when airflow is reduced, the control system should not allow the temperature rise through the gas heat section to exceed the nominal at full airflow. The discharge air temperature must be controlled to modulate when the airflow is modulated.

I. Manufacturer and Product:

1. Trane, outdoor T-Series climate changer 12
2. Equal

2.03 ACCESSORIES

- A. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 45.4 kg.
- B. Equipment Identification Plates: Furnish 16-gauge Type306 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 10mm high engraved block type black enamel filled equipment identification number and letters indicated in this Specification and as shown.
- C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer.

2.04 SOURCE QUALITY CONTROL

- A. Factory Tests and Adjustments: Test equipment furnished.
 1. Functional Test: Perform manufacturer's standard

PART 3 EXECUTION

3.01 INSTALLATION

- A. Gas-Fired Air Supply Units: Install in accordance with manufacturer's instructions.

3.02 FIELD QUALITY CONTROL

- A. Functional Tests: Conduct on MAU assisted by manufacturer's representative as follows:
 1. Startup Assistance:
 - a. Inspect all gas piping, system piping with accessories, and boiler breeching.
 - b. Initial startup of MAU, and observe four subsequent starts.
 - c. Adjust devices in fuel piping circuit.
 - d. Perform checks on operating and safety controls.
 - e. Calibrate integral controls, gauges, and thermometers.

- B. Performance Test:
 - 1. Conduct on each MAU assisted by manufacturer's representative.
 - 2. Perform under actual or approved simulated operating conditions.
 - 3. Test for a continuous 3-hour period without malfunction.

- C. Training: Minimum 4 hours' instructional time with Owner's personnel reviewing maintenance manuals and showing how each step is to be properly performed.

3.03 MANUFACTURER'S SERVICES

- A. Provide manufacturer's representative at Site. In accordance with Section 01640, manufacturer's services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified equipment.

3.04 SUPPLEMENTS

- A. The supplements listed below, following "End of Section," are a part of this Specification.
 - 1. Data Sheets: Gas Fired Air Handling Unit.

END OF SECTION

SECTION 15500-01: GAS FIRED AIR HANDLING UNIT MAU-101 DATA SHEET

Project: Winnipeg Wet Well Owner: City of Winnipeg

OPERATING CONDITIONS

Indoor or Outdoor: Outdoor Location: Outside Surge tank Ambient Temperature (min/max): -33/31 °C
 Service: _____ Duty (Continuous, Intermittent, Standby): _____

PERFORMANCE DATA

Basis of Design Manufacturer and Model: outdoor T-series climate changer D12 form Trane Arrangement: _____
 Order of Components: 1: Inlet hood 2: filter station 3: fan section 4: gas burner section
 Vibration Isolation: Spring Minimum Deflection: 25mm Weight: 2,000 kg
 Roof/Wall Opening: _____ Max Overall Length: 6.4m Width: 1.8m Height: 1.2m Base Rail: _____

FAN MODULE

Wheel Type: AF
 Diameter: 450 mm
 Class: _____
 Flow Rate: 2832/944 L/s
 Ext. Static Press: 0.25 kPa
 Outlet Velocity: _____ FPM
 Drive: Belt
 Fan Speed: _____ RPM
 Motor Speed: _____ RPM
 Brake HP: 3.43 kW
 Motor HP: 3.72 kW
 Voltage/Ph/Hz: 575/3/60
 Disch Arr: horizontal
 Adj Freq Drive: yes
 2-Speed Motor: _____

OTHER MODULES

Mixing Box:
 Top Damper: _____
 Back Damper: _____
 Bottom Damper: _____
 Minimum Outside Air: 944 L/s
 Maximum Outside Air: 2,832 L/s
 Filter Media:
 Max Face Velocity: 2.54 FPM
 Clean Filter Press Drop: 0.075 kPa
 Dirty Filter Allowance: 0.15 kPa
 Heater:
 Direct/Indirect Fired: Indirect
 Input: 205 kW
 Output: 170 kW
 Natural Gas Pressure: 3.5 kPa
 Entering Air Temp: -32.8 deg C
 Leaving Air Temp: 15.6 deg C

OTHER MODULES

Heat Recovery Coil: _____
 Pre-Heat Coil: _____
 Cooling Coil: _____
 Heating Coil: _____
 Humidifier: _____
 Moisture Eliminator: _____
 Other: _____

OPTIONS

Double-Wall Casing: _____
 Solid Inner Wall: yes
 Perf Inner Wall: _____
 Wall Thickness: 50mm
 Corrosive Resist: _____
 Spark-proof: _____
 TEFC Motor: yes

NOISE DATA

Octave Band	1	2	3	4	5	6	7	8	Lwa
Mid Frequency Hz	63	125	250	500	1000	2000	4000	8000	
Inlet Sound Power Level (dB)	88	85	80	78	71	65	58	49	
Outlet Sound Power Level (dB)	86	77	78	76	71	67	62	55	

REMARKS

1. Fan selected based on combining clean filter pressure drop and dirty filter allowance.

SECTION 15810
METAL DUCTWORK AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

1. Comply with the latest edition of the following statutes codes and standards and all amendments thereto. Air Movement and Control Association (AMCA): 500, Test Methods for Louvers, Dampers and Shutters.
2. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Handbook.
3. Association of the Nonwoven Fabrics Industry (INDA): IST 80.6, Water Resistance (Hydrostatic Pressure Test).
4. ASTM International (ASTM):
 - a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - b. A176, Standard Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip.
 - c. A240/A240M, Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
 - d. A480/A480M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
 - e. C916, Standard Specification for Adhesives for Duct Thermal Insulation.
 - f. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
 - g. C1139, Standard Specification for Fibrous Glass Thermal Insulation for Sound Absorbing Blanket and Board for Military Applications.
 - h. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
 - i. E96, Standard Test Methods for Water Vapor Transmission of Materials.
5. National Air Duct Cleaners Association (NADCA): General Specifications for the Cleaning of Commercial Heating, Ventilation and Air Conditioning Systems.
6. National Fire Protection Association (NFPA):
 - a. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
 - b. 90B Standard for the Installation of Warm Air Heating and Air Conditioning Systems.

- c. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
- d. 259, Standard Test Method for Potential Heat of Building Materials.
- 7. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
 - a. Duct Construction Standards.
 - b. Guidelines for Seismic Restraints of Mechanical Systems.
 - c. Fibrous Glass Duct Construction Standards.
 - d. Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.
 - e. HVAC Air Duct Leakage Test Manual.
- 8. Underwriters Laboratories Inc. (UL):
 - a. 181, Standard for Safety Factory-Made Air Ducts and Connectors.
 - b. 214, Tests for Flame-Propagation of Fabrics and Films.
 - c. 555, Standard for Safety Fire Dampers.
 - d. 555S, Standard for Safety Smoke Dampers.
 - e. Underwriters Laboratories of Canada (ULC).
 - f. National Fire Code of Canada.
 - g. National Building Code of Canada.

1.02 DEFINITIONS

- A. The following is a list of abbreviations which may be used in this section:
 - 1. L/s: litre per second.
 - 2. m/s: m per second.
- B. Sealing Requirements: For the purpose of duct systems sealing requirements specified in this Section, the following definitions apply:
 - 1. Seams: Joining of two longitudinally (in direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on perimeter are deemed to be joints.
 - 2. Joints, duct surface connections including:
 - a. Girth joints.
 - b. Branch and subbranch intersections.
 - c. Duct collar tap-ins.
 - d. Fitting subsections.
 - e. Louver and air terminal connections to ducts.
 - f. Access door, and access panel frames and jambs.
 - g. Duct, plenum, and casing abutments to building structures.

1.03 SUBMITTALS

- A. Action Submittals:

1. Product Data:
 - a. Rectangular and Rigid Round Ductwork:
 - 1) Schedules of duct systems, materials, joints, sealing, gage and reinforcement.
 - 2) SMACNA Figure Numbers for each shop fabricated item.
 - 3) Reinforcing details and spacing.
 - 4) Seam and joint construction details.
 - 5) Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.
 - b. Ductwork Accessories:
 - 1) Manufacturer's product data including catalog sheets, diagrams, standard schematic drawings, installation instructions and details, details of materials, construction, dimensions of individual components, and finishes, including the following items:
 - a) Fittings and volume control damper installation (both manual and automatic) details.
 - b) Duct liner.
 - c) Sealing materials.
 - d) Dampers; include leakage, pressure drop, and maximum back pressure data.
 - e) Duct-mounted access panels and doors.
 - f) Flexible ducts.
 - g) Sheet metal fasteners.

B. Informational Submittals:

1. Sound Attenuators Certified Test Data:
 - a. Dynamic insertion loss.
 - b. Self-noise power levels.
 - c. Static pressure loss.
 - d. Dimensions and weights.
2. Record Drawings: Include duct systems routing, fittings details, and installed accessories and devices.

1.04 QUALITY ASSURANCE

A. Industry Standards:

1. Unless otherwise indicated or specified, sheet metal ductwork shall be constructed and installed in accordance with SMACNA duct construction standard relevant to ductwork system being provided. These standards are herein referenced as the SMACNA Manual, unless otherwise indicated.
2. Comply with ASHRAE Fundamentals Handbook recommendations, except as otherwise indicated.
3. NFPA Compliance: NFPA 90A and NFPA 90B.

- B. Manufacturers: Firms regularly engaged in manufacture of ductwork products of types, materials, and sizes required, whose products have been satisfactorily used in similar service for not less than 5 years.
- C. Suppliers of duct and fitting components shall provide on request the following information:
 - 1. Laboratory performance data for duct, including leakage rate, bursting strength, collapse strength, seam strength, and pressure loss.
 - 2. Laboratory performance data for fittings, including zero-length dynamic losses.
- D. Installer shall be a firm with at least 3 years' experience of successful installation on ductwork systems similar to that required for this Project.
- E. Changes or alterations to layout or configuration of duct system shall be:
 - 1. Specifically approved in writing by Contract Administrator.
 - 2. Proposed layout shall provide original design results, without increasing system total pressure.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Protect ductwork from dirt, water, and debris. During storage on jobsite, keep ends of ductwork covered to prevent foreign objects and water from entering ductwork.
- B. Deliver sealant materials to site in original unopened containers labeled with manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.
- C. Store and handle sealant materials in compliance with manufacturers' recommendations to prevent deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.
- D. Deliver and store stainless steel sheets with mill-applied adhesive protective paper, maintained through fabrication and installation.

PART 2 PRODUCTS

2.01 GENERAL

- A. Specified components of this ductwork system, including facings, mastics, and adhesives, shall have fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke developed, as per test conducted in accordance with ASTM E84 and NFPA 255 methods.

- B. Internally Lined Ductwork: Duct sizes indicated for internally lined ducts are the clear inside dimensions, and shall be increased in both dimensions by twice the thickness of the liner.
- C. Ductwork Interior Surfaces:
 - 1. Smooth.
 - 2. No sheet metal parts, tabs, angles, screws, or other items may project into air ducts, unless otherwise specified.
 - 3. Seams and joints shall be external.

2.02 SHEET METAL MATERIALS

- A. Construct metal duct systems from 316 stainless steel
- B. Stainless Steel Ductwork:
 - 1. Comply with ASTM A167, A176, A240/A240M, and ASTM A480.
 - 2. Stainless Steel Sheet: Type 316, unless indicated otherwise.
 - 3. Gauge shall comply with SMACNA manual, unless specified otherwise.
- C. Finish: No. 2 B (cold-rolled, bright) finish
- D. Exposed Ductwork: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains, discoloration, and other imperfections, including those which would impair painting.
- E. Reinforcement Shapes and Plates: Unless otherwise indicated, provide reinforcements of same material as ductwork.

2.03 DUCT SEALING MATERIALS

- A. General: The term sealant used here is not limited to materials of adhesive or mastic nature, but also includes tapes and combinations of open weave fabric strips and mastics.
- B. Adhesives, Cements, Sealant, and Installation Accessories: As recommended by duct manufacturer for application.
- C. Solvent-Based Sealants:
 - 1. Ultraviolet light resistant.
 - 2. Mildew resistant.
 - 3. Flashpoint: Greater than 21 degrees C, SETA CC.
 - 4. Manufacturers and Products:
 - a. Hardcast, Inc.; Versagrip 102.

- b. Rectorseal; AT-33.
- c. Childers CP-140.

D. Water-Based Sealants:

- 1. Listed by manufacturer as nonflammable in wet and dry state.
- 2. Manufacturers and Products:
 - a. Foster; Series 32.
 - b. Childers; CP-145A, 146.
 - c. Rectorseal; Airlok 181.

2.04 DUCTWORK FASTENERS

A. General:

- 1. Rivets, bolts, or sheet metal screws.
- 2. Ductwork fasteners shall be same metal as duct being supported, unless otherwise noted.
- 3. Stainless Steel Ductwork System:
 - a. Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated Marutex® stainless steel with strength of Type 410 stainless steel and corrosion resistance of Type 316 stainless steel
 - b. Manufacturers:
 - 1) DB Building Fasteners Inc., Santa Fe Springs, CA.
 - 2) Clark Craft Fasteners, Tonawanda, NY.
 - 3) UCAN Fastening Products.

2.05 DUCTWORK PRESSURE CLASS

A. Construct duct systems to pressure classifications indicated

- 1. Supply Ducts: 750 Pa.
- 2. Return Ducts: 500 Pa WC, negative pressure.
- 3. Exhaust Ducts: 500 Pa WC, negative pressure.

B. Where no specific duct pressure designations are indicated in Specifications or on Drawings, 500 Pa pressure class shall be basis of Contract.

2.06 RECTANGULAR DUCTWORK

A. Fabricate rectangular ducts in accordance with SMACNA Rectangular Industrial Duct Construction Standards, unless specified otherwise.

B. Crossbreaking or Cross Beading: Crossbreak or bead duct sides that are 480 mm and larger and are 20-gauge or less, with more than 1.0 square meter of unbraced panel area, as indicated in SMACNA Manual, unless they are lined or are externally insulated.

2.07 RECTANGULAR DUCTWORK FITTINGS

- A. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA Rectangular Industrial Duct Construction Standards.
- B. Elbows:
 - 1. Fit square-turn elbows with vane side rails.
 - 2. Shop fabricate double-blade turning vanes of same material as ductwork.
 - 3. Fabricate with equal inlet and outlet.
 - 4. Rectangular radius elbows with inside radius of 3/4 of duct width in direction of turn.
 - 5. Manufacturers and Products:
 - a. Elgen; All-Tight.
 - b. Duro-Dyne; Type TR.

2.08 RECTANGULAR DUCTWORK BRANCH CONNECTIONS

- A. Branch duct connections to rectangular duct mains shall be made using factory fabricated fittings with spot welded tap to main duct connections

2.09 DOUBLE WALL DUCTWORK

- A. General:
 - 1. Double wall duct system consisting of outer sheet metal pressure shell, internal sheet metal liner, with insulating material in annular space.
 - 2. Location: outside air supply duct, and exhaust air duct.
- B. Construction:
 - 1. Outer shell gauge shall be based upon actual outer shell dimensions.
 - 2. Inner liner secured to outer shell with mechanical fasteners that maintain metal liner distance from duct without compressing insulation.
 - 3. Inner liner:
 - a. Solid sheet metal liner, with no insulation liner exposed to airstream, unless indicated to be perforated.
 - b. Same material as outer pressure shell, unless indicated otherwise.
- C. Insulation:
 - 1. Void space between liner and outer pressure shell shall be filled with fiberglass insulation, material and installation in accordance with Article Rectangular Ductwork Insulation Liner.
 - 2. Thickness: Minimum 50 mm or greater thickness

3. R-Value: Minimum 0.74 metre squared degrees C per Watt.

D. Liner Termination

1. Terminate internal liner with duct build-outs (metal hat sections) where double wall ductwork connects to single wall ductwork or to any uninsulated component.
2. Secure build-outs to duct wall with bolts, screws, rivets, or welds.
3. Terminate liner at fire dampers at connection to fire damper sleeve.

2.10 RIGID ROUND DUCTWORK

- A. Construct rigid round ducts in accordance with SMACNA Round Industrial Duct Construction Standards, unless specified otherwise.
- B. Basic Round Diameter: As used in this Article, is diameter of size of round duct that has circumference equal to perimeter of a given size of flat oval duct.
- C. Where space limitations prevent use of round duct or where shown on Drawings, provide ductwork of flat oval construction.
- D. Fabricate round ducts with spiral seam construction, except where diameters exceed 1800 mm. Fabricate ducts having diameters greater than 1800 mm with longitudinal butt-welded seams.
- E. Ductwork seams of Snaplock type shall not be used.

2.11 RIGID ROUND DUCTWORK FITTINGS

- A. Construct rigid round ductwork fittings in accordance with SMACNA Round Industrial Duct Construction Standards, unless otherwise specified.
- B. 90-Degree Tees, Laterals, and Conical Tees: Fabricate to conform to SMACNA manual with metal thicknesses specified for longitudinal seam straight duct.
- C. Diverging Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.
- D. Elbows:
 1. Fabricate in stamped (die-formed), pleated, or segmented (gored) construction 1.5 times elbow diameter. Two piece segment elbows are not allowed, except with turning vanes.
 2. Segmented Elbows: Fabricate with welded construction.
 3. Round Elbows 200 mm and Smaller:
 - a. Stamped elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees configuration.

- b. Fabricate nonstandard bend angle configurations or nonstandard sized (e.g., 90 and 115 mm) elbows with segmented construction.
- 4. Round Elbows 225 mm Through 350 mm:
 - a. Segmented or pleated elbows for 30, 45, 60, and 90 degrees.
 - b. Fabricate nonstandard bend angle configurations or nonstandard sized (e.g., 240 and 265 mm) elbows with segmented construction.

2.12 ROUND DUCTWORK BRANCH CONNECTIONS

- A. Branch duct connections (taps) to round duct mains shall be made using factory fabricated fittings.
- B. Field installed taps are not acceptable.

2.13 DUCTWORK HANGERS AND SUPPORTS

- A. General:
 - 1. Attachments, hangers, and supports for ductwork shall be in accordance with SMACNA Manual referenced for type of duct system being installed.
 - 2. Duct hanging system shall be composed of three elements; upper attachment to building, hanger itself, and lower attachment to duct.
 - 3. Wire hangers are not acceptable.
 - 4. Hanger Spacing:
 - a. Ducts Up to 1500 mm in Largest Dimension: 3.0 m, maximum.
 - b. Ducts Over 1525 mm in Largest Dimension: 2.4 m, maximum.
- B. Construction Materials: Supporting devices including, but not limited to, angles used for support and bracing, baseplates, rods, hangers, straps, screws, bolts shall be as follows:
- C. Building Attachments:
 - 1. Concrete inserts, powder-actuated fasteners, or structural steel fasteners appropriate for building materials.
 - 2. Do not use powder-actuated concrete fasteners for lightweight aggregate concrete or for slabs less than 102 mm thick.
 - 3. Upper Attachment (Concrete):
 - a. Drive pin fastener and expansion nail anchor may be used for ducts up to 450 mm maximum dimension.
 - b. Threaded stud fastener may be used for ducts up to 900 mm maximum dimension.
 - c. Concrete attachments shall be made of steel.

- D. Duct Fasteners: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials and conforming to requirements of Article Ductwork Fastener.
- E. Trapeze and Riser Supports: Steel shapes conforming to ASTM A36/A36M, hot-dipped galvanized after fabrication.

2.14 DUCTWORK FLEXIBLE CONNECTIONS

A. General:

1. Factory fabricated metal-edged fabric flexible connectors for commercial or industrial applications.
2. Sheet metal permanently secured to fabric with double fabric fold, double metal crimp.
3. Comply with NFPA 90A and 90B requirements.
4. Airtight and waterproof.

B. Materials:

1. Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
2. Metal Edges: Construct from same material as ductwork, unless otherwise noted.
3. Fabric:
 - a. Comply with UL 214 (except teflon coated).
 - b. Woven polyester or nylon for most applications.
 - c. Woven fiberglass for high temperature applications.
 - d. Coating: Teflon.

C. Construction:

1. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA Manual.
2. Standard Metal Edged Connectors: Strip of fabric 90 mm wide attached to two strips of 70 mm wide sheet metal.
3. Extra Wide Metal Edged Connectors: Strip of fabric 145 mm wide attached to two strips of 70 mm wide sheet metal.
4. Transverse Metal Edged Connectors: Strip of fabric 90 mm wide attached to two strips of 110 mm wide sheet metal.

D. Manufacturers:

1. Ductmate; PROflex, Commercial.
2. Ventfabrics.
3. Duro-Dyne.

2.15 DUCT INSPECTION DOORS

A. General:

1. Insulated, gasketed, and at least 375 mm by 375 mm when duct dimensions are large enough.
2. On ductwork where largest side dimension is less than 400 mm, furnish inspection doors at least 200 mm by 200 mm.
3. Complete with necessary hardware.
4. Fabricated of same material as ductwork

B. Round Spin-in Type Access Doors:

1. Size: 450 mm and 600 mm diameter will be acceptable in lieu of comparable size square or rectangular access doors specified herein.
2. Complete with insulation, spin-in frame, inner door, attachment cable, gaskets, three latches, and pull ring.
3. Manufacturers:
 - a. Flexmaster, Inspector Series.

C. Casing and Plenum Access Doors:

1. Size: 1425 mm high by 600 mm wide minimum where possible.
2. Complete with hardware, hinges, seals, and latch handles.
3. Latch Handles: Ventlock, Series No. 260.
4. Hinges: Venlock, Series No. 200 and No. 300.

D. Manufacturers:

1. Ventlock.
2. Flexmaster.
3. Duro-Dyne.

2.16 MANUAL DAMPERS

A. Butterfly Manual Dampers:

1. Fabricate from two gauges heavier than duct in which installed, of same material as ductwork
2. Align operating handle with damper blade.
3. Provide 50 mm standoff bracket for insulated duct systems.
4. Damper Manufacturers:
 - a. Ruskin.
 - b. American Warming and Ventilating.
5. Operator Manufacturers:
 - a. Accessible Ductwork: Ventlok; Type 620 or 635
 - b. Accessible Insulated Ductwork: Ventlok; Type 639

B. Manual Opposed-Blade Balancing Dampers:

1. Externally operated gang airfoil, damper blades.
2. Fabricate from same material as ductwork.
3. Stainless steel or nylon sleeve bearings.
4. Construction shall have interlocking edges and maximum 250 mm blade width.
5. Manufacturers and Products:
 - a. Ruskin; CD102
 - b. American Warming & Ventilating; Model VC-31

2.17 CONTROL DAMPERS

- A. Refer Section 15901, HVAC Controls, Field Components and Instruments, for requirements.

2.18 MISCELLANEOUS ACCESSORIES

A. Sheet Metal Plenums:

1. Fabricate from minimum 18-gauge metal of same material as ductwork.
2. Brace with frame of same material for rigidity.
3. Line with sound attenuation material where indicated.

B. Auxiliary Drain Pans:

1. Dimensions: Minimum 152 mm larger in both dimensions than equipment it is serving and 51 mm high, minimum.
2. Construction: 16-gauge galvanized steel with brazed joints. Pans shall be watertight and have hemmed edges.
3. Drain Connection:
 - a. Minimum 1 inch IPS or as shown on Drawings.
 - b. Locate at lowest point of drain pan.
 - c. In lieu of drain connection, float switch may be installed. Float switch shall shut down air handling equipment upon sensing water.

C. Accessories Hardware:

1. Instrument Test Holes:
 - a. Cast metal, material to suit duct material, including screw cap and gasket and flat mounting gasket.
 - b. Size to allow insertion of pitot tube and other testing instruments.
 - c. Provide in length to suit duct insulation thickness.
2. Flexible Duct Clamps:
 - a. Stainless steel band with cadmium-plated hex screw to tighten band with worm-gear action.
 - b. Provide in sizes from 75 mm to 450 mm to suit duct size.

3. Adhesives: High strength, quick setting, neoprene based, waterproof and resistant to gasoline, and grease.
- D. Prefabricated Roof Curb for Ductwork
1. Prefabricated roof curbs, flashing and counterflashing shall be constructed of minimum 2.0 mm aluminum
 2. Internal Insulation:
 - a. Minimum of 38 mm thick, 16 kg/m³ density, glass fiber insulation.
 - b. Seams sealed to prevent condensation.
 3. Welded or tabbed and riveted construction will be acceptable. Both types of construction shall be manufactured and sealed as required to be watertight and weatherproof.
 4. Lower section of roof curb that will be integrated with roofing system shall be constructed to accommodate roofing system provided.
 5. Top surface of curb shall have rubber weather-seal pad. Provide wooden nailer sections as required for installation.
 6. Sheet metal counterflashing shall be provided to accommodate rectangular or round ductwork.
 7. Sheet metal screws and rivets shall be stainless steel or coated with corrosion-resistant material.
 8. Height of roof curb shall be 305 mm, unless otherwise indicated herein or on Drawings.
 9. Length and width of roof curb shall be sized by Contractor for particular application.
 10. Manufacturer:
 - a. Factory fabricated by equipment manufacturer.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION

A. Miscellaneous:

1. Install sheet metal ductwork and flexible ductwork in accordance with SMACNA Manual, NFPA 90A, and NFPA 90B.
2. Install ductwork using manufacturer's recommended adhesives, cement, sealant, and insulation accessories.
3. Align ductwork accurately at connections, within 3.2 mm misalignment tolerance and with internal surfaces smooth.
4. Interface Between Ductwork and Louvers: At locations where ductwork is connected to louver for either intake or exhaust purposes, ductwork

shall be installed, sloped, and connected to louver so water entering ductwork system positively drains back to and out of louver.

B. Ductwork Location:

1. Locate ductwork runs vertically and horizontally, unless otherwise indicated.
2. Avoid diagonal runs wherever possible.
3. As indicated by diagrams, details, and notations or, if not otherwise indicated, run ductwork in shortest route that does not obstruct usable space or block access for servicing building and equipment.
4. In general, install as close to bottom of structure as possible.
5. For ductwork run above ceiling, maximize clearance between bottom of ductwork and top of ceiling construction.
6. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
7. Ductwork that must transition and drop below piping or other ductwork shall be transitioned back to bottom of structure immediately adjacent to obstruction.

C. Penetrations:

1. Provide duct sleeves or prepared openings for duct mains, duct branches, and ducts passing through roofs, walls and ceilings.
2. Clearances:
 - a. For uninsulated ducts, allow 25 mm clearance between duct and sleeve, except at grilles, registers, and diffusers.
 - b. For insulated ducts, allow 25 mm clearance between insulation and sleeve, except at grilles, registers, and diffusers.
3. Closure Collars:
 - a. Minimum 102 mm wide on each side of walls or floors where sleeves or prepared openings are installed.
 - b. Fit collars snugly around ducts and insulation.
 - c. Same gauge and material as duct.
 - d. Grind edges of collar smooth to preclude tearing or puncturing insulation covering or vapor barrier.
 - e. Use fasteners with maximum 152 mm centers on collars.
4. Packing: Mineral fiber in spaces between sleeve or opening and duct or duct insulation.

D. Concealment:

1. Wherever possible in finished and occupied spaces, conceal ductwork from view by locating in mechanical shafts, hollow wall construction, or above suspended ceiling.
2. Do not encase horizontal runs in solid partitions, except as specifically shown.

3. Limit clearance to 25 mm where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any.
- E. Coordination with Other Trades:
1. Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls, and other associated work of ductwork system.
 2. Ductwork shall be configured, positioned, and installed to permit installation of light fixtures as indicated on Drawings.
 3. Coordinate ductwork layout with suspended ceiling, lighting and sprinkler head layouts and similar finished work.
 4. Electrical Equipment Spaces: Do not run ductwork through transformer vaults and other electrical equipment spaces and enclosures.
- F. Wet Well Exhaust Ductwork:
1. Seal joints and seams with chemical-resistant mastic.
 2. Rivet butt joints with minimum of eight pop rivets.

3.02 RECTANGULAR DUCTWORK

- A. Where possible, install ductwork so seams and joints will not be cut for installation of grilles, registers, or ceiling outlets.
- B. If cutting of seams or joints is unavoidable, reinforce cut portion to original strength.

3.03 RECTANGULAR DUCTWORK FITTINGS

- A. Use bell-mouth or conical tee fittings for round duct takeoffs from rectangular mains.
- B. Use 45-degree entry fittings conforming to SMACNA requirements for rectangular takeoffs from rectangular or round mains.
- C. Make offsets with maximum angle of 45 degrees.
- D. Use fabricated fittings for changes in directions, changes in size and shape, and connections.

3.04 RECTANGULAR DUCTWORK TRANSVERSE JOINTS

- A. Install each run with a minimum of joints.
- B. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.

C. Mechanical Joint Option:

1. Construct transverse joints with Ductmate 25/35 duct connector systems, W.D.C.I. Heavy/Lite duct connector systems, or Ductlok J/E duct connector system.
2. When using W.D.C.I. Heavy/Lite system, construct ductwork in accordance to the W.D.C.I. Heavy J and Light H Assembly Manual and Duct Construction Standards.
3. When using Ductlok J/E duct connector system, construct ductwork in accordance with Ductlok's Rectangular Duct Construction Manual for Low, Medium, and High Pressure.
4. For longitudinal seams, use Pittsburgh lock seam sealed internally with permanently elastic sealer such as Ductmate 5511M mastic.
5. Conform to SMACNA Class A sealing requirements.

3.05 RIGID ROUND DUCTWORK

- A. Except where interrupted by fittings, install round ducts in lengths not less than 3.6 meters.

3.06 RIGID ROUND DUCTWORK JOINTS

- A. Rigid round ductwork joints shall be in accordance with SMACNA Round Industrial Duct Construction Standards, unless otherwise specified.
- B. Single and Double Wall Supply and Return System Joints:
1. Less than 900 mm: Slip coupling.
 2. Larger than 900 mm: Flanged connector, Van Stone, or welded companion flange type.
- C. Single and Double Wall Exhaust and Return System Joints:
1. All Sizes, Spiral Seam Duct: Welded flanged connector.
 2. All Sizes, Longitudinal Seam Duct: Van Stone flange connector.

3.07 DUCTWORK HANGERS AND SUPPORTS

- A. Install ductwork with support systems in accordance with SMACNA Manual, unless otherwise noted.
- B. Support ducts rigidly with suitable ties, braces, hangers, and anchors of type, which will hold ducts true-to-shape and to prevent buckling.
- C. Install additional bracing on ductwork as required, to prevent ballooning or breathing.

- D. Support horizontal ducts within 610 mm of each elbow and within 1220 mm of each branch intersection.
- E. Support vertical ducts at maximum interval of 4880 mm and at each floor.
- F. Upper attachments to structures shall have allowable load not exceeding 1/4 of failure (proof test) load, but are not limited to specific methods indicated.
- G. In new construction, install concrete insert prior to placing concrete.
- H. Install seismic restraints on ductwork systems and sway bracing as described in SMACNA Guidelines for Seismic Restraints of Mechanical Systems.

3.08 FLEXIBLE CONNECTIONS

- A. Flexible Collars and Connections:
 1. Use between fans and ducts.
 2. For round ducts, securely fasten flexible connections by zinc-coated steel clinch-type draw bands.
 3. For rectangular ducts, lock flexible connections to metal collars.

3.09 DAMPERS

- A. General:
 1. Inspection:
 - a. Inspect areas to receive dampers.
 - b. Notify Contract Administrator of conditions that would adversely affect installation or subsequent utilization of dampers.
 - c. Do not proceed with installation until unsatisfactory conditions are corrected.
 2. Install dampers at locations indicated on Drawings and in accordance with manufacturer's installation instructions.
 3. Install square and level.
 4. Handle damper using sleeve or frame. Do not lift damper using blades or jack-shaft.
 5. Damper blades and hardware shall operate freely without obstruction.
 6. Damper blades and hardware that bind within frame or obstructed by adjacent construction will not be acceptable.
 7. When installed, damper frames shall be gasketed or caulked to eliminate leakage between duct and damper frames.
 8. Head and sill shall have stops.
 9. Suitable for installation in mounting arrangement shown.
 10. Do not compress or stretch damper frame into duct or opening.

- B. Manual Dampers:

1. Provide balancing dampers for grilles and diffusers in branch duct as near main as possible.
 2. Add or remove balancing dampers as requested by air balancing firm for necessary control of air.
- C. Back Draft Dampers:
1. Install dampers square and free from racking with blades running horizontally.
 2. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.

3.10 ACCESS DOORS

- A. Ductwork: Install access doors in ductwork, in accordance with manufacturer's instructions, at each:
1. Duct mounted fire damper.
 2. Motorized damper.
 3. Turning vane.
 4. Volume damper.
 5. Automatic damper.

3.11 MISCELLANEOUS ACCESSORIES

- A. Auxiliary Drain Pans:
1. Under equipment for which pan is shown on Drawings and under all horizontal air handling units located above ceilings and piping located in ceiling space directly above computer facility areas; furnish and install auxiliary drain pans.
 2. Route drain lines to nearest floor or hub drain independent of any other drain.
 3. Slope drain pans toward drain connection to promote drainage.
 4. Louver and Grille Blank-off Sections: Attach airtight to louver or grille and install to allow for easy removal.
- B. Inspection Plates and Test Holes:
1. Where required in ductwork for balance measurements.
 2. Test holes shall be, airtight and noncorrosive with screw cap and gasket.
 3. Extend cap through insulation.
- C. Prefabricated Roof Curb for Exhaust Fan:
1. Provide for ductwork roof penetrations and curb-mounted roof fans.

2. Roof curb installation, including flashing and counterflashing, shall provide watertight weatherproof enclosure.
3. Attach counterflashing to ductwork via rubber gasketed sheet metal screws.
4. Fill space between counterflashing and ductwork with silicon-based sealant. Sealant shall also be applied at all sheet metal screw locations.

3.12 DUCT SEALING

- A. Seal duct seams and joints as follows:
 1. In accordance with the following:
 - a. Pressure Classifications Greater than 750 Pa: Transverse joints, longitudinal seams, and duct penetrations.
 - b. Pressure Classification Between 500 Pa and 750 Pa: Transverse joints and longitudinal seams.
 - c. Pressure Classification Less than 500 Pa: Transverse joints only.
 2. In addition to other requirements, provide the following duct sealing:
 - a. For interior ductwork, tape joints with Hardcast Lag-Rite tape and bonder or Ray-Chem shrink tape.
 - b. For exterior ductwork, tape joints with Hardcast outdoor tape and rosin.
- B. If no specific duct sealing requirements are specified, requirements of SMACNA manual shall govern.
- C. Seal externally insulated ducts prior to insulation installation.
- D. Provide additional duct sealing as required to comply with Article - Ductwork Leakage Testing.
- E. Seal all audible leak.

3.13 DUCTWORK LEAKAGE TESTING

- A. General:
 1. Tests shall be conducted on completed ductwork systems.
 2. Testing of partial installations or limited sections of ductwork will not be acceptable.
 3. All ductwork leakage test procedures and results shall be submitted to Contract Administrator for review.
 4. Contract Administrator shall retain the right to witness some or all ductwork leakage testing procedures.

5. Contractor shall notify Contract Administrator in writing at least 5 working days prior to ductwork testing.

B. Leakage Criteria:

1. Assemble and install ductwork with maximum leakage limited as follows:
2. Constant Volume Systems:
 - a. Supply Ductwork:
 - 1) Operating Pressure: 0 to 500 Pa.
 - a) Allowable Leakage: 2 percent of design airflow rate.
 - 2) Operating Pressure: 750 Pa and over.
 - a) Allowable Leakage: 1 percent of design airflow rate.
 - b. Return Ductwork:
 - 1) Operating Pressure: All.
 - 2) Allowable Leakage: 2 percent of design airflow rate.

C. Leakage Testing Method:

1. Contractor shall be responsible for providing all necessary test fans and calibrated measuring devices to accomplish ductwork leakage test and to demonstrate that ductwork systems leakage rate is less than maximum rate specified.
2. Pressure testing shall be accomplished using a pressure blower with a calibrated orifice and manometer.
3. Blower shall maintain SMACNA construction pressure classification during test.
4. Perform testing in accordance with procedures given in SMACNA HVAC Air Duct Leakage Test Manual.

3.14 BALANCING AND TESTING OF AIR SYSTEMS

- A. Perform testing in accordance with the requirements of Section 15950, HVAC Systems Testing, Adjusting, and Balancing.

3.15 PROTECTION OF INSTALLED WORK

- A. Open ends of installed ductwork systems shall be covered to prevent dust, foreign objects and water from entering ductwork.
- B. Ductwork systems shall not be used for air conveyance until adequate air filtration devices are installed in air handling equipment, to prevent ingress of construction dust.

3.16 CLEANING

- A. Ductwork shall be cleaned of rust, dust, and debris, both internally and externally, before placing in operation.
- B. Before installing air outlets, use air handler to blow dry air through entire system at maximum attainable velocity. Provide temporary air filters for this operation.
- C. If duct systems are found to contain construction debris at time of construction completion Contractor shall provide complete ductwork system cleaning in accordance with NADCA Standards.

END OF SECTION

SECTION 15830 FANS

PART 1 GENERAL

1.01 REFERENCES

1. Comply with the latest edition of the following statutes codes and standards and all amendments thereto.
2. Air Movement and Control Association International (AMCA):
 - a. 99, Standards Handbook.
 - b. 201, Fans and Systems.
 - c. 203, Field Performance Measurement of Fan Systems.
 - d. 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
 - e. 300, Reverberant Room Method for Sound Testing of Fans.
 - f. 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
3. American Bearing Manufacturers Association (ABMA): 9, Load Ratings and Fatigue Life for Ball Bearings.
4. Acoustical Society of America (ASA): S2.19, Mechanical Vibration—Balance Quality Requirements of Rigid Rotors—Part 1, Determination of Permissible Residual Unbalance.
5. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): HVAC Applications Manual.
6. ASTM International (ASTM):
 - a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
 - b. D2247, Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity.
 - c. D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
 - d. D3363, Standard Test Method for Film Hardness by Pencil Test.
 - e. D4167, Standard Specification for Fiber-Reinforced Plastic Fans and Blowers.
 - f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
7. National Electrical Manufacturers Association (NEMA): MG 1, Motors and Generators.
8. Occupational Safety and Health Act (OSHA).
9. Society for Protective Coatings (SSPC):
 - a. SP 3, Power Tool Cleaning.
 - b. SP 5, Joint Surface Preparation Standard White Metal Blast Cleaning.
 - c. SP 6, Joint Surface Preparation Standard Commercial Blast Cleaning.

- d. SP 10, Joint Surface Preparation Standard Near-White Blast Cleaning.
- 10. Underwriters Laboratories Inc. (UL/ULC): 507, Electric Fans.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this Section:

- 1. AC: Alternating Current.
- 2. CISD: Chemical Industry, Severe-Duty.
- 3. dB: Decibel.
- 4. DWDI: Double Width, Double Inlet.
- 5. FRP: Fiberglass Reinforced Plastic.
- 6. kW: Kilowatt.
- 7. ODP: Open Drip Proof.
- 8. SWSI: Single Width, Single Inlet.
- 9. TEFC: Totally Enclosed, Fan Cooled.
- 10. UV: Ultra Violet
- 11. XP: Explosion Proof.

1.03 SUBMITTALS

A. Action Submittals:

- 1. Provide for all products specified, as follows:
 - a. Identification as referenced in Contract Documents.
 - b. Manufacturer's name and model number.
 - c. Descriptive specifications, literature and drawings.
 - d. Dimensions and weights.
 - e. Fan sound power level data (reference 10 to power minus 12 Watts) at design operating point.
 - f. Fan Curves:
 - 1) Performance Curves Indicating:
 - a) Relationship of flow rate to static pressure for various fan speeds.
 - b) Brake horsepower curves.
 - c) Acceptable selection range (surge curves, maximum revolutions per minute, etc).
 - d) Static pressure, capacity, horsepower demand and overall efficiency required at the duty point, including drive losses.
 - 2) For variable air volume applications, indicate operating points at 100, 80, 60 and 40 percent of design capacity on fan curves including data to indicate effect of capacity control devices such as inlet vanes on flow, pressure and brake horsepower.
 - g. Capacities and ratings.
 - h. Construction materials.

- i. Fan type, size, class, drive arrangement, discharge, rotation and bearings.
- j. Wheel type, diameter, revolutions per minute, and tip speed.
- k. Motor data.
- l. Power and control wiring diagrams, including terminals and numbers.
- m. Vibration isolation.
- n. Factory finish system.
- o. Color selection charts where applicable.
- p. Corrosion protection coating product data.
- 2. "Or Equal" Equipment:
 - a. Where submitted equipment results in change to fan inlet or outlet ductwork configuration shown on drawings, submit system effect factor calculations indicating increased static pressure requirements as described in AMCA 201.
 - b. Where submitted equipment results in change to ductwork and equipment configuration shown on drawings, submit detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement to equipment furnished.

B. Informational Submittals:

- 1. Recommended procedures for protection and handling of products prior to installation.
- 2. Manufacturer's installation instructions.
- 3. Manufacturer's Certificate of Compliance in accordance with Section 01640, Manufacturers' Services, for the following:
 - a. Motors specified to be premium efficient type.
 - b. FRP fans.
- 4. Test reports.
- 5. Operation and maintenance data in conformance with Section 01430, Operation and Maintenance Data. Include as-built version of equipment schedules.

1.04 QUALITY ASSURANCE

- A. Performance Ratings: Tested in accordance with AMCA 210.
- B. Sound Ratings: Tested in accordance with AMCA 300.
- C. Fabrication: In accordance with AMCA 99.

1.05 EXTRA MATERIALS

- A. Furnish, tag, and box for shipment and storage the following spare parts,

Item	Quantity
------	----------

Item	Quantity
Vee Belts	One complete set per unit

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

- A. Some specific equipment requirements are listed in Equipment Schedules. Refer to Article, Supplements.

2.02 SPARK RESISTANT CONSTRUCTION

- A. Fans required to be spark resistant shall comply with requirements of AMCA 99-0401. Type B

2.03 NAMEPLATES

- A. All units shall include factory installed permanently attached nameplate displaying unit model and serial number.

2.04 OPERATING LIMITS

- A. Fans designated to meet a specified fan class shall comply with requirements of AMCA 99-2408-69.

2.05 ACOUSTICAL LEVELS

- A. Equipment selections shall produce sound power levels in each octave band no greater than shown in Equipment Schedule.

2.06 FAN DRIVES

- A. Furnish multiple drive belts where motor horsepower is 1.5 kW or larger.
- B. Drive assembly shall be sized for a minimum 140 percent of fan motor horsepower rating.
- C. Sheaves shall be capable of providing 150 percent of motor horsepower.
- D. Fan Shafts: First critical speed of at least 125 percent of fan maximum operating speed.
- E. Furnish motors for V-belt drives with adjustable rails or bases.
- F. Unless otherwise noted, furnish belt-driven fans with cast iron or flanged steel sheaves.
- G. Motors 15 kW or Smaller:

1. Variable pitch V-belt sheaves allowing at least 20 percent speed variation.
 2. Final operating point shall be at approximate sheave midpoint.
- H. Motors Larger than 15 kW: Fixed-pitch sheaves.
- I. Drive Adjustment:
1. When fixed-pitch sheaves are furnished, accomplish system air balancing by either trial of different fixed-pitch sheaves or use of temporary adjustable-pitch sheaves.
 2. Provide trial and final sheaves, as well as drive belts, as required.
- J. Weather Cover: For outdoor applications, factory fabricated drive assembly of same material as fan housing, unless specified otherwise.
- K. Belt and Shaft Guards:
1. Easily removable and to enclose entire drive assembly, meeting federal, OSHA , and Province of Manitoba requirements.
 2. Guard faces of expanded metal having minimum 60 percent free area for ventilation.
 3. Bright yellow finish.
- L. Provide speed test openings at shaft locations.

2.07 FINISHES

- A. Carbon Steel Parts: Factory finish as follows, unless indicated otherwise.
1. Parts cleaned and chemically pretreated with a phosphatizing process.
 2. Alkyd enamel primer.
 3. Air-dry enamel topcoat.
- B. Aluminum Parts: Finished smooth and left unpainted, unless stated otherwise.
- C. Stainless Steel Parts: Finished smooth and left unpainted.
- D. Fiberglass Parts: Finished in accordance with Paragraph, Fiberglass Material.

2.08 UTILITY BLOWER, CENTRIFUGAL SWSI, STAINLESS STEEL

- A. General:
1. Factory-assembled utility blower; including housing, fan wheel, drive assembly, motor, and accessories.
 2. Suitable to convey air at temperatures up to 121 degrees C.
 3. Fan Performance: AMCA 99-2408 Class I Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housing:

1. Material: Type 316 Stainless Steel.
2. Construction:
 - a. Curved scroll configuration, with continuous seam welding and side angle reinforcement.
 - b. Lifting lugs welded to housing.
 - c. Flanged and drilled outlet to permit duct connection.
 - d. Drain connection located at lowest point of fan housing.
 - e. Inlet: Spun-formed aerodynamic bell mouth.
3. Base/Pedestal: All-welded heavy gauge Type 316 stainless steel.

C. Wheel:

1. Centrifugal, one-piece, non overloading, backward inclined airfoil blade type.
2. Material: Type 316 Stainless Steel.
3. Attached to fan shaft with split taper lock bushing.

D. Shaft, Bearings, Drive:

1. Shafts:
 - a. Turned, ground and polished steel.
 - b. Ends drilled and countersunk for tachometer readings.
 - c. Keyed for sheave installation.
2. Bearings:
 - a. Grease lubricated, precision antifriction ball, self-aligning type.
 - b. Mounted in cast iron pillow block housing.
 - c. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
3. Drives:
 - a. In accordance with Article, Drives.
 - b. Factory set to specified fan revolutions per minute.
 - c. Type: Belt.
 - d. Arrangement: Arrangement 10.
 - e. Accessories: Provide as follows:
4. Housing Access Doors: Bolted and gasketed.
5. Disconnect: Factory installed, nonfused, NEMA 4X
6. Flanged Inlet: Heavy gauge construction, factory drilled and flanged.
7. Shaft Seal: Viton construction, located at shaft penetration of housing.
8. Belt Guard: OSHA type, sheet metal construction same material as fan housing, for complete coverage of belts and sheaves.
9. Shaft and Bearing Guard: Sheet metal construction same material as fan housing, for complete coverage of shaft and bearings.
10. Motor and Drive Cover:
 - a. Factory fabricated, OSHA type.
 - b. Sheet metal construction, same material as fan housing.
 - c. Vented, openings sufficient size for proper motor cooling.

11. Inlet Guard: Spiral wire type, OSHA approved, removable, same material as fan housing.
12. Unitary Subbase:
 - a. Structural metal subbase, same material as fan housing.
 - b. Bolted to bottom of fan base/pedestal.
 - c. Drilled for field installation of vibration isolators.
13. Spark Resistant Construction Classification: AMCA 99-0401 Type B
14. Corrosion Protection Coating:
 - a. Provide factory-applied corrosion protection coating on these fan components:
 - 1) Steel Component
 - b. Coating system shall be air-dry epoxy

E. Manufacturers and Products:

1. New York Blower; PLR.
2. Aerovent; Model BI.
3. Hartzell; Series 03.

2.09 CORROSION PROTECTION COATING

A. General:

1. Factory-applied corrosion protection coating for application to fan components and accessories, where required by this Section.
2. Quality Control:
 - a. Verify dry film thickness before final baking.
 - b. Finished coating system shall be free from voids, checks, cracks and blisters.
3. Surface Cleaning: Clean parts to be coated as follows:
 - a. Immerse parts in heated cleaning solution to remove lubricants, machining oils, and residual factory contamination.
 - b. Follow with immersion in potable water bath to neutralize and remove cleaning solution.
 - c. Chemical Pretreatment: Immerse parts in heated chemical solution, iron phosphate for steel, clear/yellow chromate for aluminum.

B. Air-Dry Epoxy:

1. Material: Two-part catalyzed epoxy.
2. Surface Preparation: Clean surface to SSPC-SP 3.
3. Application: Standard air-pressurized spray equipment.
4. Curing: Air dry.
5. Finished Thickness: 100 microns to 150 microns dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
 - a. Salt Spray Test: Minimum 1,500-hour duration, ASTM B117 test method.

- b. Pencil Hardness: H-2H, ASTM D3363 test method.
- c. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
- d. Service Temperature: Maximum 65 degrees C, continuous.

2.10 MOTORS

A. General:

- 1. Provide integral self-resetting overload protection on single-phase motors.
- 2. Motors for fans specified for use with variable frequency drives shall be inverter duty type.
- 3. Motors shall not operate into service factor in any case.

B. Motor requirements shall be as follows, unless designated otherwise on Equipment Schedule:

- 1. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
- 2. Winding Thermal Protection: None.
- 3. Space Heater: No.
- 4. Motor Efficiency: Premium efficient.
- 5. Shaft Type: Solid, carbon steel.
- 6. Mounting: As required for fan arrangement.
- 7. Service Factor: 1.15.

2.11 ACCESSORIES

- A. Equipment Identification Plates: Furnish 16-gauge Type 306 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 10 mm high engraved block type black enamel filled equipment identification number and letters indicated in this Specification and as shown on Drawings.
- B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 45 kg.

2.12 SOURCE QUALITY CONTROL

A. General:

- 1. Fan and motor combination shall be capable of delivering 110 percent of scheduled air quantity and static pressure. Motor shall not operate into motor service factor in any listed case.
- 2. Consider drive efficiency in motor selection according to manufacturer's published recommendation or according to AMCA 203, Appendix L.

B. Testing Provisions:

1. Provide tachometer access holes large enough to accept standard tachometer drive shaft.
2. Center punch fan shaft to accommodate tachometer readings.

C. Acoustical Levels:

1. Perform noise tests in accordance with AMCA 300 and AMCA 301.
2. Fan sound power levels (dB, Reference 10^{-12} Watts) shall be no greater than scheduled values.

D. Balancing:

1. Unless noted otherwise, each fan wheel shall be statically and dynamically balanced to ASA S2.19 Grade G6.3.
2. Fans controlled by variable frequency drives shall be dynamically balanced at speeds 25 percent, 50 percent, 75 percent, and 100 percent of design revolutions per minute.

E. Vibration Test:

1. Each fan furnished with a 3.7 kW or larger motor shall have factory run vibration test, including vibration signatures taken on each bearing in horizontal, vertical, and axial direction.
2. Vibration reading as measured at scheduled rotational speed shall not exceed the following values when fan is rigidly mounted:
 - a. Belt Drive (except Vane Axial): 0.38 cm per second peak velocity.
 - b. Belt Drive Vane Axial: 0.2 cm per second peak velocity.
 - c. Direct Drive: 0.2 cm per second peak velocity.
3. Written records of run test and vibration test shall be made available upon request.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install fans level and plumb.

B. Secure roof-mounted fans to roof curbs with Type 316 stainless steel hardware.

C. Labeling:

1. Label fans in accordance with Article, Accessories.
2. Mark exhaust fans serving fume hoods with arrows to indicate proper direction of rotation, in accordance with NFPA 45.

D. Service Access: Locate units to provide access spaces required for motor, drive, bearing servicing, and fan shaft removal.

1. Seismic Restraint Snubbers: Install with sufficient clearance so unit isolators are not restricted for proper free isolation, but do limit movement in all directions.

E. Connections

1. Refer to Section 15810, Metal Ductwork and Accessories Isolate duct connections to fans.
2. Install ductwork adjacent to fans to allow proper service and maintenance.

3.02 FIELD QUALITY CONTROL

A. Functional Tests:

1. Verify blocking and bracing used during shipping are removed.
2. Verify fan is secure on mountings and supporting devices, and connections to ducts and electrical components are complete.
3. Verify proper thermal-overload protection is installed in motors, starters, and disconnect switches.
4. Verify that cleaning and adjusting are complete.
5. Disconnect fan drive from motor; verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
6. Reconnect fan drive system; align and adjust belts and install belt guards.
7. Verify lubrication for bearings and other moving parts.
8. Verify manual and automatic volume control and fire and smoke dampers in connected ductwork are in fully open position.

B. Performance Tests:

1. Starting Procedures:
 - a. Energize motor and adjust fan to indicated revolutions per minute.
 - b. Measure and record motor voltage and amperage.
2. Operational Test:
 - a. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - b. Repair or replace malfunctioning units; retest as specified after repairs or replacement is made.
 - c. Test and adjust control safeties.
 - d. Replace damaged and malfunctioning controls and equipment.

3.03 MANUFACTURER'S SERVICES

- A. Provide manufacturer's representative at site in accordance with Section 01640, Manufacturers' Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified component, subsystem, equipment, or system.

3.04 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Lubricate bearings.
- D. Balancing:
 - 1. Perform air system balancing as specified in Section 15950, HVAC Systems Testing, Adjusting, and Balancing.
 - 2. Replace fan and motor sheaves as required to achieve design airflow.
- E. Vibration Testing:
 - 1. Perform field testing on rotating equipment, where specified in Section 15950, HVAC Systems Testing, Adjusting, and Balancing, to determine actual operating vibration.
 - 2. If vibration limits described therein are exceeded, rebalance equipment in-place until design tolerances are met.

3.05 CLEANING

- A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.
- B. On completion of installation, internally clean fans according to manufacturers' written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

3.06 SUPPLEMENTS

- A. The supplements listed below, following "End of Section," are a part of this Specification.
 - 1. 15830-01, Fan Schedule.

END OF SECTION

FANS

15830-01

SYMBOL				EF-102				
LOCATION				ON ROOF				
TYPE				UTILITY BLOWER				
FAN DATA	AIRFLOW	MAX	L/s	2882				
		@ SP	Pa	250				
		MIN	L/s	994				
	SPEED		RPM		703			
	DRIVE TYPE				BELT			
	WHEEL	TYPE						
		MIN. DIA.	mm					
	MAXIMUM		kW					
SOUND DATA	SOUND POWER LEVEL dB (RE 10 ⁻¹² W) @ MID OCTAVE BAND FREQUENCY (Hz)		63	81				
			125	78				
			250	76				
			500	73				
			1K	70				
			2K	65				
			4K	62				
			8K	60				
ELECTRICAL DATA	MOTOR		kW	1.5				
			RPM	1800				
			ENCL.	TEXP				
	VOLT			575				
	PH			3				
MAXIMUM DIMENSIONS	LENGTH		mm					
	WIDTH		mm					
	HEIGHT		mm					
	WEIGHT		kg	1000				
MANUFACTURER				New York Blower				
MODEL NO.				27-PLR				
APPLICABLE REMARKS:				A,B,C,D,E,F,G				
ABBREVIATIONS: FC: FORWARD CURVED BI: BACKWARD INCLINED AF: AIR FOIL								
REMARKS:								
A: Motor Guard				F: Fan is suitable for Class 1; Div 1; Group D				
B: 316 Stainless Steel Fan				G: Max dBA for open inlet and outlet is GS at 1m				
C: A Inverter Duty Motor with VFD (by other)								
D: Belt Guard								
E: Spark Resistant; AMCA Type B								

FANS

15830-01

SYMBOL

EF-102

SECTION 15850
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.01 REFERENCES

1. Underwriters' Laboratories of Canada. (ULC): Product Directories.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
 - 1) Manufacturer's data and descriptive literature for products specified.
 - b. Furnish the following information for each type of diffuser, register, and grille furnished.
 - 1) NC sound data.
 - 2) Static pressure loss data.
 - 3) Throw data.

B. Informational Submittals:

1. List of recommended spare parts for products specified.

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Refer to Drawings

2.02 SUPPLY GRILLES AND REGISTERS

A. Supply Grilles and Registers (SG1, SR1):

- a. Construction: Material: **Stainless Steel**
- b. SR Register Accessories:
 - 1) Gang-operated opposed-blade volume control damper.
 - 2) Material to match grille.
2. Adjustable front horizontal and rear vertical vanes on 20 mm centers.
3. Continuous sponge rubber gasket at face flange.
4. 25 mm minimum flat rectangular frame.
5. Performance: As follows:
 - a. Maximum Pressure Drop: 5Pa.
 - b. Sound: Maximum NC 30.

6. Manufacturers and Products:
 - a. Krueger; 880/5880 Series.
 - b. Titus; 300 Series.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install diffusers, grilles, and registers tight on their respective mounting surfaces, level, plumb, and true with room dimensions.

END OF SECTION

SECTION 15900
HVAC INSTRUMENTATION AND CONTROLS - GENERAL

PART 1 GENERAL

1.01 REFERENCES

1. Comply with the latest edition of the following statutes codes and standards and all amendments thereto. American National Standards Institute (ANSI): INCITS 4, Information Systems - Coded Character Sets - 7-Bit American National Standard Code for Information Interchange (7-Bit ASCII).
2. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):
 - a. Handbook Fundamentals.
 - b. Guideline 3, Reducing Emission of Fully Halogenated Refrigerants in Refrigeration and Air-Conditioning Equipment and Systems.
 - c. 135, Data Communication Protocol for Building Automation and Control Networks.
3. American Society of Mechanical Engineers (ASME): B19.3, Safety Standard for Compressors for Process Industries.
4. American Water Works Association (AWWA): C704, Propeller-Type Meters for Waterworks Applications.
5. Electronic Industries Alliance (EIA):
 - a. TIA-232-F, Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
 - b. 485, Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multi-point Systems.
6. Canadian Standards Association (CSA).
7. International Organization for Standardization (ISO): 8802-3, Information Technology - Telecommunication and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Carrier Sense Multiple Access with Detection (CSMA/CD) Access Method and Physical Layer Specifications.
8. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
9. National Fire Protection Association (NFPA):
 - a. 70, National Electric Code.
 - b. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
10. Underwriters Laboratories, Inc. (UL): 916, Standard for Safety Energy Management Equipment.
11. Underwriters Laboratories of Canada (ULC).

1.02 DEFINITIONS

- A. The terms “HVAC Control System,” “Automatic Temperature Control System,” “Building Automation System,” and “Environmental Management and Control System” shall be considered equivalent and used interchangeably for the purposes of this Contract.
- B. Algorithm: A software procedure for solving a recurrent mathematical or logical problem.
- C. Analog: A continuously varying signal or value (temperature, current, velocity, etc.).
- D. Binary: A two-state system where an “ON” condition is represented by a high signal level and an “OFF” condition is represented by a low signal level.
- E. Control Wiring:
 - 1. Wiring, high or low voltage other than power wiring required for proper operation of mechanical systems.
 - 2. Includes conduit, wire and wiring devices to install complete control system including motor control circuits, interlocks, thermostats, PE and EP switches and like devices.
 - 3. Includes wiring from DDC cabinet to all sensors and points defined in the Points List summary or specified herein and required to execute sequence of operation.
 - 4. Includes necessary power wiring to HVAC control devices, digital controllers including terminal units and actuators.
- F. Control Process: Software required to complete control loop from input signal to interlock logic and process calculation to final output signal control.
- G. Deadband: Temperature range over which no heating or cooling energy is supplied, such as 22 to 25 degrees C; as opposed to single point changeover or overlap, or a range from set point over which no control action is taken.
- H. Direct Digital Control (DDC): Consists of microprocessor-based controllers with control logic performed by software. Analog-to-digital (A/D) converters transform analog values into digital signals that microprocessor can use.
- I. Power Wiring: Line voltage wiring to mechanical equipment. Line voltage wiring that also serves as control circuit, such as line voltage thermostat or involves interlocking with damper shall be considered control wiring.
- J. Abbreviations that may be used in this section:
 - 1. ATC: Automatic Temperature Control.
 - 2. BAS: Building Automation System.

3. DDC: Direct Digital Control.
4. EMCS: Environmental Management and Control System.
5. HCP: HVAC Control Panel.
6. HMI: Human-Machine Interface.
7. HOA: Hand-Off-Auto (Switch).
8. HVAC: Heating, Ventilation, and Air Conditioning.
9. IP: Current (I) - Pressure (P), as in IP transducer.
10. LCD: Liquid Crystal Display.
11. LED: Light Emitting Diode.
12. PLC: Programmable Logic Controller.
13. RAM: Random Access Memory.
14. RTD: Resistance Temperature Detectors.

1.03 SYSTEM DESCRIPTION

A. General Requirements:

1. Provide control wiring, power wiring, conduit, hardware, and electrical work associated with the HVAC control system.
2. Provide control wiring between HVAC control panel contacts and field control devices, such as duct smoke detectors and motor starter control coil contacts.
3. Provide controls necessary for entire system to have fail-safe operation.
4. Control sequences and functions including alarms, monitoring and resetting functions, and operational sequences shall not be limited to point schedules and sequences of operation.
5. Provide sequences and functions as required to deliver a fully functioning HVAC system.

B. Control System Types:

1. The following control system types are used in this Project:
 - a. Standalone DDC Control System (STANDALONE DDC):
 - 1) Microprocessor-based DDC Control System utilizing standalone DDC controllers.
 - 2) No information sharing between controllers.
 - 3) User interface at DDC controller.
 - 4) Refer to Section 15902, Microelectronic Control Components, for additional requirements.
2. Provide control system(s) of architecture defined in Control Type Schedule, below:

Control Type Schedule		
Location	System	Control Type
Process Areas	All	STANDALONE DDC

- C. Performance Requirements: Design control system and equipment to perform under the following conditions:
 - 1. Temperature, Ambient:
 - a. Summer maximum 31 DB/20 WB degrees C.
 - b. Winter minimum minus 33 DB degrees C.
 - c. Based on ASHRAE Handbook Fundamentals weather data for the City of Winnipeg.
 - 2. Temperature, Indoor:
 - a. Heated and Ventilated Process Areas: Summer maximum 39 degrees C; winter minimum 10 degrees C.
- D. Refer to Section 01600, Material and Equipment, for additional environmental performance requirements.

1.04 SUBMITTALS

A. Action Submittals:

- 1. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature that includes make, model, dimensions, weight of equipment, and electrical schematics, for all control system components.
- 2. Complete system power, interlock, control, and data transmission wiring diagrams no smaller than 280 mm by 432 mm.
- 3. Complete drawings and schematics of proposed control system, including panel power requirements.
- 4. System operating sequences to be programmed, in exact English language.
- 5. Complete points list.
- 6. Interfaces with HVAC equipment.
 - a. Schematic diagram of each equipment item.
 - b. Indicate location of each control item in equipment.
 - c. Show equipment manufacturer controls where installed.
- 7. Panel face layout drawings.
- 8. Damper actuator sizing calculations, in schedule form.
- 9. Automatic control valve sizing calculations, in schedule form.

B. Information Submittals:

- 1. Recommended procedures for protection and handling of equipment and materials prior to installation.
- 2. Certificates, in accordance with section 0160, manufacturer's service:
 - a. Manufacturer's Certificate of Compliance.
 - b. Manufacturer's Certificate of Proper Installation.
- 3. Performance test plan and schedule.
- 4. Test Results:
 - a. Functional and performance test documentation.

5. Operation and maintenance data: In accordance with Section 01430, Operation and maintenance data. In addition, include the following detailed information:
 - a. Operation and maintenance instructions for control system as furnished and installed, including control of associated mechanical and electrical equipment.
 - b. Record of system adjustments and calibration methods.
 - c. Performance test results.

1.05 QUALITY ASSURANCE

- A. Materials, devices, appliances, and equipment used shall be indicated as acceptable by established standards of Underwriters Laboratories, Inc. (UL), Underwriters Laboratories of Canada (ULC) and Canadian Standards Association (CSA).
- B. Codes and Standards: Meet requirements of applicable standards and codes, except when more detailed or stringent requirements are indicated by Contract Documents, including requirements of this section.
 1. Underwriters Laboratories: Products shall be UL 916-PAZX listed or equivalent ULC and CSA listed.
 2. National Electrical Code NFPA 70.
 3. Networked DDC Control Systems shall comply with ASHRAE 135 (BACnet).
- C. Qualifications of HVAC Controls System Supplier:
 1. Minimum of 15 years' experience in design, installation, and maintenance of fully electronic building automation systems.
 2. Minimum of 10 years' experience in design, installation, and maintenance of computer based, direct digital control, facility automation systems.
 3. Minimum of 5 years' experience as manufacturer's authorized representative in design, installation, and maintenance of manufacturer's system and products.
 4. Capable of furnishing factory-trained technicians, competent to provide instruction, routine maintenance, and emergency service onsite within 4 hours after receipt of request.
 5. Factory trained certified engineering and commissioning staff, and complete offsite training facilities.
 6. Necessary facilities to provide Owner with complete maintenance, periodic inspection, and service contract. Refer to Paragraph, MAINTENANCE.

D. Regulation: Electronic equipment shall conform to requirements of Regulation, Governing Radio Frequency Electromagnetic Interference and be so labeled.

E. Compatibility:

1. System shall have documented history of compatibility by design for minimum of 15 years. Future compatibility shall be supported for no less than 10 years.
2. Compatibility shall be defined as:
 - a. Ability to upgrade existing field panels to current level of technology, and extend new field panels on previously installed network.
 - b. Ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers, or protocol converters.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Comply with Section 01600, Material and Equipment.

B. Corrosion Protection:

1. Control panels, enclosures, and other equipment containing electrical or instrumentation and control devices, including spare parts, shall be protected from corrosion through use of corrosion-inhibiting vapor capsules.
2. Prior to shipment, capsules shall be provided within shipping containers and equipment as recommended by capsule manufacturer.
3. During construction period, capsules shall be replaced in accordance with capsule manufacturer's recommendations.

1.07 MAINTENANCE

A. Maintenance Service Agreement:

1. Furnish a draft maintenance agreement, prepared and signed by the Controls Supplier, to provide the necessary preventive maintenance to keep the various control systems in proper working condition.
2. Fully describe the maintenance work to be performed and estimate cost of the maintenance during the 1-year correction period and the subsequent year.
3. This service contract shall include 24-hour emergency service, 7 days per week.

1.08 EXTRA MATERIALS

A. Tools:

1. For each building, furnish one complete set of special tools recommended by manufacturer for maintenance, dismantling, or repair of each separate type of equipment item.
2. Furnish toolbox for storage of special tools. Identify purpose by means of stainless steel or solid plastic nametag attached to box.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Materials, equipment, and accessories specified shall be products of the following manufacturers, unless indicated otherwise:
 1. Trane
 2. Landis Division of Siemens Building Technology, Inc.
 3. Johnson Controls.
 4. Honeywell.

2.02 MATERIALS

- A. General:
 1. Products used in this installation shall be new, currently under manufacture, and shall have been applied in similar installations for minimum of 2 years.
 2. System shall not be used as test site for new products, unless explicitly approved by Owner's representative, in writing.
- B. Control Components:
 1. Control range to obtain specified capacities.
 2. Sensitivity to maintain control points close enough to set point for acceptable offset, without cycling equipment more frequently than recommended by manufacturer.
 3. Field or computer adjustable to actual set point, ranges. Adjustable to other settings that will provide proper operation of entire control system.
- C. Controls Interfacing:
 1. Interface controls properly with factory supplied components of mechanical systems. Coordinate special control interfacing requirements.
 2. For equipment that requires special interfacing with control system, provide equipment with integral controls or provide accessory devices required for operation of total mechanical system.
 3. Coordinate interfaces with electrical work as necessary.

4. Provide electric, electronic, and mechanical devices as required to properly interface with prewired control panels furnished with HVAC equipment and with other mechanical and electrical components.

2.03 LABELING

- A. All products, namely electrical materials, devices, appliances, and equipment used, shall be indicated as acceptable by established standards of Underwriters Laboratories, Inc. (UL), Underwriters Laboratories of Canada (ULC), Factory Mutual (FM) and Canadian Standards Association (CSA).
- B. Valid label affixed to item shall provide indication of product acceptance by required agencies.
- C. HVAC control panels and control components that consist of multiple components shall bear UL, ULC and CSA listing mark on unit.

2.04 SERVICE CONDITIONS

- A. Use materials and methods, and enclose devices in NEMA enclosure types suitable for classification indicated, and as required by NFPA 70.
- B. Exhaust ductwork shall be considered same classification as area served.
- C. Instruments within 900 mm of ducts conveying air from spaces classified as Class I, Division 1 or 2 (in accordance with NFPA 70) shall be suitable for same area classification as space exhausted.

2.05 ELECTRICAL COMPONENTS AND ACCESSORIES

- A. Wiring:
 1. In accordance with NFPA 70.
 2. Insulation shall be rated 600 volts, minimum.
- B. Provide surge suppressors on each power connection.

2.06 FIELD COMPONENTS AND INSTRUMENTS

- A. Refer to HVAC controls detailed specification, Section 15901, HVAC Controls, Field Components, and Instruments.

2.07 MICROELECTRONIC CONTROL COMPONENTS

- A. Refer to HVAC controls detailed specification, Section 15902, Microelectronic Control Components.

2.08 ACCESSORIES

- A. Corrosion-inhibiting vapor capsules as manufactured by:
 - 1. Northern Instruments; Model Zerust VC.
 - 2. Hoffman; Model A-HCI
- B. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 45 kg.
- C. Equipment Identification Plates:
 - 1. Provide 16-gauge Type 306 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 10 mm high engraved block type black enamel filled equipment identification number and letters indicated in this Specification and as shown.
 - 2. Provide adjacent to the following control devices, and for equipment whose function is not readily apparent.
 - a. Night low limit thermostats.
 - b. Manual override timers.
 - c. START/STOP switches.
 - d. Emergency STOP switches.
 - e. Special purpose devices.
 - f. HVAC control panels.
- D. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer.

2.09 EQUIPMENT FINISH

- A. Provide materials and equipment with manufacturer's standard finish system. Provide manufacturer's standard finish color, except where specific color is indicated.
- B. If manufacturer has no standard color, provide gray finish as approved by Owner.

PART 3 EXECUTION

3.01 SEQUENCES OF OPERATION

- A. Reference Contract Drawings.

3.02 INSTALLATION

A. General:

1. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings, and equipment details.
2. Changes in location or installation of control devices or equipment shall be approved by Contract Administrator before proceeding with the Work.
3. Mount devices requiring manual reset and all other user serviceable control devices in readily accessible locations.

B. Hazardous and Corrosive Areas:

1. In the following areas, provide control equipment and wiring suitable for installation in Class 1, Division 1, Group C or D hazardous areas:
 - a. Wet Well Room
 - b. Wet Well exhaust system
2. In the following areas, control equipment and wiring shall be suitable for corrosive environments, as follows:
 - a. Wet Well Room
 - b. Wet Well exhaust system
3. Protect control equipment located in areas identified as being corrosive as follows:
 - a. Use corrosion-inhibiting vapor capsules.
 - b. Replace capsules prior to Owner's acceptance of equipment.

C. Wiring:

1. General:
 - a. Install electric wire, cable, fittings, and conduit associated with systems specified in this section, in accordance with requirements of NFPA 70.
 - b. Install control and interlock wiring separate from power wiring.
 - c. Number code or color code conductors, excluding those used for individual zone controls, appropriately for future identification and servicing of control system.
 - d. Provide wire markers on each conductor in panel and at load connections. Identify circuit with control wire number.
 - e. Restrain wiring in control panels by plastic ties or ducts.
 - f. Hinge wiring shall be secured at each end so that any bending or twisting will be around longitudinal axis of wire and bend area shall be protected with sleeve.
 - g. Arrange wiring neatly, cut to length, and remove surplus wiring. Provide abrasion protection for any wire bundles that pass through holes or across edges of sheet metal.
 - h. Use manufacturer's recommended tool with proper sized anvil for crimp terminations. No more than two wires may be terminated in

single crimp lug and no more than two lugs may be installed on single screw terminal.

- i. Wiring shall not be spliced or tapped except at device terminals or terminal blocks.
 - j. Properly support and run wiring in a neat manner.
 - k. Run wiring parallel or at right angles to building structure.
2. Concealment:
- a. Generally conceal wiring from view, except in mechanical rooms and areas where other conduit and piping are exposed; install exposed wiring and conduit to be as unobtrusive as possible.
 - b. Install line voltage control wiring, wiring exposed to view, surface-mounted wiring, and wiring concealed within walls in conduit.
 - c. Install exposed and concealed low voltage control wiring systems in conduit.
 - d. Wiring within enclosures shall be neatly bundled and anchored to prevent obstruction to devices and terminals.
 - e. Conduit shall be sized to suit the number, type, and size of conductors.

D. End-User Accessible Control Components:

1. Do not mark room thermostats.
2. Mount user adjustable control components (room thermostats, humidistats, temperature sensors, humidity sensors, etc.) level and in accordance with applicable accessibility requirements of local Building Code.

E. Control Dampers:

1. Verify correctness of installation.
2. For pneumatic systems, calibrate and adjust positioners and IP transducers.
3. Verify proper control action.
4. Adjust limit switch settings.
5. Adjust opening and closing speeds, and travel stops.
6. Stroke control dampers by means of associated control output.

F. Adjustable Frequency Drives:

1. Verify control wiring installed to adjustable frequency drive.
2. Calibrate and adjust remote speed control loop and feedback loop.
3. Verify control actions and interlocks.
4. Adjust minimum and maximum speed settings.
5. Ramp adjustable frequency drive by simulation of associated controller output.

G. DDC Controllers:

1. Verify control wiring for correctness.
2. Verify power wiring.
3. Calibrate and adjust manual and auto control actions of controllers.
4. Tune control loop.
5. Stroke associated final element through controller output.
6. Verify set points and alarm functions.

H. HVAC Control Panel (HCP) Equipment:

1. Mount HCPs level, plumb, and securely to wall or column. Verify that adequate clearance is provided to allow for full front panel swing.
2. Provide field terminations and conduit knockouts for control/instrumentation wiring.
3. Field termination wiring shall have designated instrument tag.
4. Panel cutouts shall be cut, punched, or drilled and smoothly finished with round edges.
5. Provide separate conduit entry for each power feeder circuit.
6. Signals requiring grounding shall be grounded within panel.
7. Field end of conductor shield/drain wires shall be folded back and placed under heat-shrink tubing without being grounded.
8. Panel end of conductor shield/drain wires shall be covered with clear tubing at panel and grounded.
9. Calibrate instrumentation provided on control panels.
10. Provide labels for internal panel material (e.g., terminal blocks, power supplies, relays, PLC racks).

3.03 FIELD QUALITY CONTROL

A. Performance and Functional Testing:

1. HVAC controls interface with process control system shall be coordinated with the owner.
2. Test and certification shall be as specified in section 01840, Equipment testing and facility startup and section 01640, Manufacturers' services

3.04 MANUFACTURER'S SERVICES

1. Provide manufacturer's services in conformance with requirements of Section 01640, Manufacturers' Services.
2. Manufacturer's Representative: Present at site or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:
 - a. One person-days for installation, assistance, and inspection.
 - b. One person-days for functional and performance testing and Manufacturer's Certificate of Proper Installation.

- c. 0.5 person-days for prestartup classroom or site training.
- d. 0.5 person-days for facility startup.
- e. 0.5 person-days for post-startup training.

3.05 TRAINING

- A. Provide training of Owner's personnel to enable them to operate HVAC equipment in available modes, to adjust set points, and to interpret alarm signals.
- B. Training sessions shall be prepared in advance, and arranged for clear, effective transfer of information in minimum time.

3.06 ADJUSTING AND CALIBRATING

- A. Control system shall be adjusted and calibrated by qualified manufacturer's representative.
- B. Calibrate control devices at time of installation to ensure measuring and reading accuracy.
- C. Adjustment Record:
 - 1. Prepare complete record of system adjustments for each control system.
 - 2. Indicate deviations from specified temperatures.
 - 3. Include copy of completed record in each copy of Operation and Maintenance Manual.

3.07 CLEANING AND TOUCHUP PAINTING

- A. Touchup scratches, scrapes, or chips in exterior surfaces with finish matching type, color, consistency, and type of surface of original finish.

END OF SECTION

SECTION 15900-01
SEQUENCE OF OPERATION – CONTROL TYPES

- A. Motorized Damper Control:
 - 1. When fan is commanded to start, first open its intake damper.
 - 2. Provide end switch for open position of each damper.
 - 3. Once damper is proved fully open, start respective fan.
 - 4. Damper end switches shall stop respective fan if damper begins to close.
 - 5. Close damper on fan shutdown.

- B. Automatic Smoke Detection Shutoff:
 - 1. Upon signal of alarm at a given duct smoke detector, de-energize associated supply fan and associated return or exhaust fans. Prevent fans from restarting until smoke detector has been reset.
 - 2. Following reset signal, provide adjustable time delay (30 to 120 seconds) before responding to another alarm signal to allow smoke to clear.
 - 3. Monitor smoke detection signal from building Fire Alarm Control Panel. Coordinate with the owner.

- C. Motor START/STOP Control:
 - 1. Provide single contact closure for START/STOP control from HCP to each motor starter.
 - 2. Contact shall be closed to START motor.
 - 3. Contact shall be opened to STOP motor.
 - 4. Provide terminal contacts for connection by Electrical.
 - 5. Hardwire ON and OFF poles of manual ON/OFF and ON/OFF/AUTO switches directly to terminal contacts, so that malfunction of microprocessor hardware does not prevent manual on and off override.
 - 6. Coordinate with Electrical.

- D. Fan Failure and Ventilation Failure Alarms:
 - 1. Work of Electrical, includes provision of starter ON/OFF status signal to HCP for each fan motor controlled.
 - 2. For controlled motors, initiate Fan Failure Alarm signal when motor is commanded to START and starter ON/OFF status indicates it is OFF.
 - 3. In addition, provide differential pressure switch for each fan to determine actual flow failure. On lack of pressure differential, initiate Ventilation Failure Alarm. Include dual contacts at each differential pressure switch, one set for connection by Electrical.

- E. Low Temperature Shutdown:

1. Upon signal from Mixed Air or Discharge Temperature Sensors that temperature is below setpoint (3 degrees C adjustable), shut off fan, close outside air damper, open upstream heating coil control valve (if there is one), open cooling coil control valve (if there is one), and initiate Low Temperature Shutdown Alarm.
 2. Remain shutdown until manually reset or until temperature rises above 12 degrees C.
- F. Common Alarm Output:
1. Initiate common alarm signal to SCADA process control system when alarm condition exists.
 2. Provide terminals for connection by Electrical of alarm contact closure output signals.
 3. Contacts shall be rated for minimum of 2 amps at 120V ac.
 4. Coordinate with work of Electrical.
- G. Room Temperature Monitoring Output to SCADA System:
1. Provide 4 to 20 mA analog output signals to plant SCADA System for indicated room temperatures.
 2. Provide terminals at HVAC control panel (HCP) for connection by Electrical.
- H. Change Filter Alarm: Unless otherwise indicated, sense filter pressure drop for each filter bank by means of differential pressure switch that closes electrical contact when filter pressure differential exceeds adjustable setpoint.
- I. Room Temperature Control:
1. Modulate heating coil control valve, or heating and cooling coil control valves in sequence with economizer cycle (where applicable) to maintain discharge temperature at set point.
 2. Reset discharge temperature setpoint to maintain space temperature at set point.
 3. Heating coil control valves shall fail normally open to coil, and cooling coil control valves shall fail normally closed to coil, except where indicated otherwise.
- J. Occupied/Unoccupied Control:
1. Modes shall be determined by 7-day schedule with holiday calendar.
 2. Provide momentary contact manual after-hours override switch at room temperature sensor.
 3. Initially set after-hours override duration for 4 hours.
- K. Freeze Protection Control:

1. Thermostat, with 6.2 m length (minimum) capillary, secured to leaving heating coil face and responsive to coldest temperature shall stop fan, close outside air and exhaust dampers, stop associated supply and exhaust fans, and position heating valve for full flow through coil in event coil face temperature drops below 4 degrees C.
2. Freezestat shall be manually reset.
3. On blow-through units, locate freeze protection control in mixed air entering coil plenum.

L. Smoke Safety Control:

1. Locate duct mounted ionization detectors in return air inlet and supply air discharge from air handling systems as required by NFPA 90A to sense airborne products of combustion.
2. Provide wiring from detectors to fire alarm system.

END OF SECTION

SECTION 15901
HVAC CONTROLS, FIELD COMPONENTS, AND INSTRUMENTS

PART 1 GENERAL

1.01 GENERAL

- A. This section is a supplement to Section 15900, HVAC Instrumentation and Controls - General.
- B. The requirements of this section shall be provided in addition to those listed in Section 15900, HVAC Instrumentation and Controls - General.

1.02 EXTRA MATERIALS

- A. HVAC Control Panel (HCP) Spare Lamps: Furnish spare lamps for each type and color of pilot light used, a minimum of one per HCP, stored inside HCP in dummy light sockets secured to back panel surface.

PART 2 PRODUCTS

2.01 HVAC CONTROL PANELS (HCP)

- A. Provide at locations shown on Drawings for convenient operator interface with control system.
- B. A single 120-volt, 20-amp feeder shall serve each HCP, unless otherwise indicated.
- C. HCP Contents: Set point adjustment dials, gauges, receiver controllers, manual timers, time clocks, microprocessor control modules, electronic indication relays, control switches, transformers, pilot lights, alarm lights, display screens, keypads, and other devices necessary for particular system.
- D. HCP Construction:
 - 1. Construct each HCP to NEMA 250 rating as indicated in Schedule below, except where indicated otherwise:

HVAC Control Panel (HCP) NEMA 250 Construction
 Schedule

Location	NEMA 250 Type
Indoor	12

2. Metal enclosure to accommodate secure conduit fittings and protect against electrical transients.
 3. Hinged front door with locking handle.
 4. Flush-mount manual switches, pilot lights, and direct-reading gauges on front panel face.
 5. Identify front panel mounted devices and HCP with labeling in accordance with Section 15900, HVAC Instrumentation and Controls – General.
- E. Control Devices:
1. Mount inside HCP.
 2. Prewired internally.
 3. Terminate wires leaving HCP at separately numbered terminal strips (one terminal pair per circuit).
 4. Furnish individual connectors for every item of mechanical equipment, integral and remote pilot lights, and other devices described for each panel.
 5. Refer to Drawings for power and control circuit requirements.
 6. Identify wires by color coding or numerical tags at both ends.
 7. Wire control devices without splices to the terminal strip.
 8. Furnish integral circuit protection for panel mounted control devices.
- F. Terminal Blocks:
1. One-piece molded plastic blocks with screw type terminals and barriers rated for 600 volts.
 2. Double sided and supplied with removable covers to prevent accidental contact with live circuits.
 3. Furnish permanent, legible identification, clearly visible with protective cover removed.
 4. Terminate wires at terminal blocks with crimp type, preinsulated, ring-tongue lugs.
 5. Size lugs for terminal block screws and for the number and size of wires terminated.
 6. Provide screwdriver access for blade width of a minimum of 5 mm or Klein 601 Series screwdrivers. Terminals requiring use of special screwdrivers are not acceptable.
- G. Miscellaneous Accessories:
1. Furnish panel as-built electrical wiring diagrams and schematics, secured to inside of panel door, or enclosed in plastic jackets placed inside each panel.
 2. Install plastic or stick-on labels on interior control devices to identify them in conjunction with control schematics.

2.02 CONTROL DAMPERS

A. General:

1. Specification applies to control dampers, except those specified to be furnished with equipment.
2. Furnish opposed-blade type for proportional action and parallel-blade type for two-position action, except where indicated otherwise.

B. Heavy Duty Control Dampers (M):

1. Frame:
 - a. 203 mm by 51 mm by minimum 2 mm channel.
 - b. Bolt Holes: Both flanges
 - c. Material: Type 316 stainless steel.
2. Blades:
 - a. Style: Airfoil-shaped, double-skin.
 - b. Orientation: Horizontal or vertical with thrust washers, as indicated on Drawings.
 - c. Minimum 14 gauge (2 mm) equivalent thickness.
 - d. Material: Type 316 stainless steel.
 - e. Width: 127 mm to 203 mm maximum.
3. Bearings: Stainless steel sleeve pressed into frame
4. Seals:
 - a. Blade Seals: Stainless steel blade seals, maximum 204 degrees C. Mechanically attached to blade edge.
 - b. Jamb Seals: Compressible stainless steel located between blade edge and jamb.
5. Linkage:
 - a. Side linkage out of airstream.
 - b. Constructed of minimum 10-gauge (3.5-mm) galvanized steel clevis arms with minimum 4.8 mm by 19 mm plated steel tie bars pivoting on minimum 9.5-mm diameter stainless steel pivot pins with lock-type retainers.
6. Axles:
 - a. Minimum 20 m diameter, hex-shaped, mechanically attached to blade.
 - b. Material: Type 316 stainless steel.
7. Performance Data: As follows:
 - a. Maximum Operating Temperature: 121 degrees C.
 - b. Maximum System Pressure: 2.5 kPa.
 - c. Maximum System Velocity: 1,219 meter per minute.
 - d. Ultra-Low Leakage:
 - 1) Percent of Maximum Flow: 0.07.
 - 2) Leakage: 0.8 cubic meter per minute per square meter.
8. Accessories: As follows:

- a. Actuator: with explosion proof enclosure suitable for class 1, Div 1, Group D
 - b. Switch Package: Two-position indicator switches linked directly to damper blade to remotely indicate damper blade position.
9. Manufacturers and Products:
- a. Ruskin; Model CD-80AF.
 - b. American Warming and Ventilating.
 - c. TAMCO.

2.03 CONTROL DAMPER OPERATORS

A. General:

- 1. Drawings and Control Diagrams indicate only one damper motor for each motorized damper (M).
- 2. Select actual quantity of motors required to operate each damper in accordance with size of damper provided.
- 3. Coordinate exact quantity of damper motors with electrical work to ensure that necessary wiring and conduit is provided for installation.
- 4. Provide operators for motorized dampers and motorized louvers.

B. Electric Damper Operators:

- 1. Performance: As follows:
 - a. 120V, 60-Hz, two-position
 - b. Fail Position: Closed
- 2. Mounting: External side plate.
- 3. Ample power to overcome friction of damper linkage and air pressure acting on damper blades.
- 4. Furnished with external adjustable stops to limit stroke.
- 5. Operators on modulating dampers that are to be sequenced with other control devices shall have full relay type pilot positioner and interconnecting linkage to provide mechanical feedback that will accurately position and control damper.
- 6. Intake, relief, and exhaust dampers shall close and return dampers shall open on control failure, unless indicated otherwise.
- 7. Operating Torque:
 - a. Provide multiple independent damper sections, each with separate actuator, as needed to provide minimum of 120 percent of operating torque required by damper(s).
 - b. Required damper operating torque for actuator sizing calculations shall include friction of damper linkage and 200 Pa air pressure on damper blades:
 - 1) Opposed-Blade Dampers: Minimum 6 Nm per square meter of damper area, unless higher values are recommended by damper manufacturer.

- 2) Parallel-Blade Dampers: Minimum 8.5 Nm per square meter of damper area, unless higher values are recommended by damper manufacturer.
- 8. Manufacturers:
 - a. Belimo.
 - b. Neptronic.

2.04 ELECTRONIC SENSORS

A. Temperature (TS):

- 1. General Requirements:
 - a. Sensors and transmitters shall be provided, as outlined in input/output summary and sequence of operations.
 - b. Temperature sensor shall resistance type, and shall be either two-wire 1,000-ohm nickel RTD or two-wire 1,000-ohm platinum RTD.
 - c. The following point types (and accuracy of each) are required, and their associated accuracy values include errors associated with sensor, lead wire, and A to D conversion:

Point Type	Accuracy
Room Temperature	$\pm 0.3^{\circ}\text{C}$.
Duct Temperature	$\pm 0.3^{\circ}\text{C}$.
All Others	$\pm 0.4^{\circ}\text{C}$.

- 2. Room Temperature
 - a. Constructed for either surface or wall box mounting.
 - b. Nonlocking wire protective guards for room temperature sensors installed in process areas.
 - c. Shall have the following options when specified:
 - 1) Set point reset slide switch providing plus or minus 1.7 degrees C (adjustable) range.
 - 2) Individual heating/cooling set point slide switches.
 - 3) Momentary override request pushbutton for activation of after-hours operation.
 - 4) Analog thermometer.
- 3. Room Temperature Sensors with Integral DisplayP:
 - a. Constructed for either surface or wall box mounting.
 - b. Nonlocking wire protective guards for room temperature sensors installed in process areas.
 - c. Integral LCD display and four button keypad with the following capabilities:
 - 1) Display room and outside air temperatures.
 - 2) Display and adjust room comfort set point.

- 3) Display and adjust fan operation status.
 - 4) Timed override request pushbutton with LED status for activation of after-hours operation.
 - 5) Display controller mode.
 - 6) Password selectable adjustment of set point and override modes.
4. Duct Temperature:
 - a. Accuracy: Plus or minus 1 degree C.
 - b. Range:
 - 1) Heating: 4 to 60 degrees C.
 - 2) Cooling: minus 1 to 38 degrees C.
 - c. Element:
 - 1) Rigid insertion, 300 mm length, through sealed opening in center of duct.
 - 2) Averaging, for ducts or plenums with any dimension greater than 908 mm. Sealed opening in duct. Sensing element incorporated in copper capillary a minimum of 6.1 m long, serpentine across full area of airflow.
 5. Outdoor Temperature:
 - a. Accuracy: Plus or minus 0.5 degree C.
 - b. Range: Minus 4 to 60 degrees C.
 - c. Cover: Weathertight, with sealed conduit connection and sun shield.
- B. Differential Pressure:
1. General:
 - a. Temperature compensated.
 - b. Vary output voltage with change in differential pressure. Voltage shall vary linearly from 0 to 10V dc according to differential pressure between high and low pressure ports.
 - c. Sensing range shall be suitable for application with linearity of 1.5 percent of full scale and offset of less than 1 percent of full scale.
 - d. Capable of withstanding up to 150 percent of rated pressure without damage.
 - e. Compatible with 14V to 30V dc supply voltage range.
 2. Space Air Static Differential Pressure: MAMAC transmitter.
- C. Position Indicator:
1. 0 to 100 percent open, for damper, inlet vane, or similar.
 2. Potentiometer, 0 to 2,000 ohm equals 0 to 100 percent.
- D. Current Sensors (CS):
1. Fixed Setpoint, Digital Output Current Switch:

- a. Application: Monitoring status of direct drive equipment.
 - b. Current-operated solid state relay.
 - c. Split core design.
 - d. Trip Setpoint: Fixed.
 - e. Output: Digital switch.
 - f. Sensor Power: Induced from line.
 - g. Manufacturer and Product: Veris; Hawkeye 600/800.
2. Adjustable Setpoint, Digital Output Current Switch:
 - a. Application: Monitoring status of belt drive equipment.
 - b. Current-operated solid state relay.
 - c. Split core design.
 - d. Trip Setpoint: Adjustable.
 - e. Output: Digital switch, with status LED.
 - f. Sensor Power: Induced from line.
 - g. Manufacturer and Product: Veris; Hawkeye 708/908.
 3. Adjustable Setpoint, Digital Output, AFD Current Switch:
 - a. Application: Monitoring status of belt-drive or direct-drive equipment controlled by an AFD.
 - b. Microprocessor-based current-operated solid state relay.
 - c. Automatic compensation for AFD frequency and current changes.
 - d. Split core design.
 - e. Trip Setpoint: Self-calibrating.
 - f. Output: Digital switch, with normal and alarm status LED.
 - g. Sensor Power: Induced from line.
 - h. Manufacturer and Product: Veris; Hawkeye 904.

2.05 MISCELLANEOUS DEVICES

A. General:

1. RTD to voltage (0- to 5-volt) converters with zero span adjustments for use with analog inputs.
2. Limited range thermistors are acceptable provided they sense expected range for point at specified accuracy with 0- to 5-volt output.
3. Auxiliary contacts in each motor starter, Work of Division 16, Electrical.
4. START/STOP relay module for either momentary or maintained switch action as indicated.

B. Pilot Relays:

1. Plug-in type.
2. Interchangeable.
3. Mounted on a circuit board.
4. Wired to numbered terminal strips.

- C. Motorized Step Controllers: Furnish with adjustable (from minus 17 to minus 12 degrees C) deadband between heating and cooling functions.

D. Receiver Controllers:

1. Modulating temperature, pressure, or humidity type.
2. Adjustable gain with amplification ratio up to 40 to 1.
3. Dual input (submaster) instruments to have adjustable ratio or reset range.
4. Furnish dials for set point, gain and, where applicable, ratio or reset range.
5. Mount inside HCP.
6. Furnish test probe points to permit analysis of input signal(s) without interrupting controller.
7. Include proportional integral control.
 - a. Designed to minimize internal hysteresis.
 - b. Either integral or remote set point adjustment.
 - c. Integral time constant adjustment.
 - d. Function as integral feedback device with output that varies progressively, depending on degree of offset and time since transient was detected.
8. Capable of being remotely reset from existing building automation system.

E. Manual Timer (MT):

1. 12-hour, SPST, 120-volt, 20-amp.
2. Spring wound.
3. HOLD feature to override the time clock during off-hour operation.
4. Install on front cover of HCP.
5. Manufacturers and Products:
 - a. Marktime;
 - b. Dayton;
 - c. Nutone.

F. Time Clock (TC):

1. Electronic 7-day programmable type.
2. 8-hour battery backup feature.
3. Mount inside HCP.
4. Manufacturers and Products:
 - a. Paragon;
 - b. Omron;

G. Electronic Indication:

1. Furnish temperature-indicating dials or digital read-outs on HCP.
2. 65 mm minimum rectangular.
3. Temperature sensing dc bridge circuit.

H. Duct Mounted Ionization Detection (I):

1. Furnish duct smoke detectors for air handling systems, number and location as shown on Drawings.
2. Type: Duct mounted, suitable for airstream sensing.
3. Voltage: 120V ac.
4. Detector Type: Ionization.
5. Furnish with remote reset button or key switch.
6. Include mounting bracket for installation on the ductwork.
7. Coordinate with other trades to accomplish specified Automatic Smoke Detection shutoff control sequence.
8. Manufacturers and Products:
 - a. BRK Electronics; Model DH1851AC.
 - b. Pyrotronics Pyr-Alarm; Model CA-4

PART 3 EXECUTION

3.01 INSTALLATION

A. Control Dampers:

1. Install at locations indicated on Drawings and in accordance with manufacturer's instructions.
2. Install square and free from racking with blades running horizontally.
3. Operate opposed blade dampers from a power blade or drive axle.
4. Bracing:
 - a. Install for multiple section assemblies to support assembly weight and to hold against system pressure.
 - b. Install at every horizontal and vertical mullion.

END OF SECTION

SECTION 15902
MICROELECTRONIC CONTROL COMPONENTS

PART 1 GENERAL

1.01 GENERAL

- A. This Section is a supplement to Section 15900, HVAC Instrumentation and Controls - General.
- B. The requirements of this Section shall be provided in addition to those listed in Section 15900, HVAC Instrumentation and Controls - General.

1.02 DEFINITIONS

- A. ASCII: ANSI X3.4, Information Systems - Coded Character Sets - 7-Bit American National Standard Code for Information Interchange (7-Bit ASCII).
- B. BACnet: ASHRAE 135, BACnet, Data Communication Protocol for Building Automation and Control Networks.
- C. Distributed Control: System whereby control processing is decentralized and independent of central computer. Control system is built up of standalone controllers. Single controller failure shall not impact more than one system.
- D. Ethernet: ISO/IEC 8802-3. The most common high performance peer-to-peer LAN protocol.
- E. Integration:
 - 1. Ability of control system components from different manufacturers to connect together and provide coordinated control via real-time data exchange through common communications data exchange protocol.
 - 2. Integration shall extend to operator's workstation software, which shall support user interaction with control system components.
 - 3. Methods of integration include industry standard protocols, such as: BACnet, LonMark/LonTalk, OLE for Process Control (OPC), or integrator interfaces between manufacturer's systems.
- F. Interoperability: Ability of equipment to communicate mutually.
- G. Input/Output (I/O): Connections between computer and sensors and actuators.
- H. Human-Machine Interface (HMI): Method by which operator communicates with HVAC Control System. Allows operator to command, monitor, and program control system.

- I. Internet Protocol (IP): Network layer protocol originally created by Defense Advanced Research Project Agency to facilitate data communication between U.S. Defense Department and defense contractors, including universities and manufacturers
- J. Local Area Network (LAN): Network in which devices can communicate directly without going through intervening routers. LANs commonly used by DDC system Suppliers include Ethernet (ISO 8802-3), ARCNET, Echelon LonTalk, and EIA 485.
- K. Master-Slave/Token-Passing (MS/TP): One of the data link layers created specifically for use with BACnet messages.
- L. Network:
 - 1. System of distributed control units that are linked together on communication highway.
 - 2. Allows sharing of point information between control units.
 - 3. Provides central monitoring and control of entire system from any distributed control unit location.
 - 4. Primary networks provide peer-to-peer communications.
 - 5. Secondary networks provide either peer-to-peer, master-slave, or supervised token-passing communications.
- M. Peripheral: Input/Output equipment used to communicate with computer and make copies of system outputs. Peripherals include CRT, printer, tape deck, diskette.
- N. PID (Proportional, Integral, Derivative) Control Loop: Mathematical calculation used to evaluate control input and determine control output value required to maintain input value at set point. Shall have operator adjustable maximum rate of change, P and D gains, and loop response time delay. Loop shall be self-integrating so no integral constant is required and not be subject to integral windup.
- O. Transmission Control Protocol (TCP): Connection-oriented protocol used to convey multiple related messages (e.g., file transfers, Web pages, etc.).
- P. Abbreviations that may be used in this Section:
 - 1. BIOS: Basic Input Output System.
 - 2. DDC: Direct Digital Control.
 - 3. IBM: International Business Machines, Inc.
 - 4. LCD: Liquid Crystal Display.
 - 5. PC: Personal Computer.
 - 6. PID: Process Instrumentation Diagram.
 - 7. PI: Pressure Indicator.

1.03 QUALITY ASSURANCE

A. Compatibility:

1. System shall have documented history of compatibility by design for minimum of 15 years.
2. Future compatibility shall be supported for no less than 10 years.
3. Compatibility shall be defined as:
 - a. Ability to upgrade existing microelectronic controllers to current level of technology, and extend new microelectronic controllers on previously installed network.
 - b. Ability for any existing microelectronic controller microprocessor to be connected and directly communicate with new microelectronic controllers without bridges, routers, or protocol converters.

1.04 SYSTEM PERFORMANCE

A. System shall conform to the following performance standards:

1. Graphic Display:
 - a. Minimum of 20 dynamic points.
 - b. Current data displayed within 20 seconds of request.
2. Graphic Refresh: System shall update dynamic points with current data within 30 seconds.
3. Object Command:
 - a. Maximum time between command of binary object by operator and reaction by device shall be 10 seconds.
 - b. Analog objects shall start to adjust within 10 seconds.
4. Object Scan: Changes of state and change of analog values shall be transmitted over high-speed network such that any data used or displayed at controller or workstation will be current, within prior 60 seconds.
5. Alarm Response Time: Maximum time from when object goes into alarm to when it is annunciated at workstation shall not exceed 45 seconds.
6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 seconds. Select execution times consistent with mechanical process under control.
7. Performance: Programmable Controllers shall be able to execute DDC PID control loops at selectable frequency from at least once every 5 seconds. Controller shall scan and update process value and output generated by this calculation at this same frequency.
8. Multiple Alarm Annunciation: Workstations on network shall receive alarms within 5 seconds of each other.
9. Reporting Accuracy: Table 1 lists minimum acceptable reporting accuracies for values reported by specified system.

Table I -- Reporting Accuracy	
Measured Variable	Reported Accuracy
Space temperature	±0.5°C
Ducted air	±1.0°C
Outside air	±1.0°C
Water temperature	±0.5°C
Delta-T	±0.15°C
Relative humidity	±5% RH
Water flow	±5% of full scale
Air flow (terminal)	±10% of reading *Note 1
Air flow (measuring stations)	±5% of reading
Air pressure (ducts)	±25 Pa
Air pressure (space)	±3 Pa
Water pressure	±2% of full scale *Note 2
Electrical Power	5% of reading *Note 3
Carbon Monoxide (CO)	± 50 PPM
Carbon Dioxide (CO ₂)	± 50 PPM
Note 1: (10%-100% of scale) (cannot read accurately below 10%)	
Note 2: for both absolute and differential pressure	
Note 3: not including utility company supplied meters	

PART 2 PRODUCTS

2.01 STANDALONE DDC CONTROL SYSTEM

A. Standalone Custom Controllers (DDC-):

1. General:

- a. Provide adequate number of controllers to provide performance specified in Article System Performance and as indicated on Drawings.
- b. Microprocessor based true no-host system; no PC or “host” computer required to perform control functions or communications, capable of standalone operation, providing control functions without being connected to a network.

2. Performance:
 - a. Set points, controller operating system, and programming shall be resident in EEPROM, within controller.
 - b. Capable of executing DDC loops and custom control routines.
 - c. DDC loop control programming with editable proportional, integral, and derivative control parameters.
 - d. DDC loops shall have editable high and low output limits as well as editable failure output values.
 - e. Software control reaction time shall be programmable to be no slower than 5 seconds.
 - f. DDC loops shall be programmable to operate at user defined intervals with maximum frequency of 1 second.
 - g. Sufficient memory to support its operating system, database, and programming requirements.
3. Environment: Controller hardware shall be suitable for anticipated ambient conditions.
 - a. Controller shall be mounted in locking enclosure. Refer to Section 15901, HVAC Controls Field Components and Instruments, Article HVAC Control Panels (HCP), for enclosure details.
 - b. Controller used outdoors or in wet ambient conditions shall be mounted within waterproof enclosure and rated for operation at minus 40 degrees C to 65 degrees C.
 - c. Controller used in conditioned ambient shall be mounted in dust-proof enclosure and shall be rated for operation at 0 degrees C to 50 degrees C.
4. Clock:
 - a. Real time clock that shall remain active during power failure for up to 7 days under normal operating conditions.
 - b. When controller is used with higher level system, time clock shall be automatically synchronized with system controller.
5. Software:
 - a. Software for controller setup, programming, and editing of database.
 - b. In English language.
 - c. IBM PC compatible.
 - d. PI and PID control loops.
 - e. Programming subroutine blocks available to be used in any combination for program modifications.
 - f. As a minimum, routines shall include:
 - 1) Time- or event-based scheduling.
 - 2) Offline, fill-in-the-blank programming of controller.
 - 3) Operating and programming error messages and diagnostics.
 - 4) Database save and restore.
 - 5) Adaptive optimum start/stop.

- 6) Run time totalization.
 - 7) Alarm detection and dial out.
 - 8) Historical Trending: Trend data shall be fully compatible with Microsoft Access and Excel.
- g. Documentation: Provide to Owner, before completion of Project:
 - 1) Electronic copy of programming tool software.
 - 2) Electronic copy of control logic program used in controller.
 - 3) User's manual for software operation.
 - 4) Include appropriate cable for interconnection between PC serial port and controller.
- 6. Diagnostics: Controller shall contain the following diagnostic information:
 - a. LEDs indicating status of main board, communications Transmit and Receive, and Binary Output on/off.
 - b. Information regarding failure of analog or change of state of any binary point. Controller must then capture an image of all points at value or state at time of event/alarm. This data must be able to be viewed from a set of screens that are labeled with alarm point, date and time of occurrence, and cause of failure.
 - c. Self test procedure for checking communications and verifying functionality of memory and database.
 - d. Upon detection of communication loss, retransmission shall be attempted.
 - e. Continuing failure shall cause trouble signal to be annunciated at HCP.
 - 7. External Communication:
 - a. Allow service tool editing of programming while controller is in total standalone operation.
 - b. Include RS232 port for connection to portable operator interface device for commissioning, adjustment, diagnosis, upload, download, and editing of data.
 - c. Provide port for connection to LAN.
 - d. Allow interface and communicate with plant DCS control system
 - 8. Electrical:
 - a. Power:
 - 1) On/Off switch inside cabinet.
 - 2) Controller Power: 24V, 50/60 Hz.
 - 3) On-board isolation transformer or dedicated transformer, rated at minimum of 125 percent of maximum power consumption, and shall be fused or current limiting type.
 - 4) Battery Backup: Local controller must provide backup of all memory for period of 7 days under normal operating conditions if commercial power to controller is interrupted.
 - b. Connections:

- 1) Plug-in terminal blocks, in accordance with requirements of Section 15901, HVAC Controls Field Components And Instruments, Article HVAC Control Panels (HCP).
 - 2) Logic card containing active electrical components shall be easily removable from wiring base without use of tools.
 - 3) Provide quick disconnect interconnection with electrical wiring.
- c. Immunity to Power and Noise:
- 1) Controller shall be able to operate at 90 percent to 110 percent of nominal voltage rating and shall perform orderly shutdown below 80 percent nominal voltage.
 - 2) Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5W at 1 meter.
 - 3) Provide filters, as required to comply with applicable FCC regulations.
- d. Power Loss/Restart:
- 1) Tolerant of power failures.
 - 2) Memory shall be nonvolatile or unit shall hold memory up to 30 days minimum on backup batteries.
 - 3) When power failure has occurred and power is restored, controller shall restart automatically and without operator intervention.
 - 4) Restart Procedures:
 - a) Come online.
 - b) Update monitored functions.
 - c) Implement special facility startup strategies as required.
 - 5) Resume operation based on current time and status.
9. Input/Output:
- a. Controller shall be configurable using modular Input/Output points to allow for system customization and expansion.
 - b. Each controller shall monitor analog inputs and analog outputs, and perform minimum 10 bit A-to-D and 8 bit D-to-A conversion.
 - c. Local controller shall receive signals from industry standard sensors and input devices and directly control actuators and control devices.
 - d. Controller shall have capability to monitor and control the following types of inputs and outputs:
 - 1) Analog Inputs:
 - a) Current: 4 to 20 mA.
 - b) Voltage: 0 to 10 VDC.
 - c) Thermistor.
 - d) 1000 Ohm RTD.
 - 2) Binary Inputs:
 - a) Isolated dry contact closure.
 - b) Pulse.

- 3) Analog Outputs:
 - a) Current: 4 to 20 mA.
 - b) Voltage: 0 to 10 VDC.
- 4) Binary Outputs: 24 VAC, Triac switch.
- e. Output points must be available with manual software and hardware overrides with feedback indication that an output is presently overridden.
- f. Port Isolation:
 - 1) Individually, electrically isolated to protect against transients, spikes, and power surges.
 - 2) Optically isolated from each other, controller circuit board, and from power wiring.
 - 3) Optical isolation either as integral component to controller or as a separate interface device between controller and field wiring.
- g. Quantity of I/O Points: As required to provide equipment function as described in sequences of operation.
- 10. Expansion Capability:
 - a. Capable of accepting expansion modules for addition of:
 - 1) Memory.
 - 2) Input/Output points.
- 11. Trending:
 - a. Minimum of eight user selectable points shall be able to be logged, with a minimum of 24 samples per log.
 - b. Start and stop times for each trend log shall be definable or continuous.
- 12. User Interface:
 - a. Local keypad and display shall be provided for each controller for interrogating and editing data.
 - b. Keypad and display shall be built-in to controller, with minimum one line by 20 character LCD display.

PART 3 EXECUTION

3.01 GENERAL

- A. Refer to Section 15900, HVAC Instrumentation and Controls - General for requirements.

END OF SECTION

SECTION 15950
HVAC SYSTEMS TESTING, ADJUSTING, AND BALANCING

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. Air Moving and Conditioning Association, Inc. (AMCA): 203, Field Performance Measurement of Fan Systems.
 2. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE): HVAC Applications Handbook.
 3. Canadian Associated Air Balance Council (CAABC): National Standards for Field Management and Instrumentation Total System Balance.
 4. National Environmental Balancing Bureau of Canada(NEBBC):
 - a. Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.
 - b. Procedural Standards for Measuring Sound and Vibration.
 5. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): HVAC Testing, Adjusting, and Balancing Manual.

1.02 SUBMITTALS

- A. Informational Submittals:
1. Documentation of experience record of testing authority.
 2. Documentation of current CAABC or NEBBC certifications for those technicians in responsible charge of the work under this Contract.
 3. Submit detailed test and balance procedures, including test conditions for systems to be tested, prior to beginning the Work.
 4. Written verification of calibration of testing and balancing equipment.
 5. Balancing Log Report following completion of system adjustments including test results, adjustments, and rebalancing procedures.

1.03 QUALITY ASSURANCE

- A. Air Balancing and Test Agency Qualifications:
1. Certification by CAABC or NEBBC for testing, adjusting and balancing of HVAC systems.
 2. Corporately and financially independent organization functioning as an unbiased testing authority.
 3. Professionally independent of manufacturers, suppliers, and installers of HVAC equipment being tested.
 4. Have a proven record of at least five similar projects.

5. Employer of engineers and technicians regularly engaged in testing, adjusting and balancing of HVAC equipment and systems.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Provide materials, tools, test equipment, computers and instrumentation required to complete the work included.
- B. Test Hole Plugs: Plug test holes in ducts with plugs made for that purpose and replace any insulation removed to specified conditions.
- C. Drives for Belt-Driven Fans:
 1. Furnish cast iron or flanged steel sheaves.
 2. Sheaves and belt combination shall be capable of providing 150 percent of motor horsepower.

PART 3 EXECUTION

3.01 GENERAL

- A. Adjust and balance air and water systems in accordance with standard procedures and recognized practices of the CAABC, NEBBC or SMACNA.
- B. Adjust and balance the following systems:
 1. New Supply, return and exhaust air systems of Wet well.
 2. Existing exhaust fan on MF-11 in existing Tower

3.02 ADJUSTING AND BALANCING AIR SIDE

- A. Preparation:
 1. Prior to beginning the Work, perform the following activities:
 - a. Review shop drawings and installed system for adequate and accessible balancing devices and test points.
 - b. Recommend to Contract Administrator dampers that need to be added or replaced in order to obtain proper air control.
 - c. Verify proper startup procedures have been completed on the system
 - d. Verify controls installation is complete and system is in stable operation under automatic control.
 - e. Verify test instruments have been calibrated to a recognized standard and are within manufacturer's recommended calibration interval before beginning the Work.
- B. General:

1. When adjustments are made to a portion of a fan system, reread other portions of that same system to determine effects imposed by adjustments. Readjust as necessary.
2. Lock and mark final positions of balancing dampers with permanent felt pen.

C. Equipment Data:

1. Collect the following data and included in final report:
 - a. Type of unit.
 - b. Equipment identification number.
 - c. Equipment nameplate data (including manufacturer, model, size, type, and serial number).
 - d. Motor data (frame, kW, volts, FLA rpm, and service factor).
 - e. Sheave manufacturer, size, and bore.
 - f. Belt size and number.
 - g. Sheave centerline distance and adjustment limits.
 - h. Starter and motor overload protection data.
 - i. Include changes made during the course of system balancing.

D. Fan Systems:

1. Measure fan system performance in accordance with AMCA 203.
2. In each system at least one airpath from fan to final branch duct termination shall have dampers fully open. Achieve final air quantities by adjusting fan speed.
3. Adjust Fan Air Volumes:
 - a. Adjust fan speeds and motor drives for required equipment air volumes, with allowable variation of plus 10 percent minus 0 percent.
 - b. After final adjustments, do not operate motor above nameplate amperage on any phase.
 - c. After final adjustments, do not operate fan above maximum rated speed.
 - d. Perform airflow test readings under simulated or actual conditions of full cooling, full heating, minimum outside air, full outside air and exhaust, and full return air.
 - e. Provide and make drive and belt changes on motors or fans as required to adjust equipment to specified conditions. Drives shall be able to deliver 150 percent of motor horsepower. Provide written notice to air handling unit manufacturer and Owner if drive or belt changes were made.
4. Adjust outside air dampers, return air dampers, relief air dampers, exhaust air dampers, and motorized louvers for maximum and minimum air requirements.

5. Read and record static pressures at unit inlet and discharge, each filter set, coils, dampers, plenums, and mixing dual-duct or adjustable-volume boxes, on every supply, return, and exhaust fan for each test condition.
 6. Read and record motor amperage on all phases for each test condition.
- E. Air Terminal Devices:
1. Terminal Airflow Calibration: Calibrate and set the flow coefficients in terminal controller units to ensure controller readings are identical to measured values. This shall be a one-point calibration at maximum flow conditions. Record coefficient values.
 2. Test each terminal flow device at minimum and maximum flow conditions. Ensure terminal controller is under control at time of each test.
 3. If airflow of terminal device is derived from two or more flow streams, the individual air streams shall be measured and recorded independently for each test.
 4. In each terminal system at least one airpath from terminal to final duct termination shall have dampers fully open.
 5. Adjust air volumes on each terminal to quantity shown, with allowable variation of plus 10 percent minus 5 percent.
- F. Air Outlets and Inlets:
1. In each system at least one air path from fan to final branch duct termination shall have dampers fully open.
 2. Adjust air volumes on supply diffusers and grilles, and on return and exhaust grilles, to the quantity shown, with allowable variation of plus or minus 10 percent.
 3. Adjust diffusers and grilles for proper deflection, throw, and coverage. Eliminate drafts and noise where possible.
 4. After final adjustments are made secure dampers to prevent movement and mark final positions with permanent felt pen.
- G. Existing exhaust fan MF-11 in existing Tower:
1. After seal off the existing ductwork in the WetWell room, rebalancing the existing exhaust fan MF-11.
 2. Make drive and belt changes to cust airflow rate from 1416L/s to 708L/s
- H. Zone Differential Pressure:
1. Test and adjust differential pressures by setting design flows to meet required flow direction and pressure differential during worst case conditions of systems serving zone being adjusted and of adjacent zones.

2. Zone differentials for this project include:
 - a. Wet Well room
3. Provide written notice to Contract Administrator of zone leakage conditions preventing design differential requirements to be met.

3.03 FIELD QUALITY CONTROL

A. General: Perform functional tests as required by Section 01810, Equipment Testing and Facility Startup.

B. Performance Testing:

1. Vibration Testing:

a. Upon completion of air and water system balance, perform vibration testing as specified below for the following rotating or reciprocating equipment:

- 1) New make up air unit supply fan
- 2) New Exhaust fan

b. Vibration Test Procedures:

- 1) Take measurements at each bearing housing, using a calibrated electronic analyzer.
- 2) Record log shall include equipment symbol, location, identification, and peak-to-peak displacement in a direction parallel to shaft in a horizontal plane, and in a direction perpendicular to shaft in both horizontal and vertical planes.

3) Maximum Peak-to-Peak Amplitude Levels:

Rotational Speed (rpm)	Vibration Amplitude (mils)
250	3.5
500	2.0
750	1.5
1,000	1.0
1,500	0.75

- 4) Notify Contract Administrator if amplitude exceeds upper limit specified.
- 5) After readjustment for vibration, measure and record only the readjusted equipment to determine its conformance with design.

C. Balancing Log Report Requirements:

1. Include narrative description for each system explaining TAB methodology and assumptions used. Clearly identify test conditions for tests performed. Include control setpoint.
2. Log and record operational information from every test for each system, as necessary to accomplish services described.
3. Include equipment data for units tested.
4. Include reduced set of HVAC Drawings or system schematic diagrams with each element uniquely identified and indexed to balance log.
5. Indicate recorded site values, and velocity and mass correction factors used to provide equivalent standard air quantities.
6. Include separate section in log, if necessary, describing operating difficulties in air or water systems that could not be eliminated by specified procedures. Identify these problems by system and location within building; include outline or summary of condition and its effect on building, and describe corrective actions attempted and recommended.

D. Quality Control Verification:

1. After adjustments have been completed and balance logs submitted, balancing and testing agency shall be available to demonstrate the following:
 - a. Air and water balancing procedures, vibration tests, and verification of test results.
 - b. Perform spot tests on a maximum of 20 percent of total diffusers and grilles, on two air handling fan devices per building, and on 10 percent of total water balance fittings, with measuring equipment used in original tests, at random points selected by Contract Administrator.
 - c. Results of these spot tests shall agree with balance logs within plus or minus 10 percent. Where this accuracy cannot be verified, rebalance portions of system as requested by Contract Administrator.
 - d. At completion of rebalance procedures, perform another spot test if required to verify results.

END OF SECTION