SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification, as listed in, but not limited to, the “Saudi Sanitary Code-Plumbing”, SBC 701, and the standards listed below in this section; whichever is more stringent.

C. Comply with NEMA MG1.

D. Comply with IEC 60034.

E. Comply with IEC 60072.

F. Comply with IEC 60529.

1.2 GENERAL MOTOR REQUIREMENTS

A. Motors shall be of the energy efficient design.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

D. Motors 0.746 kW (1 HP) and Larger: Three phase.

E. Motors smaller than 0.746 (1 HP): Single phase.

1.3 MOTOR CHARACTERISTICS

A. Motors shall be NEMA design B or design N or NY as applicable to IEC 60034-12, unless otherwise recommended by manufacturer and approved by the Engineer for high torque applications.

B. Duty: Continuous duty at ambient temperature of 46.1 deg C and at altitude of 625 m above sea level.

C. Service Factor: 1.15 according to NEMA MG1 or shall be duty type S1 - continuous running duty to IEC 60034-1, unless otherwise indicated. Motors used for excessive intermittent periodic operation shall be suitably designed for the expected number of starts. Motors’ dimensions shall comply with NEMA MG1 or IEC 60072 as applicable.

D. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

E. Low Voltage Motors’ Enclosure: Totally enclosed, fan-cooled type (TEFC) to NEMA MG1 or IC 411 to IEC 60034-6 as applicable, unless otherwise indicated or recommended by manufacturer and approved by the Engineer.

F. Medium Voltage Motors' Enclosures: Totally enclosed, air to air cooled (TEAAC) to NEMA MG1 or IC 611 to IEC 60034-6 as applicable or totally enclosed, water to air cooled (TEWAC) to NEMA MG1 or IC 817 to IEC 60034-6 as applicable. Enclosure type shall be as recommended by manufacturer and approved by the Engineer, unless otherwise indicated.

G. Degree of Protection (IP): Motors shall be IP55 to IEC 60529 for outdoor use and IP54 to IEC 60529 for indoor motors as a minimum .

H. Temperature Rise: Shall not exceed 80 deg. C based on 50 deg. C (122 deg. F) ambient temperature, unless otherwise indicated or recommended by manufacturer and approved by the Engineer for specific applications such as: overhead cranes or submersible pumps, where temperature rise not exceeding 105 deg. C may be used.

I. Motors that utilize a Variable Frequency Drive (VFD) shall be inverter duty to NEMA MG1 or Class I to IEC 60034-18-41and shall be classified as energy efficiency to NEMA MG1 or high efficiency class IE2 to IEC 60034-30.

J. Low Voltage Motors Terminal Boxes: Shall have the same motor's degree of protection.

K. Medium Voltage Motors Terminal Boxes: Shall have the same motor's degree of protection and shall be designed for differential CT's and/or surge protection (surge arrestor and surge capacitor). Enough space shall be provided below main terminal box for cable connection.

L. Include built-in terminal blocks and built in thermistors PTC100 / RTD200 for winding protection for all low voltage motors rated 50 HP and above and for all low voltage VFD motors.

M. Include built-in terminal blocks and built in thermistors PTC100 / RTD200 for winding and bearing protection for all medium voltage motors.

N. The contractor is responsible for coordination between the motor and motor controller suppliers to ensure compatibility, proper starting and satisfactory operation.

1.4 MATERIALS

A. Polyphase Motors: Design B, medium induction motors.

1. Efficiency: Premium efficient, as defined in NEMA MG 1 or class IE3 to IEC 60034-30 unless otherwise indicated.
2. Service Factor: 1.15.
3. Stator: Copper windings unless otherwise indicated.
4. Multispeed Motors: Variable torque or Separate winding for each speed as applicable.
5. Rotor: Random-wound, squirrel cage.
6. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading.
7. Temperature Rise: Match insulation rating.
8. Insulation: Unless otherwise indicated, Class F for motors with temperature rise 80 deg. C and Class H for motors with temperature rise 105 deg. C as indicated in paragraph 2.1 M above.
9. Code Letter Designation:

    a. Motors 15 HP and Larger: NEMA starting Code F or Code G.
    b. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

10. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

B. Additional Requirements for Polyphase Motors:

1. Motors used with reduced-voltage and multispeed controllers.
2. Premium-efficient and inverter-duty motors used with variable-frequency controllers.
3. Severe-duty motors: Where indicated, motors are totally enclosed with 1.15 minimum service factor to NEMA MG1 and IEEE 841.

C. Single-Phase Motors:

1. Motors Larger Than 1/20 HP: Permanent-split capacitor; split phase; capacitor start, inductor run; or capacitor start, capacitor run to suit starting torque and requirements of specific motor application. Class B insulation may be used, unless otherwise indicated.
2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
4. Motors 1/20 HP and Smaller: Shaded-pole type.
5. Internal thermal protection.

D. Electronically Commutated Motors (ECM):

1. Brushless, permanent magnet type, with ball bearing design.
2. Designed for synchronous rotation and able to be mounted with shaft in horizontal or vertical orientation.
3. Energy-Efficient Design: Super premium efficiency to NEMA MG1 or class IE4 to IEC 60034-30-1.
4. EC Motor Service Factor: 1.15.
5. Motor shall be resiliently mounted, self-aligning and oiled for life.
6. ECM built-in electronic drive suitable for either manual and/or DDC controlled flow adjustments.
7. Variable speed with motor speed input compatible with the DDC analog outputs range.
8. Motor shall be completed with Thermal Overload Protector (TOP).
9. Motor to be controlled and regulated by a DC signal supplied from a field instrument, DDC controller or BMS.

END OF SECTION 230513

SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials and installation for sleeves and sleeve seals for plumbing piping, as listed in, but not limited to, the “Saudi Building Code – General“, SBC 201, and “Saudi Mechanical Code”, SBC 501, and the standards listed below in this section; whichever is more stringent.

1.2 SLEEVES WITHOUT WATERSTOP

A. Cast-Iron Pipe Sleeves: Cast or fabricated ductile iron, with plain ends.

B. Steel Pipe Sleeves: Hot-dip galvanized, ASTM A53/A53M, Type E, Grade B, Schedule 40, with plain ends.

C. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

D. PVC Pipe: ASTM D1785, Schedule 40.

E. Molded-PVC Sleeves: With nailing flange.

F. Molded-PE or -PP Sleeves: Removable, with nailing flange.

1.3 SLEEVES WITH WATERSTOP

A. Cast-Iron Pipe Sleeves: Cast or fabricated ductile iron, with plain ends and integral waterstop collar.

B. Manufactured, [**PVC/HDPE**] [**ASTM A53/A53M, Type E, Grade B, Schedule 40, galvanized steel**] sleeve-type, waterstop assembly for imbedding in concrete slab or wall.

1.4 STACK-SLEEVE FITTINGS

A. Manufacturered, galvanized cast-iron sleeve with integral cast flashing flange, with underdeck clamp.

1.5 SLEEVE-SEAL SYSTEMS

A. Field-assembled, modular sealing-element unit for filling annular space between piping and sleeve.

1. Sealing Elements: Nitrile (Buna N).
2. Pressure Plates: Stainless steel.
3. Connecting Bolts and Nuts: Stainless steel.

1.6 GROUT

A. Nonshrink, factory packaged; ASTM C1107/C1107M, Grade B.

1.7 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, non-sag, plus 25 percent and minus 25 percent movement capability, non-traffic-use, neutral-curing silicone joint sealant.

B. Silicone, S, P, T, NT: Single-component, 25 pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade P, Class 25, Uses T and NT.

C. Silicone Foam: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

1.8 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Exterior Concrete Walls above Grade: Sleeves with waterstops.

1. Piping Smaller than NPS 6 (DN 150): Galvanized Steel pipe sleeves
2. Piping NPS 6 (DN 150) and Larger: Galvanized Steel pipe sleeves

B. Exterior Concrete Walls below Grade: Sleeves with waterstops.

1. Piping Smaller Than NPS 6 (DN 150): Galvanized Steel pipe sleeves with sleeve-seal system.
2. Piping NPS 6 (DN 150) and Larger: Galvanized Steel pipe sleeves with sleeve-seal system.

C. Concrete Slabs-on-Grade: Sleeves with waterstops.

1. Piping Smaller Than NPS 6 (DN 150) : Galvanized Steel pipe sleeves with sleeve-seal system.
2. Piping NPS 6 (DN 150) and Larger: Galvanized Steel pipe sleeves with sleeve-seal system.

D. Concrete Slabs above Grade that are Not Fire Rated nor Smoke Rated: Sleeves with waterstops.

1. Piping Smaller Than NPS 6 (DN 150): Galvanized Steel pipe sleeves.
2. Piping NPS 6 (DN 150) and Larger: Galvanized Steel pipe sleeves.

E. Interior Walls and Partitions that are Not Fire Rated nor Smoke Rated: Sleeves without waterstops.

1. Piping Smaller Than NPS 6 (DN 150): Galvanized Steel pipe sleeves
2. Piping NPS 6 (DN 150) and Larger: Galvanized-steel sheet sleeves.

END OF SECTION 230517

SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

1.1 SUMMARY

A. Section includes:

1. Escutcheons.
2. Floor plates.

1.2 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations, for materials, and installation for escutcheons for HVAC piping, and as per the standards listed below in this section; whichever is more stringent.

1.3 PRODUCTS

A. Escutcheons for New Piping:

1. Piping with Fitting or Sleeve Protruding from Wall: One-piece deep pattern.
2. Chrome-Plated Piping: One-piece cast brass with polished, chrome-plated finish.
3. Insulated Piping: One-piece stamped steel with polished, chrome-plated finish or Split-plate stamped steel, exposed hinge, with polished, chrome-plated finish.
4. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
5. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stamped steel with polished, chrome-plated finish or Split-plate stamped steel, concealed hinge, with polished, chrome-plated finish.
6. Bare Piping in Unfinished Service Spaces: One-piece cast brass or split-casting brass type with polished, chrome-plated finish.
7. Bare Piping in Equipment Rooms: One-piece cast brass with polished, chrome-plated finish, or One-piece stamped steel with polished, chrome-plated finish, or Split-plate, stamped steel, concealed hinge, with polished, chrome-plated finish.

B. Floor Plates: Split-plate stamped steel with concealed hinge.

END OF SECTION 230518

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

1.1 SUSTAINABILITY REQUIREMENTS

A. Comply with the requirements as specified in Section 0181134.14 “Sustainability Design Requirements.”

1.2 PERFORMANCE REQUIREMENTS

A. Pipe hangers and equipment supports designed by Contractor.

B. Seismic-restraint hangers and supports designed by Contractor and approval obtained from authorities having jurisdiction.

1.3 SUBMITTALS

A. Shop Drawings: Signed and sealed by a professional engineer.

1.4 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) for materials, tests, and installation, as listed in the “Saudi Sanitary Code-Plumbing”, SBC 701, and the standards listed below in this section; whichever is more stringent.

C. AWS D1.1/D1.1M.

1.5 COMPONENTS

A. Metal Pipe Hangers and Supports: Carbon steel.

B. Trapeze pipe hangers.

C. Fiberglass pipe hangers.

D. Metal Framing Systems:

1. Manufacturer: MFMA.
2. Material: Carbon steel Coating: None.

E. Fiberglass strut systems.

F. Thermal-Hanger Shield Inserts:

1. For Cold Piping: Cellular glass.

G. Fastener Systems: Powder-actuated fasteners and mechanical-expansion anchors.

H. Pipe Stands: Compact Equipment supports.

I. Outside equipment stands.

END OF SECTION 230529

SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for vibration and seismic controls, as listed in, but not limited to, the “Saudi Building Code-General”, SBC 201, “Saudi Mechanical Code” SBC 501, and “Saudi Fire Code” SBC 801, and the standards listed below in this section; whichever is more stringent.

C. Professional Engineer Qualifications: A professional engineer who is legally registered and qualified to practice in the jurisdiction where the Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of vibration isolation bases and seismic restraints that are similar to those indicated for this Project in material, design, and extent.

D. Manufacturer’s recommendations shall be considered in selection of vibration and seismic restraints. All selection shall be certified by manufacturer.

E. Manufacturer Seismic Qualification Certification: Submit certification that all specified equipment will withstand seismic forces identified in "Performance Requirements" Article below. Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
    b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.2 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Applicable Wind-Restraint Loading Reference: Comply with ASCE/SEI 7-10.
2. Basic Wind Speed (3 second gust): 45 m/s.
3. Risk Category: II as per SBC 201.
4. Exposure Category: D as per SBC 201.
5. .

B. Seismic-Restraint Loading:

1. Applicable Seismic-Restraint Reference: Comply with SBC and ASCE 7-10.
2. Building Site Classification: D.
3. Building importance factor = 1.

4. Design Spectral Response Acceleration at Short Periods (0.2 Second): 5% Critical damping Ss=0.55g.
5. Design Spectral Response Acceleration at Short Periods (1.0 Second): 5% Critical damping S1 =0.13g.

1.3 COMPONENTS

A. Vibration Isolators:

1. Elastomeric Isolation Pads: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area. Material to be oil and water resistant with elastomeric properties.

    a. Sandwich Core Material: Resilient and elastomeric
    b. Surface Pattern: Smooth, ribbed, or waffle pattern.
    c. Infused nonwoven cotton or synthetic fibers.
    d. Load-bearing metal plates adhered to pads.

2. Double-Deflection, Elastomeric Isolation Mounts: Molded, oil-resistant rubber, neoprene, or other elastomeric material.
3. Restrained Elastomeric Isolation Mounts: All-directional isolator with seismic restraints; molded, oil-resistant elastomeric material with cast-ductile-iron or welded-steel housing.
4. Open-Spring Isolators: Freestanding, laterally stable, with not less than 80 percent of the compressed height of the spring at rated load.
5. Housed-Spring Isolators: Freestanding, laterally stable, in two-part telescoping housing.
6. Restrained-Spring Isolators: Freestanding, laterally stable, open-spring isolators with vertical-limit stop restraint.
7. Housed-Restrained-Spring Isolators: Freestanding, steel, open-spring isolators with vertical-limit stop restraint in two-part telescoping housing.
8. Pipe-Riser Resilient Support: All-directional, acoustical pipe anchor.
9. Resilient pipe guides.
10. Air-Spring Isolators: Freestanding, single or multiple, compressed-air bellows.
11. Restrained-Air-Spring Isolators: Freestanding, single or multiple, compressed-air bellows with vertical-limit stop restraint.
12. Elastomeric hangers.
13. Spring Hangers: Combination coil-spring and elastomeric-insert hangers with spring and insert in compression and with vertical-limit stop.

B. Seismic-Restraint Devices:

1. Snubbers: Welded structural-steel shapes and replaceable resilient isolation washers and bushings.
2. Restraint Channel Bracings: Shop- or field-fabricated bracing assemblies.
3. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.
4. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
5. Anchor Bolts: Mechanical type, seismic rated.

C. Vibration Isolation Equipment Bases:

1. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.
2. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for field-applied, cast-in-place concrete.

END OF SECTION 230548

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, and installation for HVAC identification, as listed in, but not limited to, the “Saudi Mechanical Code” SBC 501 and the standards listed below in this section; whichever is more stringent.

C. Quality Standard for Piping Identification: ASME A13.1.

1.2 PRODUCTS

A. Equipment Labels: Plastic.

B. Warning Signs and Labels: 1/8 inch (3.2 mm) thick with fasteners.

C. Pipe Labels: Self-adhesive.

D. Duct Labels: 1/8 inch (3.2 mm) thick with adhesive.

E. Stencils: Aluminum Brass Fiberboard Fiberboard or metal.

F. Valve Tags: aluminum, 0.032-inch (0.8-mm) minimum thickness.

G. Warning Tags: Approximately 4 by 7 inches (100 by 178 mm); brass grommet and wire fasteners.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

1.1 PREINSTALLATION MEETINGS

A. TAB Conference: Conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan, to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1.2 QUALITY ASSURANCE

A. TAB Specialists Qualifications: AABC or TABB certified.

1.3 SUMMARY

A. TAB for the following:

1. Air Systems:
    a. Constant-volume air systems.
    b. Dual-duct systems.
    c. Variable-air-volume systems.
    d. Multizone systems.
2. Fuel oil systems for HVAC.
3. Equipment:
    a. Motors.
    b. Condensing units.
4. Exhaust hoods.
5. Sound tests.
6. Vibration tests.
7. Duct leakage tests verification.
8. Pipe leakage tests verification.
9. UFAD plenum leakage tests verification.
10. HVAC-control system verification.
11. Smoke-control system tests.
12. Stair-pressurization system tests.
13. Elevator-pressurization system tests.

1.4 EXECUTION

A. Tolerances: Plus or minus 10 percent of design values.

B. Inspections: Random checks by TAB firm to verify final TAB report.

C. Additional Tests: Random tests within 90 days of completing TAB to verify balance conditions and seasonal tests.

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, and installation, for duct insulation, as listed in, but not limited to, the “Saudi Energy Conservation Code-”, SBC 601, “Saudi Mechanical Code” SBC 501, and the standards listed below in this section; whichever is more stringent.

C. Surface-Burning Characteristics: Flame-spread index of 25, and smoke-developed index of 50 for insulation installed indoors 75, and smoke-developed index of 150 for insulation installed outdoors; according to ASTM E84.

D. Mockup of each type of duct insulation and finish.

1.2 SUSTAINABILITY REQUIREMENTS

A. Comply with the requirements as specified in Section 0181134.14 “Sustainability Design Requirements.”

1.3 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Mineral-Fiber Board Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.

1. Thermal Conductivity: 0.038W/mK at 20 deg. C (68 deg. F).
2. Density : 48kg/m^3.

F. Mineral-Fiber Blanket Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.

1. Thermal Conductivity: 0.038W/mK at 20 deg. C (68 deg. F).
2. Density : 24kg/m^3.

1.4 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

C. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1.5 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.009 metric perm at 1.09-mm dry film thickness.
2. Service Temperature Range: Minus 29 to plus 82 deg C.
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 0.033 metric perm at 0.8-mm dry film thickness.
2. Service Temperature Range: Minus 46 to plus 104 deg C.
3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.

1.6 FIELD-APPLIED JACKETS

A. General: ASTM C 921, Type 1, maximum moisture vapor transmission 0.02 perms, (measured before factory application or installation), minimum puncture resistance 50 Beach units on all surfaces. Minimum tensile strength, 6.1 N/mm width.

B. Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant, all purpose, kraft paper and aluminum foil (FSK).

C. Aluminum Jacket: Deep corrugated sheets manufactured from aluminum alloy complying with ASTM B 209M , and having an integrally bonded moisture barrier over entire surface in contact with insulation.

1. Finish and Thickness: Stucco embossed finish, 0.6 mm thick for indoor installation and 0.8 mm for outdoor installation unless otherwise noted.

1.7 FIELD QUALITY CONTROL

A. Field Inspections: By Owner-engaged agency.

1.8 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
7. Outdoor, concealed supply and return.

8. Outdoor, exposed supply and return.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

1.9 INDOOR DUCT AND PLENUM APPLICATION SCHEDULE

A. Service: Supply-air ducts.

1. Material: Mineral-fiber blanket.
2. Thickness: 50 mm.
3. Number of Layers: One.
4. Field-Applied Jacket: Foil and paper where concealed; aluminum jacket where exposed to view or in mechanical rooms.
5. Vapor Retarder Required: Yes.

B. Service: Return-air ducts and Exhaust air ducts.

1. Material: Mineral-fiber blanket.
2. Thickness: 50 mm.
3. Number of Layers: One.
4. Field-Applied Jacket: Foil and paper where concealed; aluminum jacket where exposed to view or in mechanical rooms.
5. Vapor Retarder Required: Yes.

C. Service: Outside-air ducts.

1. Material: Mineral-fiber blanket.
2. Thickness: 25 mm.
3. Number of Layers: One.
4. Field-Applied Jacket: Foil and paper where concealed; aluminum jacket where exposed to view or in mechanical rooms.
5. Vapor Retarder Required: No.

1.10 OUTDOOR DUCT AND PLENUM APPLICATION SCHEDULE

A. Service: Supply-air ducts.

1. Material: Mineral-fiber board.
2. Thickness: 50 mm.
3. Number of Layers: One.
4. Field-Applied Jacket: Aluminum.

    a. Aluminum Thickness: 0.8 mm.
    b. Corrugation Dimension: 64 by 16 mm.

5. Vapor Retarder Required: Yes.

B. Service: Return-air ducts and Exhaust-air ducts connected to heat recovery units.

1. Material: Mineral-fiber board.
2. Thickness: 50 mm.
3. Number of Layers: One.
4. Field-Applied Jacket: Aluminum.

    a. Aluminum Thickness: 0.8 mm.
    b. Corrugation Dimension: 64 by 16 mm.

5. Vapor Retarder Required: Yes.

END OF SECTION 230713

SECTION 230923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

1.1 SYSTEM DESCRIPTION

A. System Description: Microprocessor-based monitoring and control including analog/digital conversion and program logic.

B. DDC System: Complete turnkey Building Management System (BMS) with web interface capabilities.

C. Delegated Design: Engage a qualified professional engineer to design DDC system.

D. DDC System Speed:

1. Response Time of Connected I/O:

a. AI Point Values: Two seconds.
b. BI Point Values: Two seconds.
c. AO Points: Two seconds.
d. BO Point Values: Two seconds.

E. Network Bandwidth: 30 percent available spare bandwidth.

F. Future Expandability: Two times total I/O points.

G. Environmental Conditions for equipment:

1. All components shall be IP 2X finger protected to IEC 60529 such that live components cannot be accidentally touched. Interior enclosures shall be, at minimum, IP 54 to IEC 60529 and exterior enclosures shall be weatherproof IP 67 to IEC 60529 unless specifically noted otherwise within these documents.

2. Hazardous Locations: Intrinsically safe or Explosion-proof rating for condition.

H. Electric Power Quality:

1. Power-Line Surges:

a. Protect DDC system products connected to ac power circuits from power-line surges.
b. No fuses for surge protection.
c. Two waveforms:

1) 10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.
2) 8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.

2. Power Conditioning: DDC system products.
3. Ground Fault: Protect products.

I. Backup power source.

J. BMS Products Powered by UPS:

1. Desktop operator workstation.

2. Printer.
3. Server.
4. Gateways.
5. Network Automation Controllers (NAC's)
6. DDC controllers, except application-specific controllers (ASC's).

K. Continuity of operation after electric power interruption for applications with systems and equipment connected to backup power systems.

1.2 SYSTEM COMPONENTS

A. Panel-Mounted, Manual Override Switches:

1. Manual override of control dampers.

1.3 SYSTEM ARCHITECTURE

A. System architecture shall consist of no more than two levels of LANs.

B. The converged data network shall be used for the Management Level whereas dedicated LAN's can be provided at the Automation Level to connect ASC's, factory supplied control panels and other equipment to NAC's

C. Modular and able to expand to not less than two times system size.

D. Perform modifications without having to remove and replace existing network equipment.

E. Number of LANs and associated communication transparent to operator.

F. Independence of any single device for system alarm reporting and control execution.

1.4 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access:

1. Desktop operator workstation with hardwired connection.
2. Portable operator terminal with hardwired connection through LAN port.
3. Portable operator terminal with wireless connection through LAN router.
4. Mobile device with wireless connection through LAN router.
5. Remote connection using outside of system personal computer or mobile device through web access.
6. Remote connection using portable operator workstation and telephone dial-up modem.

B. Operator transparent access to system, regardless of operator means used.

C. Hardwired Network Ports:

1. Each mechanical equipment room.
2. Each different roof level with roof-mounted air-handling units or rooftop units.
3. Control room at Utility Building.

D. Desktop Workstations:

1. Connect to Level one LAN through a communications port directly on LAN.
2. Able to communicate with any device located on any DDC system LAN.

3. Able to communicate, with modems, remotely with any device connected to any DDC system LAN.

E. Mobile Touch Panel:

1. Connect DDC controller through a communications port local to controller.
2. Able to communicate with any DDC system controller that is directly connected with LAN.

F. Critical Alarm Reporting:

1. Operator-selected critical alarms sent by DDC system.
2. Send alarm notification to multiple recipients.
3. Notify recipients by any or all means, including e-mail, text message, and prerecorded phone message to mobile and landline phone numbers.

G. Simultaneous Operator Use: Five simultaneous operators.

1.5 SERVER

A. Rack Mounted.

B. 50% spare processing capabilities (CPU load).

C. 5 years storage capacity.

D. 19” rack with all accessories.

E. I/O cabling.

F. Latest Microsoft Windows Server operating system.

1.6 DESKTOP WORKSTATION

A. Personal computer.

B. Keyboard.

C. Pointing device.

D. Two Flat panel display monitors (23”).

E. Speakers.

F. I/O cabling.

G. Latest Microsoft Windows operating system.

1.7 MOBILE TOUCH PANEL

A. 15” 1024x800 pixels display.

B. True color and capacitive touch screen.

C. Ethernet data port.

D. Wireless Ethernet connection.

E. The display shall have a dimmable backlight .

F. Latest Microsoft Windows operating system.

1.8 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser 64 bit operating system.
2. Capable of operating DOS and Microsoft Windows applications.
3. Database management software.
4. Network communications software manages and controls multiple network communications.
5. Operator interface software includes day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

1. English language.
2. Minimize use of a typewriter-style keyboard.
3. Manual operator sign-off.
4. Programmable automatic sign-off period.
5. Recorded and printed operator sign-on and sign-off activity.
6. Security access.
7. Data segregation.
8. Operators Commands:

    a. Start or stop selected equipment.
    b. Adjust set points.
    c. Add, modify, and delete time programming.
    d. Enable and disable process execution.
    e. Lock and unlock alarm reporting for each point.
    f. Enable and disable totalization for each point.
    g. Enable and disable trending for each point.
    h. Override control loop set points.
    i. Enter temporary override schedules.
    j. Define holiday schedules.
    k. Change time and date.
    l. Enter and modify analog alarm limits.
    m. Enter and modify analog warning limits.
    n. View limits.
    o. Enable and disable demand limiting.
    p. Enable and disable duty cycle.
    q. Display logic programming for each control sequence.

9. Reporting:

    a. General listing of points.
    b. List points currently in alarm.
    c. List of off-line points.
    d. List points currently in override status.
    e. List of disabled points.
    f. List points currently locked out.

g. List of items defined in a "Follow-Up" file.
h. List weekly schedules.
i. List holiday programming.
j. List of limits and deadband.

10. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Graphic interface software.

D. Project-specific graphics.

E. Customizing software.

F. Alarm handling software.

G. Reports and logs.

H. Standard Reports:

1. All I/O: With current status and values.
2. Alarm: All current alarms, except those in alarm lockout.
3. Disabled I/O: All I/O points that are disabled.
4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
6. Logs:

a. Alarm history.
b. System messages.
c. System events.
d. Trends.

I. Custom reports.

J. Tenant override reports.

K. HVAC equipment reports.

L. Project-specific utility reports.

M. Project-specific daily, weekly, monthly and annually energy reports.

N. Project-specific daily, weekly, monthly and annually HVAC system efficiency reports.

O. Project-specific daily, weekly, monthly and annually PUE reports.

P. Weather reports.

Q. Standard trends.

R. Custom trends.

S. Database management software.

1.9 OFFICE APPLICATION SOFTWARE

A. Multiple separate applications using a common platform for all applications and including the following:

1. Database.
2. E-mail.
3. Presentation.
4. Publisher.
5. Spreadsheet.
6. Word processing.

1.10 ENERGY MONITORING SYSTEM

A. Best-in-class cutting-edge smart solution with a history of successful implementation on previous projects, global and available in multiple languages and currencies

B. Web based, accessible by a standard web browser.

C. The software can be accessed by multiple number of users at the same time.

D. Friendly user interface.

E. Modular: the client can select or choose any of the functionalities based on his needs and requirements.

F. The software is scalable and can handle all meters at the project with an expandable database / graphics / point tags for future capacity expansion.

G. The software is hardware independent. Integrate data from the BMS based on a wide range of systems and formats.

H. The software will support customer specific branding requirements such as logos and color schemes.

I. The BMS Energy Management software tool shall achieve the comprehensive energy management requirements throughout the following functions and features:

1. Meter Management:
   The EMS shall help to understand energy baseline use in real time, and shall use industry proven algorithms for data validation to clean, interpolate and manage data from multiple types of meters.
2. Alarm Management:
   The EMS shall generate alarms based on preset thresholds for energy demand, forecast loads and variable price factors, and configure custom rules along with standard alarms for building systems and energy management.
3. Flexible Reporting and Analysis:
   The EMS shall provide comprehensive customizable reports and advanced charting, graphics, and analytics with Web based Reports for facility energy performance.
4. Baseline Management:
   The EMS shall provide a benchmark for each facility against itself or similar facilities, capture performance data and prioritize improvements, and calculate an estimated baseline each day and each hour of the day to analyze actual performance against the estimated baselines.
5. Trending:

The EMS shall be able to forecast potential benefits and verify the energy management strategies.

6. The Energy Management System shall be the best-in-class and cutting-edge smart solution and capable to manage all meters at the project and to be expandable for future capacity expansion.

7. The BMS shall have all the modules to ensure functional and operational Energy Management System (EMS), that might include Reporting, Dashboards, Analytics Module and Digital Billing Module. The EMS architecture shall fully support a multi-vendor environment and be able to integrate with other platforms. The Operator shall be able to monitor the Input points status and override them when necessary. The EMS GUI shall be able to display trended records, both stored and archived. Trend log records shall be displayed in standard engineering units.

1.11 ASHRAE 135 (BACnet) GATEWAYS

A. Gateway Minimum Requirements:

1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.
3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.
4. Includes data sharing read property, data sharing write property, device management dynamic device binding, and device management communication control.
5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

1.12 DDC CONTROLLERS

A. DDC Controller Spare Processing Capacity:

1. Network Controllers: 50 percent.
2. Programmable Application Controllers: 50 percent.
3. Application-Specific Controllers: 50 percent.

B. DDC Controller Spare I/O Point Capacity:

1. Network Controllers: 20 percent of each AI, AO, BI, and BO point connected to controller.
2. Programmable Application Controllers: 20 percent of each AI, AO, BI, and BO point connected to controller.
3. Application-Specific Controllers: 20 percent of each AI, AO, BI, and BO point connected to controller.

C. Input and Output Point Interface:

1. Controller AIs perform analog-to-digital (A-to-D) conversion with a minimum resolution of 12 bits or better to comply with accuracy requirements indicated.
2. Controller AOs perform analog-to-digital (A-to-D) conversion with a minimum resolution of 12 bits or better to comply with accuracy requirements indicated.
3. BIs include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.
4. Controller BOs include relay contact closures or triac outputs for momentary and maintained operation of output devices.

1.13 NETWORK CONTROLLERS

A. BTL listed as BACnet/IP Building Controller (B-BC)

B. Communication: Communicate with other devices on DDC system network.

C. Operator Interface: Equipped with a service communications port for connection to a portable operator's workstation or mobile device.

D. Local keypad and display.

1.14 PROGRAMMABLE APPLICATION CONTROLLERS

A. BTL listed as BACnet/IP Advanced Application Controller (B-AAC)

B. Communication: Communicate with other devices on network.

C. Operator Interface: Equipped with a service communications port for connection to a portable operator's workstation or mobile device.

D. Local keypad and display.

E. One DDC shall handle a maximum of one AHU, in addition to monitoring and control points of other equipment.

1.15 APPLICATION-SPECIFIC CONTROLLERS

A. BTL listed as BACnet MS/TP Application Specific Controller (B-ASC)

B. Communication: Communicate with other devices on network.

C. Microprocessor-based controllers.

1.16 CONTROLLER SOFTWARE

A. General Controller Software Requirements: I/O points shall be identified by up to 30 character point name and up to 16 character point descriptor. Same names shall be used at operator workstations.

B. Security: Individual security passwords and user names.

C. Scheduling:

1. Weekly Schedule: Include separate schedules for each day of week.
2. Exception Schedules: Operator able to designate any day of the year as an exception schedule.
3. Holiday Schedules: Operator able to define up to 99 special or holiday schedules.

D. System Coordination: Operator able to group equipment based on function and location.

E. Binary Alarms: Alarm based on operator-specified state.

F. Analog Alarms: Both high and low alarm limits and able to be automatically and manually disabled.

G. Logical Alarms: Alarm based on several conditions, such as mismatch between damper position and command, simultaneous operation of cooling and heating coils, etc.

H. Alarm Reporting: Able to determine action to be taken in event of an alarm, routed to appropriate operator workstations based on time and other conditions, and able to start programs, print, be logged in event log, generate custom messages, and display graphics.

I. Remote Communication: Able to dial out in the event of an alarm.

J. Electric power demand limiting.

K. Maintenance Management: Monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.

L. Sequencing: Application software to properly sequence AC units, and other applicable HVAC equipment.

M. Control Loops

1. Support Control Loops:

a. Two-position (on/off, open/close, slow/fast) control.
b. Proportional control.
c. Proportional plus integral (PI) control.
d. Proportional plus integral plus derivative (PID) control.
e. Adaptive (automatic tuning).

N. Staggered-start applications.

O. Energy calculations.

P. Anti-short cycling.

Q. On and off control with differential.

R. Run-time totalization.

S. Energy saving algorithms including trim and respond logic for VAV boxes

1.17 RELAYS

A. General-purpose relays.

B. Multifunction time-delay relays.

C. Latching relays.

D. Current sensing relay.

E. Combination on-off status sensor and on-off relay.

1.18 ELECTRICAL POWER DEVICES

A. Transformers.

B. Power-line conditioner.

C. Transient voltage suppression and high-frequency noise filter unit.

D. DC power supply.

1.19 PIPING AND TUBING

A. Pneumatic, and Pressure Instrument Signal Air, Tubing and Piping:

1. Copper tubing.
2. Copper tubing connectors and fittings.
3. Galvanized-steel piping.
4. Polyethylene tubing.
5. Polyethylene tubing connectors and fittings.

B. Process Tubing:

1. Copper tubing.
2. Copper tubing connectors and fittings.
3. Stainless steel tubing.
4. Stainless steel tubing connectors and fittings.

1.20 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.

B. Single Twisted Shielded Instrumentation Cable above 24 V.

C. Single Twisted Shielded Instrumentation Cable 24 V and Less.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

E. All cables shall be LS0H and wire section shall be minimum 18AWG.

1.21 ACCESSORIES

A. Pressure electric switches.

B. Damper blade limit switches.

C. Instrument enclosures.

D. Manual valves.

1. Needle type.
2. Ball type.

E. Wall-mounted cabinets.

1.22 IDENTIFICATION

A. Instrument Air Pipe and Tubing: Engraved tags with the service and pressure range.

B. Control Equipment, Instruments, and Control Devices: Engraved tags.

C. Valve tags: Brass tags and brass chains attached to valve.

D. Raceway and Boxes: Painted labels on cover plates.

E. Equipment Warning Labels: Acrylic label with pressure-sensitive adhesive back and peel-off protective jacket.

1.23 SOURCE QUALITY CONTROL

A. Testing Agency: Contractor engaged.

1.24 FIELD QUALITY CONTROL

A. Testing Agency: Contractor engaged.

END OF SECTION 230923

SECTION 230923.11 - CONTROL VALVES

1.1 BALL-STYLE CONTROL VALVES

A. Ball Control Valves NPS 2 (DN 50) and Smaller:

1. Body: Forged brass, nickel plated, and with threaded ends.
2. Ball: Chrome-plated brass.
3. Stem and Stem Extension: Chrome-plated brass, blowout-proof design.
4. Flow Characteristic: Equal percentage.

1.2 GLOBE-STYLE CONTROL VALVES

A. Two-Way Globe Control Valves NPS 2 (DN 50) and Smaller:

1. Globe Style: Single port.
2. Body: Cast bronze or forged brass.
3. End Connections: Threaded.
4. Bonnet: Screwed.
5. Plug, Seat, and Stem: Brass or stainless steel.
6. Equal percentage flow characteristic.

B. Two-Way Globe Control Valves NPS 2-1/2 to NPS 6 (DN 65 to DN 150):

1. Globe Style: Single port.
2. Body: Cast iron.
3. End Connections: Flanged.
4. Bonnet: Bolted.
5. Flow Characteristic: Equal percentage for coils application and Linear for bypass control valves.

1.3 SOLENOID VALVES

A. Description:

1. Body: Brass or stainless steel.
2. Seats and Discs: NBR or PTFE.

1.4 SELF-CONTAINED TEMPERATURE REGULATING VALVE

A. Description:

1. Self-contained and self-operated temperature regulating valve.
2. Body: Carbon steel.
3. Trim and Seats: Stainless steel.
4. Yoke: Cast iron.
5. Actuator: Stainless steel.
6. Capillary, Bulb, and Armor: Stainless steel.
7. Thermowell: Stainless steel.
8. Flow Control: From 5 to 100 percent of rated capacity.

1.5 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

A. Type: Motor operated, with or without gears, electric and electronic.

B. Voltage: 24-V ac.

C. Field adjustable.

D. Two-Position Actuators: Single direction, spring return or reversing type.

E. Modulating Actuators:

1. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:

a. Three point, tristate, or floating point.
b. Proportional.
c. Pulse width modulation (PWM).
d. Programmable multi-function.

F. Position Feedback:

1. Two-position actuators with remote monitoring.
2. Modulating actuators with remote monitoring.

G. Fail-safe.

H. Integral overload protection.

I. Valve attachment.

J. Stroke Time: Fully closed to fully open within 90 seconds.

K. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

END OF SECTION 230923.11

SECTION 230923.12 - CONTROL DAMPERS

1.1 RECTANGULAR CONTROL DAMPERS

A. Rectangular Dampers with Aluminum Airfoil Blades:

1. Performance:

a. Leakage: 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1-in. wg (250-Pa) differential static pressure.
b. Pressure Drop: 0.05-in. wg (12.5 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper.
c. Velocity: Up to 6000 fpm (30 m/s).
d. Temperature: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

2. Construction:

a. Frame and Blades: Extruded aluminum.
b. Blade Seal: Extruded silicone, vinyl, or plastic composite.
c. Jamb Seal: Stainless steel, compression type.
d. Axles: Plated or stainless steel.
e. Bearings: Molded synthetic or stainless steel.
f. Linkage: Aluminum and plated or stainless steel with stainless-steel hardware.
g. Additional corrosion protection for corrosive environments.

3. Airflow Measurement Accuracy: Within 5 percent of the actual flow rate.
4. Airflow Control:

a. Suitable for 150 to 2000 fpm (0.8 to 10 m/s).
b. Ambient Operating Temperature Range: Minus 40 to plus 140 deg F (Minus 40 to plus 60 deg C).
c. Ambient Operating Humidity Range:5 to 95 percent relative humidity, non-condensing.

B. Rectangular Dampers with Steel Airfoil Blades:

1. Performance:

a. Leakage: 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1-in. wg (250-Pa) differential static pressure.
b. Pressure Drop: 0.06-in. wg (15 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper.
c. Velocity: Up to 6000 fpm (30 m/s).
d. Temperature: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

2. Construction:

a. Frame and Blades: Hollow airfoil, galvanized steel.
b. Blade Seal: Extruded silicone, vinyl, or plastic composite.
c. Jamb Seal: Stainless steel, compression type.
d. Axles: Plated or stainless steel.
e. Bearings: Stainless steel.
f. Linkage: Aluminum and plated or stainless steel with stainless-steel hardware.
g. Additional corrosion protection for corrosive environments.

C. Industrial-Duty Rectangular Dampers with Steel Airfoil Blades:

1. Performance:

    a. Leakage: 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1-in. wg (250-Pa) differential static pressure.
    b. Pressure Drop: 0.06-in. wg (15 Pa) at 2000 fpm (10 m/s) across a 48-by-48-inch (1200-by-1200-mm) damper.
    c. Velocity: Up to 4000 fpm (20 m/s).
    d. Temperature: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).

2. Construction:

    a. Frame: Galvanized or stainless steel.
    b. Blades: Hollow, airfoil, galvanized or stainless steel.
    c. Blade Seal: EPDM or extruded silicone.
    d. Jamb Seal: Stainless steel, double compression type.
    e. Axles: Plated or stainless steel.
    f. Bearings: Stainless steel.
    g. Linkage: Plated or stainless steel with stainless-steel hardware.

D. Rectangular Dampers with Aluminum Flat Blades:

1. Performance:

    a. Leakage: 3.2 cfm/sq. ft. (16.2 L/s per sq. m) against 1-in. wg (250-Pa) differential static pressure.
    b. Pressure Drop: 0.07-in. wg (17.5 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper.
    c. Velocity: Up to 2000 fpm (10 m/s).
    d. Temperature: Minus 50 to plus 250 deg F (Minus 46 to plus 121 deg C).

2. Construction:

    a. Frame and Blades: Extruded aluminum.
    b. Blade Seal: Extruded silicone, vinyl or plastic composite.
    c. Jamb Seal: Stainless steel, compression type.
    d. Axles: Plated or stainless steel.
    e. Linkage: Plated or stainless steel.
    f. Additional corrosion protection for corrosive environments.

E. Rectangular Dampers with Steel Flat Blades:

1. Performance:

    a. Leakage: 4.8 cfm/sq. ft. (24.3 L/s per sq. m) against 1-in. wg (250-Pa) differential static pressure.
    b. Pressure Drop: 0.1-in. wg (25 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper.
    c. Velocity: Up to 1500 fpm (7.6 m/s).
    d. Temperature: Minus 25 to plus 180 deg F (Minus 32 to plus 82 deg C).

2. Construction:

    a. Frame and Blades: Galvanized or stainless steel.
    b. Blade Seal: PVC-coated polyester.
    c. Jamb Seal: Stainless steel, compression type.
    d. Axles: Plated or stainless steel.
    e. Linkage: Plated or stainless steel.

F. Insulated Rectangular Dampers:

1. Performance:

a. Leakage: 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1-in. wg (250-Pa) differential static pressure and 4.9 cfm/sq. ft. (25 L/s per sq. m) against 4-in. wg (1000-Pa) differential static pressure at minus 40 deg F (minus 40 deg C).
b. Pressure Drop: 0.1-in. wg (25 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper.
c. Velocity: Up to 4000 fpm (20 m/s).
d. Temperature: Minus 100 to plus 185 deg F (Minus 73 to plus 85 deg C).

2. Construction:

a. Frame and Blades: Extruded aluminum.
b. Seals: Flexible silicone.
c. Axles: Plated or stainless steel.
d. Bearings: Celcon inner bearing fixed to axle, polycarbonate outer bearing inserted in the frame.
e. Linkage: Aluminum and plated or stainless steel.
f. Additional corrosion protection for corrosive environments.

1.2 ROUND CONTROL DAMPERS

A. Round Dampers, Sleeve Type:

1. Performance:

a. Leakage: 0.15 cfm/in. (0.0028 L/s per mm) of perimeter blade at 4-in. wg (1000-Pa) differential static pressure.
b. Pressure Drop: 0.02-in. wg (5 Pa) at 1500 fpm (7.6 m/s) across a 12-inch (300-mm) damper.
c. Velocity: Up to 4000 fpm (20 m/s).
d. Temperature: Minus 25 to plus 200 deg F (Minus 32 to plus 93 deg C).
e. Pressure Rating: 8-in. wg (2000 Pa) for sizes through 12 inches (300 mm), 6-in. wg (1500 Pa) for larger sizes.

2. Construction:

a. Frame and Blades: Galvanized or stainless steel, with double-thick blades.
b. Blade Seal: Polyethylene foam.
c. Axle: Plated or stainless steel.
d. Bearings: Stainless steel.

B. Round Dampers, Flanged Type:

1. Performance:

a. Leakage: 0.15 cfm/in. (0.0028 L/s per mm) of perimeter blade at 4-in. wg (1000-Pa) differential static pressure.
b. Pressure Drop: 0.03-in. wg (7.5 Pa) at 1500 fpm (7.6 m/s) across a 12-inch (300-mm) damper.
c. Velocity: Up to 4000 fpm (20 m/s).
d. Temperature: Minus 25 to plus 250 deg F (Minus 32 to plus 121 deg C).
e. Pressure Rating: 8-in. wg (2000 Pa) for sizes through 36 inches (900 mm) in diameter, 6-in. wg (1500 Pa) for larger sizes.

2. Construction:

    a. Frame and Blades: Galvanized or stainless steel
    b. Blade Stop: Full circumference, located in airstream; galvanized or stainless steel bar.
    c. Blade Seal: Neoprene.
    d. Axle: Plated or stainless steel.
    e. Bearings: Stainless steel.

1.3 ELECTRIC AND ELECTRONIC ACTUATORS

A. Type: Motor operated, electric and electronic.

B. Voltage: 24 V or 120 V.

C. Field adjustable.

D. Two-Position Actuators: Single direction, spring return or reversing type.

E. Modulating Actuators: Capable of stopping at all points across full range, and starting in either direction from any point in range.

F. Position Feedback:

1. Two-position actuators with remote monitoring.
2. Modulating actuators with remote monitoring.
3. Position indicator and graduated scale.

G. Fail-safe.

H. Integral overload protection.

I. Stroke Time:

1. Fully closed to fully open within 60 seconds.

J. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

END OF SECTION 230923.12

SECTION 230923.13 - ENERGY METERS

1.1 ELECTRIC POWER METERS

A. Fully Programmable Multifunction Electric Power Meter:

1. Voltage Inputs: Three voltage inputs.
2. Current Inputs: Three 5-A nominal (10-A full-scale) current inputs.
3. Power Supply: 95- to 240-V ac (within 10 percent) at 47 to 440 Hz, 110- to 300-V dc, or 20- to 60-V dc power source; with maximum load of 12 W.
4. On-board I/O.
5. Provisions for future external I/O.
6. Front-panel display.
7. Memory to store setup data, time-stamped event log, and two programmable data recorders.
8. Instrument:

    a. Display Web pages.
    b. Automatically e-mail alarm notifications or scheduled system status updates.
    c. Data logs sent on an event-driven or scheduled basis.
    d. Accommodate high-speed Modbus TCP communications when connected to Ethernet port.
    e. Measure and calculate the following information at one-second intervals:

        1) Voltage line-to-neutral and line-to-line for each phase and average of all three phases.
        2) Percent voltage unbalance.
        3) Current for each phase and average of three phases.
        4) Percent current unbalance.
        5) kW for each phase and total of three phases.
        6) kVAR for each phase and total of three phases.
        7) kVA for each phase and total of three phases.
        8) kWh for total of three phases.
        9) kVARh for total of three phases.
        10) kVAh for total of three phases.
        11) Power factor for each phase and total of three phases.
        12) Frequency.
        13) Harmonic distortion.
        14) K-Factor calculations of the first 15 harmonics for all current inputs.

9. Operator interface features as follows:

    a. Thermal demand calculations for any parameter.
    b. Sliding window demands for any parameter.
    c. Predicted Demand calculations of sliding window demand parameters.
    d. Minimum value for any measured parameter.
    e. Maximum value for any measured parameter.
    f. Derived values for any combination of measured or calculated parameter.
    g. Support direct display of all parameters on the front panel or remote display in user-programmable groups, using plain language labels. Simultaneous access to all parameters available through any communication port.
    h. Field programmable.
    i. Periodic or non-periodic schedules for up to two years.
    j. Alarming and set-point control.

B. Multifunction Electric Power Meter:

1. Voltage Inputs: Three voltage inputs.

2. Current Inputs: Three 5-A nominal (6-A full-scale) current inputs.
3. Power Supply: 100- to 240-V ac (within 10 percent) at 50 to 60 Hz, 110- to 300-V dc, or 20- to 60-V dc power source; with maximum load of 15 W.
4. Onboard I/O.
5. Memory: Store setup data and accumulated energy values.
6. Instrument:

    a. Voltage line-to-neutral and line-to-line for each phase and average of three phases.
    b. Current for each phase and average of three phases.
    c. Peak current demand.
    d. Neutral current.
    e. Power (kW).
    f. Peak power demand (kW).
    g. Energy (kWh) import/export.
    h. Power factor total.
    i. Frequency.

7. Field Programmable Operator Interface:

    a. Basic parameters.
    b. Customized configurations of all operating parameters.
    c. User ID and password.
    d. Programming through the front panel is secured by password.
    e. Digital outputs support pulse output relay operation for kWh total, kWh imported, kWh exported, kVARh total, kVARh imported, kVARh exported, and kVAh values.

END OF SECTION 230923.13

SECTION 230923.14 - FLOW INSTRUMENTS

1.1 AIRFLOW MEASUREMENT STATIONS AND SENSORS

A. Pitot-Tube Airflow Sensor Station: Multiple total- and static-pressure sensors.

B. Copper or Anodized Aluminum Pitot-Tube Fan Inlet Airflow Traverse Sensor: Traverse manifold for mounting in fan inlets.

C. Stainless-Steel Pitot-Tube Fan Inlet Airflow Traverse Sensor: Traverse manifold for mounting in fan inlets.

D. Piezometer Ring Fan Inlet Airflow Sensor: Integral to fan inlet cones with multiple pressure sensor points.

E. Thermal Airflow Measurement Stations: One or more sensor probes and a remotely mounted microprocessor-based transmitter.

1.2 AIRFLOW SWITCHES

A. Polymer Film Sail Switch: Polyester film sail encasing a wire frame.

B. Stainless-steel single vane switch.

1.3 AIRFLOW TRANSMITTERS

A. Airflow transmitter with 0.10 percent accuracy and auto-zero feature.

1. Accuracy: Within 0.10 percent of natural span.
2. Repeatability: Within 0.15 percent of calibrated span.
3. Linearity: Within 0.2 percent of calibrated span.
4. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.
5. Integral digital LED or digital display.

B. Airflow transmitters with 0.25 percent accuracy and auto-zero feature.

1. Calibrated Span: Field adjustable, minus 40 percent of the range.
2. Accuracy: Within 0.25 percent of natural span.
3. Repeatability: Within 0.15 percent of calibrated span.
4. Linearity: Within 0.2 percent of calibrated span.
5. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.
6. Integral digital display.

C. Pressure differential transmitters for airflow measurement.

1. Accuracy: Within 1 percent of the full-scale range.
2. Hysteresis: Within 0.10 percent of full scale.
3. Repeatability: Within 0.05 percent of full scale.
4. Stability: Within 1 percent of span per year.
5. Overpressure: 10 psig (69 kPa).
6. Temperature Limits: Zero to 150 deg F (Minus 18 to plus 66 deg C).
7. Compensate Temperature Limits: 40 to 150 deg F (4 to 66 deg C).
8. Thermal Effects: 0.033 percent of full scale per degree F.
9. Shock and vibration resistant.

10. Display: Four-digit digital with minimum 0.4-inch- (10-mm-) high numeric characters.
11. Operator Interface: Zero and span adjustments located behind cover.

D. Pressure differential indicating transmitter, switch, and controller for airflow measurement.

1. Accuracy including hysteresis and repeatability:

a. Ranges Less than 5-Inch wg (1250 Pa): Within 1 percent.
b. Other Ranges: Within 0.5 percent at 77 deg F (25 deg C).

2. Stability: Within 1 percent per year.
3. Response Time: 250 ms.
4. Overpressure:

a. Ranges Less than 50-Inch wg (12.5 kPa): 5 psi (34.5 kPa).
b. Range of 100-Inch wg (25 kPa): 9 psi (62 kPa).

5. Temperature Limits: 32 to 140 deg F (Zero to 60 deg C).
6. Thermal Effects: 0.020 percent per deg F (deg C).
7. Warm-up Period: One hour.
8. Display: Four-digit digital, with minimum 0.4-inch- (10-mm-) high alphanumeric characters.
9. Display: Two LEDs for set point and two LEDs for alarm status.
10. Operator Interface:

a. Set-point adjustment through keypad on face of instrument.
b. Zero and span adjustments accessible through menu.
c. Programming through keypad.

1.4 LIQUID FLOW METERS

A. In-line Body Electromagnetic Flow Meter:

1. Accuracy for Velocities between 3.3 and 33 fps (1 and 10 m/s): Within 0.2 percent of reading.
2. Accuracy for Velocities between 1.0 and 3.3 fps (0.3 and 1 m/s): Within 0.75 percent of reading.
3. Accuracy for Velocities Less than 1.0 fps (0.3 m/s): Within 0.0075 fps (0.0023 m/s).
4. Ambient Temperature: Minus 4 to plus 140 deg F (Minus 20 to plus 60 deg C).
5. Process Temperature: Minus 4 to 212 deg F (Minus 20 to plus 100 deg C).
6. Digital Output Signal: M-bus.
7. Operator Interface:

a. Keypad.
b. Digital Display: Multiple-line digital display of alphanumerical characters.
c. LED for normal and alarm operation.

1.5 LIQUID FLOW SWITCHES

A. Liquid Flow Switch (Bellows Type): Field-adjustable four-vane combinations or set-point adjustment screw.

1. Flow Rate Actuation and De-actuation: Varies with vane combination and set-point adjustment.
2. Pressure Limit: 145 psig (1000 kPa).
3. Temperature Limit: 230 deg F (110 deg C).

4. Electrical Rating: 10 A resistive, 3 A conductive at 250-V ac.
5. Switch Type: SPDT snap switch.

1.6 LIQUID FLOW TRANSMITTERS

A. Pressure Differential Transmitter with 0.07 Percent Accuracy for Flow Measurement in Hazardous Environment:

1. Range: Minus 250- to 250-inch wg (Minus 62.5 to 62.5 kPa).
2. Span: Field adjustable.
3. Minimum Span: 2.5-inch wg (500 Pa).
4. Accuracy: Within 0.07 percent of span or better.
5. Stability: Within 0.125 percent of upper range limit for 5 years.
6. Overpressure Limits: 3626 psig (25000 kPa).
7. Process Temperature Limits: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
8. Ambient Temperature Limits: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
9. Temperature Effect: Within 0.025 percent of upper range limit plus 0.125 percent of span.
10. Shock and vibration shall not harm the transmitter.
11. Display: Five-digit, two-line digital display with 0.4 inch (10 mm) high alphanumeric characters.
12. Five-valve manifold.

B. Liquid Pressure Differential Transmitter for Flow Measurement:

1. Range: Approximately 2 times the set point.
2. Span: Adjustable plus or minus 1 mA, non-interactive.
3. Accuracy: Within 0.25 percent of full scale.
4. Maximum Operating Pressure: 2.5 times range.
5. Temperature Limits: Zero to 175 deg F (Minus 18 to plus 79 deg C).
6. Compensate Temperature Limits: 30 to 150 deg F (Minus 1 to plus 66 deg C).
7. Thermal Effects: 0.02 percent of full scale per degree F.
8. Response Time: 30 to 50 ms.
9. Shock and vibration resistant.

END OF SECTION 230923.14

SECTION 230923.16 - GAS INSTRUMENTS

1.1 SINGLE-POINT HYDROGEN MONITORING SYSTEM

A. Performance:

1. Range: Full scale, zero to 100 percent LEL.
2. Accuracy / Repeatability: ±3% LEL.
3. Approval: ATEX.
4. Step Change Response Time: Within 30 seconds.

B. Visual Display: Four-digit LED or backlight LCD display visible from front face of enclosure.

C. Audible Alarm: Audible horn when an alarm condition occurs.

D. Operator Interface:

1. Door audible alarm acknowledge switch.
2. Operating Modes and Parameters Selection: Programming and selection via internal push buttons and jumpers.

E. Output Signal:

1. Relays.
2. Analog Output or Digital Communication.

F. Sensor: Catalytic bead.

G. Installation Height: 0.3m below ceiling level

END OF SECTION 230923.16

SECTION 230923.17 - LEVEL INSTRUMENTS

1.1 LEVEL SWITCHES

A. Liquid-Level Switch (Magnetic Type with Float): Float arm with hinge design limits vertical movement to prevent sticking.

1. Level Actuation and De-Actuation: 0.75-inch (20-mm) deadband.
2. Body Pressure Limit: 1000 psig (6895kPa) for brass body; 2000 psig (13790 kPa) for Type 316 stainless-steel body.
3. Float Pressure Limit: 150 psig (1034 kPa).
4. Temperature Range: Minus 4 to 275 deg F (Minus 20 to 135 deg C).
5. Electrical Rating: 10 A at 125/250-V ac.
6. Switch Type: SPDT snap switch.

B. Electrode-Type Liquid-Level Switches: Conductivity technology, dual-point level settings, and adjustable sensitivity.

1. Pressure Limit: 30 psig (207 kPa).
2. Temperature Limit: 212 deg F (100 deg C).
3. Power Supply: 120-V ac, 50 or 60 Hz.
4. Electrical Rating: 5 A at 240-V ac.
5. Switch Type: SPDT snap switch.

C. RF Admittance-Type Liquid-Level Switches: Capacitive technology with eight selectable settings.

1. Pressure Limit: 365 psig (2517 kPa).
2. Ambient Temperature Range: Minus 40 to 185 deg F (Minus 40 to 85 deg C).
3. Process Temperature Range: Minus 40 to 250 deg F (Minus 40 to 121 deg C).
4. Universal Power Supply: 12- to 240-V ac and dc.
5. Electrical Rating: 8 A at 120- and 240-V ac.
6. Switch Type: SPDT snap switch, selectable for normally open or closed operation.
7. Response Time: 0.2 seconds.
8. Time Delay: Adjustable, zero to 60 seconds.

D. Drain Pan Leak-Detection Float Switches, Inline Type: Float switch for direct mounting onto primary or secondary drain pan outlet, or for inline mounting in drainline pipe, to detect drain pan pre-overflow condition and trigger equipment shutdown.

1. Mechanical switch and float valve.
2. Switch cap assembly to be removable to permit access for cleaning and clearing of clogs.
3. Schedule 40 PVC housing.
4. Alarm Action: Equipment shutdown via minimum 72-inch (1.8-m) 18 AWG cables suitable for 24 VAC Class 2 circuit.
5. Standard: UL 508 listed.

E. Drain Pan Leak-Detection Float Switches, Right-Angle Type: L-shaped float switch for direct mounting onto secondary drain pan outlet to detect drain pan pre-overflow condition and trigger equipment shutdown.

1. Mechanical switch and float valve.
2. Switch and cap assembly to be removable to permit access for cleaning and clearing of clogs.
3. Schedule 40 PVC housing.
4. Alarm Action: Equipment shutdown via pre-wired 72-inch (1.8-m) 18 AWG cables suitable for 24 VAC Class 2 circuit.
5. Standard: UL 508 listed.

F. Drain Pan Leak-Detection Float Switches, In-Pan Type: Float switch for direct mounting in primary drain pan to detect drain pan pre-overflow condition and trigger equipment shutdown.

1. Mechanical switch and float valve, in sealed waterproof housing.
2. Corrosion-resistant clip to position and secure float switch to side of drain pan.
3. Alarm Action: Equipment shutdown via pre-wired 72-inch (1.8-m) 18 AWG cables suitable for 24 VAC Class 2 circuit.
4. Standard: UL 508 listed.

1.2 LEVEL TRANSMITTERS

A. RF Admittance-Type Liquid-Level Sensor and Transmitter: Electronic unit, sensing element, connecting cable.

1. Sensor: Stainless steel.
2. Calibrated Range: At least 20 percent beyond high- and low-level set point and alarm levels.
3. Accuracy: Within 1 percent of calibrated range.
4. Two wire, loop powered.
5. Supply Voltage: 11.5 to 50-V dc.
6. Maximum Load: 625 ohms at 24-V dc.
7. Output Signal: 4 to 20 mA dc.
8. Response Time: 0.5 to 30 seconds, adjustable.
9. Temperature Range: 32 to 165 deg F (0 to 74 deg C).
10. Zero and Span Adjustments: Non-interacting.
11. Visual Indication: Continuous digital display of level.
12. Field-changeable failsafe condition and phasing in event measurement requires changes to optimize level reading.
13. Free from effects of radio frequency interference.
14. Free from harmful effects of static electricity on sensing element with discharges of up to 10 A without damage.
15. Adjustable time delay (signal dampening).

END OF SECTION 230923.17

SECTION 230923.18 – LEAK DETECTION INSTRUMENTS

1.1 LEAK-DETECTION SWITCHES

A. Cable-Type, Leak-Detection Switches:

1. Power and alarm LEDs.
2. Alarm test switch.
3. Continuous tape integrity self check.
4. Service: Fuel.
5. Switch Type: DPDT.
6. Field Power: 24-V ac or 24- to 30-V dc.

END OF SECTION 230923.18

SECTION 230923.19 - MOISTURE INSTRUMENTS

1.1 MOISTURE SENSORS AND TRANSMITTERS

A. Sensors and Transmitters with Digital Display:

1. Accuracy including non-linearity, hysteresis, and repeatability: Within 3 percent from zero to 90 percent relative humidity and within 5 percent from 90 to 100 percent relative humidity between 60 to 77 deg F (16 to 25 deg C).
2. Relative Humidity Range: Zero to 100 percent.
3. Factory calibrated and NIST traceable with certificate included.

B. Sensor and Transmitter without Display:

1. Accuracy including non-linearity, hysteresis, and repeatability: Within 3 percent from zero to 90 percent relative humidity and within 5 percent from 90 to 95 percent relative humidity at 68 deg F (20 deg C).
2. Relative Humidity Range:

    a. Duct: Zero to 100 percent.
    b. Space: Zero to 95 percent relative.

3. Factory calibrated and NIST traceable with certificate included.

C. Sensor and Transmitter without Display:

1. Relative Humidity Range: Zero to 100 percent.
2. Accuracy: Within 3 percent.
3. Operating Temperatures: Minus 30 to 130 deg F (Minus 1 to 54 deg C).
4. Hysteresis: Within 1 percent.

D. Combination Humidity and Temperature Sensor and Transmitter with Display: Digital display, keypad user interface, installation hardware, interconnecting sensor cabling, installation instructions, and operating manual.

1. Alphanumeric display of the following on the face of the enclosure:

    a. Percent relative humidity.
    b. Absolute humidity.
    c. Mixing ratio.
    d. Dry-bulb temperature.
    e. Wet-bulb temperature.
    f. Dew point temperature.
    g. Enthalpy.

2. Visual display of measurement trends, and minimum and maximum values over a one-year period.
3. Three Analog Outputs: 4 to 20 mA or zero to 10-V dc for each output.
4. Temperature Sensor:

    a. Minus 40 to 140 deg F (Minus 40 to 60 deg C).
    b. Within 0.5 deg F (0.3 deg C) accuracy over 50 to 100 deg F (10 to 38 deg C) and within 1 deg F (0.6 deg C) over the remainder of the range.

5. Humidity Sensor:

a. Zero to 100 percent.
b. Response time in still air within 40 seconds.
c. Accuracy including non-linearity, hysteresis, and repeatability:

1) For Temperature Between 59 and 77 Deg F (15 to 25 Deg C) and Relative Humidity between Zero and 90 Percent: Within 1 percent.
2) For Temperature between 59 and 77 Deg F (15 to 25 Deg C) and Relative Humidity between 90 and 100 Percent: Within 1.7 percent.
3) For Temperature between Minus 4 and 104 Deg F (Minus 20 to 40 Deg C): Within 1 percent plus 0.008 times relative humidity reading.
4) For Temperature between Minus 40 and 356 Deg F (Minus 40 to 180 Deg C): Within 1.5 percent plus 0.015 times the relative humidity reading.

END OF SECTION 230923.19

SECTION 230923.21 - MOTION INSTRUMENTS

1.1 INDOOR MOTION SENSORS

A. PIR Type: Ceiling mounting; detect occupancy by sensing heat and movement.

B. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing reflected ultrasonic energy.

C. Dual-Technology Type: Ceiling mounting; combination PIR and ultrasonic detection.

1.2 SWITCHBOX-MOUNTED MOTION SENSORS

A. Wall-Switch Sensor Tag WS1:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft. (84 sq. m)
2. Ambient-light override.
3. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
4. Adaptive Technology: Self-adjusting circuitry.

B. Wall-Switch Sensor Tag WS2:

1. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).
2. Sensing Technology: PIR.
3. Ambient-light override.
4. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
5. Adaptive Technology: Self-adjusting circuitry.

END OF SECTION 230923.21

SECTION 230923.22 - POSITION INSTRUMENTS

1.1 POSITION LIMIT SWITCHES

A. Description: Type of actuating head (plunger, roller lever, or rod) to suit application.

1. Life expectancy: 30 million mechanical operations and 750,000 electrical operations.
2. Operating Frequency: 300 mechanical operations per minute and 30 electrical operations per minute.
3. Voltage: 125-, 250-, 480-, and 600-V ac or 8-, 12-, 14-, 24-, 30-, 48-, 125-, and 250-V dc, as required by application.
4. Temperature Rise: 50 deg C.
5. Ambient Temperature: 14 to 175 deg F (Minus 10 to 79 deg C).
6. Ambient Relative Humidity: 35 to 95 percent.

END OF SECTION 230923.22

SECTION 230923.23 - PRESSURE INSTRUMENTS

1.1 AIR-PRESSURE SENSORS

A. Duct Insertion Static Pressure Sensor: Four radial holes of 0.04-inch (1-mm) diameter.

1. Brass or stainless-steel construction.
2. Suitable for flat oval, rectangular, and round duct configurations.

B. Duct Insertion Static Pressure Sensor: Probe with two opposing orifices designed to reduce error-associated air velocity.

1. Sensor made of aluminum alloy or stainless steel.
2. Mounting flange suitable for flat oval, rectangular, and round duct configurations.
3. Pressure Rating: 10 psig (69 kPa).

C. Duct Traverse Static Pressure Sensor: At least one pickup point every 6 inches (150mm) along length of sensor.

1. Sensor made of 18-gage extruded and anodized aluminum.
2. Accuracy within 1 percent of actual operating static pressure.
3. Suitable for velocities of 100 to 10000 fpm (0.51 to 51 m/s) and temperatures of up to 200 deg F (93 deg C).
4. Sensor air resistance less than 0.1 times the velocity pressure at probe-operating velocity.
5. Suitable for flat oval, rectangular, and round duct configurations.

1.2 AIR-PRESSURE SWITCHES

A. Air-Pressure Differential Switch: Diaphragm operated to actuate an SPDT snap switch.

1. Fan safety shutdown applications: Switch with manual reset.

B. Air-Pressure Differential Switch with Set-Point Indicator: Diaphragm operated to actuate an SPDT snap switch.

C. Air-Pressure Differential Switch with Dual Scale Adjustable Set Point: Diaphragm operated to actuate an SPDT snap switch.

D. Air-Pressure Differential Indicating Switch: Combination gage with low- and high-limit switches.

1.3 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Differential Transmitter:

1. Range: Approximately 2 times set point.
2. Accuracy: Within 0.5 percent of the span at reference temperature of 70 deg F (21 deg C).
3. Hysteresis: Within 0.02 percent of the span.
4. Repeatability: Within 0.05 percent of the calibrated span.
5. Stability: Within 0.25 percent of span per year.
6. Overpressure: 15 psig (103 kPa).
7. Temperature Limits: Minus 20 to 160 deg F (Minus 29 to 71 deg C).
8. Compensate Temperature Limits: 35 to 135 deg F (2 to 57 deg C).
9. Thermal Effects: 0.015 percent of full scale per degree F.
10. Warm-up Time: Within 5 seconds.

11. Response Time: One second.
12. Shock and vibration shall not harm the transmitter.
13. Operator Interface:

    a. Zero and span adjustments within 10 percent of full span.
    b. Potentiometer adjustments located on face of transmitter.

B. Air-Pressure Differential Indicating Transmitter:

1. Range: Approximately 2 times set point.
2. Accuracy Including Hysteresis and Repeatability: Within 0.25 percent of full scale.
3. Stability: Within 1 percent of full scale per year.
4. Overpressure: Varies with range. At least 1.5 times range.
5. Temperature Limits: Zero to 140 deg F (Minus 18 to 60 deg C).
6. Compensate Temperature Limits: 20 to 120 deg F (Minus 7 to 49 deg C).
7. Thermal Effects: 0.02 percent of full scale per degree F.
8. Display: Digital with minimum 0.4-inch- (10-mm-) high numeric characters.
9. Operator Interface: Zero and span adjustments.

C. Air-Pressure Differential Indicating Transmitter with Field-Selectable Features:

1. Field-Selectable Features:
2. Accuracy Including Hysteresis and Repeatability:

    a. Within 2 percent for 0.10 in. wg (25 Pa), 1.0 in. wg (250 Pa) and all bi-directional ranges.
    b. Within 1 percent for other ranges.

3. Stability: Within 1 percent of full scale per year.
4. Response Time: Adjustable 0.5- to 15-second time constant with 95 percent response within 1.5 to 45 seconds.
5. Overpressure: 1 psig (6.9 kPa) maximum operating; 10 psig (69 kPa) burst pressure.
6. Temperature Limits: Zero to 150 deg F (Minus 18 to 66 deg C).
7. Display: Four-digit digital display with minimum 0.4-inch- (10-mm-) high numeric characters.
8. Operator Interface:

    a. Selectable pressure ranges, where indicated.
    b. Zero and span adjustments.
    c. Selectable air velocity mode with square root function.
    d. Adjustable signal dampening.

D. Air-Pressure Differential Transmitter with 0.10 Percent Accuracy and Auto Zero Feature:

1. Range: Approximately 2 times set point.
2. Calibrated Span: Field adjustable, minus 40 percent of the range.
3. Accuracy: Within 0.10 percent of natural span.
4. Repeatability: Within 0.15 percent of calibrated span.
5. Linearity: Within 0.2 percent of calibrated span.
6. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.
7. Integral digital display for continuous indication of pressure differential.

E. Air-Pressure Differential Transmitter with 0.25 Percent Accuracy and Auto Zero Feature:

1. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
2. Calibrated Span: Field adjustable, minus 40 percent of the range.
3. Accuracy: Within 0.25 percent of natural span.
4. Repeatability: Within 0.15 percent of calibrated span.

5. Linearity: Within 0.2 percent of calibrated span.
6. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.
7. Integral digital display for continuous indication of pressure differential.

F. Air-Pressure Differential Indicating Transmitter, Switch and Controller:

1. Accuracy Including Hysteresis and Repeatability:

   a. Within 1 percent for ranges less than 5 in. wg (1250 Pa).
   b. Within 0.5 percent at 77 deg F (25 deg C) for other ranges.

2. Stability: Within 1 percent per year.
3. Response Time: 250 ms.
4. Overpressure: 5 psig (34 kPa) for instrument ranges less than 50 in wg (12.5 kPa) and 9 psig (62 kPa) for 100 in. wg (25 kPa) range.
5. Temperature Limits: 32 to 140 deg F (Zero to 60 deg C).
6. Thermal Effects: 0.020 percent per degree F.
7. Warm-up Period: One hour.
8. Controller programming through menu keys.
9. Display:

   a. Digital, four-digit display with backlight, with 0.4-inch- (10-mm-) high alphanumeric characters.
   b. Four indicators; two for set point and two for alarm status.

10. Operator Interface:

    a. Set-point adjustment through keypad on face of instrument.
    b. Zero and span adjustments accessible through menu.
    c. Programming through keypad.

1.4 LIQUID-PRESSURE SWITCHES

A. Liquid Gage Pressure Switch, Diaphragm Operated, Low Pressure:

1. Diaphragm operated to actuate an SPDT snap switch.
2. User Interface: External screw with visual set-point adjustment.
3. Operating Data:

   a. Electrical Rating: 15 A at 120-V ac.
   b. Pressure Limits:

      1) Range 1 to 30 psig (7 to 207 kPa): 60 psig (414 kPa).
      2) Range 10 to 125 psig (69 to 862 kPa): 160 psig (1103 kPa).

   c. Temperature Limits: Minus 30 to 150 deg F (Minus 35 to 66 deg C).
   d. Operating Range: [**1 to 30 psig (7 to 207 kPa)**] [**10 to 250 psig (69 to 862 kPa)**].
   e. Deadband: Fixed.

B. Liquid Gage Pressure Switch-Diaphragm Operated:

1. Diaphragm operated to actuate a snap switch.
2. User Interface: Internal hex nut set-point adjustment with enclosed set-point indicator and scale.

   a. Process Connection: Threaded, NPS 1/2 (DN 15).

3. Operating Data:

    a. Electrical Rating: 15 A at 120-, 240-, and 480-V ac.
    b. Pressure Limits: 1200 psig (8274 kPa).
    c. Ambient Temperature Limits: Minus 30 to 180 deg F (Minus 35 to 82 deg C).
    d. Process Temperature Limits: Minus 4 to 167 deg F (Minus 20 to 75 deg C).
    e. Adjustable Operating Range.
    f. Deadband: Adjustable.

C. Liquid Gage Pressure Switch-Bourdon Tube Operated:

1. Bourdon tube operated to actuate a snap switch.
2. Provide switches used in safety limiting applications with reset.
3. Wetted Materials: Brass or stainless steel.
4. User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.

D. Liquid-Pressure Differential Switch with Set-Point Indicator:

1. Brass stainless-steel double opposing bellows operate to actuate a SPDT snap switch.
2. Electrical Connections: Screw terminal.
3. Enclosure Conduit Connection: Knock out or threaded connection.
4. User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
5. High and Low Process Connections: Threaded, NPS 1/8 (DN 3).

E. Liquid-Pressure Differential Switch:

1. Type 316 stainless-steel double opposing bellows operate to actuate an SPDT snap switch.
2. Wetted materials: Type 316 stainless steel.
3. Seal: as required by the application
4. User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
5. High and Low Process Connections: Threaded, NPS 1/4 (DN 10).

1.5 LIQUID-PRESSURE TRANSMITTERS

A. Liquid Gage Pressure Transmitter with Adjustable Span for Hazardous Environments:

1. Range: Minus 300 to 300 psig (Minus 2068 to 2068 kPa).
2. Span: Field adjustable.
3. Minimum Span: 3psig (21 kPa).
4. Reference Accuracy: Within 0.07 percent of span or better.
5. Stability: Within 0.125 percent of upper range limit for 5 years.
6. Overpressure Limits: 3626 psig (25 000 kPa).
7. Process Temperature Limits: Minus 40 to 250 deg F (Minus 40 to 121 deg C).
8. Ambient Temperature Limits: Minus 40 to 185 deg F (Minus 40 to 85 deg C).
9. Temperature Effect: Within 0.025 percent of upper range limit plus 0.125 percent of span.
10. Shock and vibration shall not harm the transmitter.
11. Operator Interface: Zero and span adjustments located behind cover.
12. Display: Digital, five-digit, two-line display with 0.4-inch- (10-mm-) high alphanumeric characters.

B. Liquid-Pressure Differential Transmitter with Adjustable Span for Hazardous Environments:

1. Range: Minus 300 to 300 psig (Minus 2068 to 2068 kPa).
2. Span: Field adjustable.
3. Minimum Span: 3psig (21 kPa).

4. Reference Accuracy: Within 0.07 percent of span or better.
5. Stability: Within 0.125 percent of upper range limit for 5 years.
6. Overpressure Limits: 3626 psig (25 000 kPa).
7. Process Temperature Limits: Minus 40 to 250 deg F (Minus 40 to 121 deg C).
8. Ambient Temperature Limits: Minus 40 to 185 deg F (Minus 40 to 85 deg C).
9. Temperature Effect: Within 0.025 percent of upper range limit plus 0.125 percent of span.
10. Shock and vibration shall not harm the transmitter.
11. Operator Interface: Zero and span adjustments located behind cover.
12. Display: Digital, five-digit, two-line display with 0.4-inch- (10-mm-) high alphanumeric characters.

C. Liquid-Pressure Differential Transmitter:

1. Range: Approximately 2 times the set point.
2. Span: Adjustable plus or minus one milliamp, noninteractive.
3. Accuracy: Within 0.25 percent of full scale.
4. Hysteresis: Within 0.1 percent of full scale.
5. Repeatability: Within 0.05 percent of full scale.
6. Maximum Working Pressure: 250 psig (1724 kPa).
7. Temperature Limits: Zero to 175 deg F (Minus 18 to 79 deg C).
8. Compensate Temperature Limits: 30 to 150 deg F (Minus 1 to 66 deg C).
9. Thermal Effects: 0.02 percent of full scale per degree F.
10. Response Time: 30 to 50 ms.
11. Shock and vibration resistant.
12. Operator Interface:

    a. Zero and span adjustments located behind cover.
    b. Bleed screws on side of body, two screws on low-pressure side, and one screw on high-pressure side, for air in line and pressure cavity.

13. Three-valve manifold. Brass, bronze, or stainless steel.

D. Liquid-Pressure Differential Transmitter with Field-Selectable Ranges:

1. Field-Selectable Ranges.

2. Accuracy: Within 1 percent of the full-scale range.
3. Static Pressure: 2 times full-scale range.
4. Overpressure: Proof pressure 3 times full-scale range, burst pressure 5 times full scale.
5. Compensate Temperature Limits: Zero to 180 deg F (Minus 18 to 82 deg C).
6. Thermal Effects: 0.025 percent of full scale per degree F.
7. Shock and vibration resistant.
8. Operator Interface:

    a. Zero button located behind cover.
    b. Range selector located behind cover.

9. Three-valve stainless steel manifold.

END OF SECTION 230923.23

SECTION 230923.27 - TEMPERATURE INSTRUMENTS

1.1 AIR TEMPERATURE SENSORS

A. Platinum RTD, Single-Point Air Temperature Duct Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
3. Probe: Single-point sensor with a stainless-steel sheath.

B. Platinum RTD, Air Temperature Averaging Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
3. Multiple sensors to provide average temperature across entire length of sensor.
4. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
5. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch (100-mm) radius.

C. Platinum RTD Outdoor Air Temperature Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Solar Shield: Stainless steel.

D. Platinum RTD Space Air Temperature Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 212 deg F (Minus 45 to 100 deg C).
3. Sensor assembly shall include a temperature-sensing element mounted under a bright white, non-yellowing cover.

1.2 COMBINATION AIR TEMPERATURE SENSOR AND SWITCH

A. Air Temperature Switch:

1. Factory preset set point of 38 deg F (3 deg C). Field-adjustable set point from 30 to 44 deg F (minus 1 to 7 deg C).
2. Responsive to coldest 12-inch (300-mm) section of sensor length.
3. DPST latching relay rated at 25 A and 120-V ac, with powered controller, coil, and manual rest at panel.

B. Air Temperature Sensor:

1. Temperature-averaging type over sensor length.
2. Platinum RTD with a value of 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
3. Accuracy: Within 0.9 deg F (0.5 deg C).

1.3 AIR TEMPERATURE SWITCHES

A. Thermostat and Switch for Low Temperature Control in Duct Applications:

1. Two-position control.
2. Field-adjustable set point.
3. Manual reset.
4. Operating Temperature Range: 15 to 55 deg F (Minus 9 to 13 deg C).
5. Temperature Differential: 5 deg F (2.8 deg C), non-adjustable and additive.
6. Enclosure Ambient Temperature: Minus 20 to 140 deg F (Minus 11 to 60 deg C).
7. Sensing Element Maximum Temperature: 250 deg F (121 deg C).
8. Voltage: 120-V ac.
9. Current: 16 FLA.
10. Switch Type: Two SPDT snap switches operate on coldest 12-inch (300-mm)section along element length.

B. Thermostat and Switch for High Temperature Control in Duct Applications:

1. Two-position control.
2. Field-adjustable set point.
3. Manual reset.
4. Temperature Range: 100 to 160 deg F (38 to 71 deg C).
5. Temperature Differential: 5 deg F (2.8 deg C).
6. Ambient Temperature: Zero to 260 deg F (Minus 18 to 127 deg C).
7. Voltage: 120-V ac.
8. Current: 16 FLA.
9. Switch Type: SPDT snap switch.

1.4 AIR TEMPERATURE RTD TRANSMITTERS

A. Functional Characteristics:

1. 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
2. 1000-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
3. Span (Adjustable):

    a. Space: 40 to 90 deg F (4 to 32 deg C).
    b. Supply Air Cooling and Heating: 40 to 120 deg F (4 to 49 deg C).
    c. Supply Air Cooling Only: 40 to 90 deg F (4 to 32 deg C).
    d. Supply Air Heating Only: 40 to 120 deg F (4 to 49 deg C).
    e. Exhaust Air: 50 to 100 deg F (10 to 38 deg C).
    f. Return Air: 50 to 100 deg F (10 to 38 deg C).
    g. Mixed Air: Minus 40 to 140 deg F (Minus 40 to 60 deg C).
    h. Outdoor: Minus 40 to 140 deg F (Minus 40 to 60 deg C).

4. Calibration Accuracy: Within 0.1 percent of the span.
5. Stability: Within 0.2 percent of the span for at least 6 months.
6. Combined Accuracy: Within 0.5 percent.

1.5 LIQUID AND STEAM TEMPERATURE SENSORS, INDUSTRIAL GRADE

A. RTD:

1. Resistance temperature sensors shall comply with IEC 60751, Class A requirements.
2. Platinum with a value of 100 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
3. Encase RTD in a stainless-steel sheath with a 0.25-inch (8-mm) OD.
4. Four-wire, PTFE-insulated, nickel-coated, 22-gage, stranded copper leads.
5. Spring-loaded RTDs for thermowell installations.

6. Range: Minus 328 to 932 deg F (Minus 200 to 500 deg C).
7. Interchangeable Accuracy: Within 0.27 deg F (0.15 deg C) at 32 deg F (zero deg C).
8. Stability: Within 0.05 percent maximum ice-point resistance shift after 1000 hours at 752 deg F (400 deg C).
9. Hysteresis: Within 0.04 percent of range.
10. Response Time: 62.8 percent of change in 4 seconds with water flowing across sensor at 3 fps (0.9 m/s).
11. Self-Heating: 18-mW minimum power dissipation required to cause a 1.8 deg F (1 deg C) temperature measurement error in water flowing at 3 fps (0.9 m/s).

B. Thermowells:

1. Stem: Straight or stepped or tapered shank formed from solid bar stock.
2. Material: stainless steel.

C. Connection Heads:

1. Housing: Low-copper cast-aluminum alloy, complying with NEMA 250, Type 4.
2. Terminals: Six or eight as required by sensor, nickel-plated brass.

1.6 LIQUID TEMPERATURE SWITCHES

A. Thermostat and Switch for Temperature Control in Pipe Applications:

1. Two-position control.
2. Field-adjustable set point.
3. Manual reset.
4. Operating Temperature Range: 65 to 200 deg F (18 to 3 deg C).
5. Temperature Differential Deadband: 5 to 30 deg F (3 to 17 deg C), adjustable.
6. Enclosure Ambient Temperature: 150 deg F (66 deg C).
7. Sensing Element Pressure Rating: 200 psig (1379 kPa).
8. Voltage: 120-V ac.
9. Current: 8 FLA.
10. Switch Type: SPDT snap switch.

1.7 LIQUID AND STEAM TEMPERATURE TRANSMITTERS, INDUSTRIAL GRADE

A. Digital Accuracy: Within 0.27 deg F (0.15 deg C) with a 180 deg F (82 deg C) span.

B. Digital to Analog Accuracy: Within 0.03 percent of span.

C. Total Accuracy: Within 0.32 deg F (0.18 deg C) with a 180 deg F (82 deg C) span.

D. Stability: Within 0.15 percent of output reading for 24 months.

E. Ambient Temperature Limits: Minus 4 to 185 deg F (Minus 20 to 85 deg C).

F. Humidity Limits: Zero to 99 percent.

G. Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C.

H. Range: Minus 328 to 1562 deg F (Minus 200 to 850 deg C).

I. Field-Adjustable Span: 18 deg F (10 deg C) minimum.

J. Default Spans:

1. Chilled Water: Zero to 100 deg F (Minus 18 to 38 deg C).
2. Condenser Water: Zero to 120 deg F (Minus 18 to 49 deg C).
3. Heating Hot Water: 32 to 212 deg F (Zero to 100 deg C).
4. Heat Recovery: Zero to 120 deg F (Minus 18 to 49 deg C).
5. Self-Calibration: The analog-to-digital measurement circuitry automatically self-calibrates for each temperature update by comparing the dynamic measurement to extremely stable and accurate internal reference elements.

END OF SECTION 230923.27

SECTION 231113 - FACILITY FUEL-OIL PIPING

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification for facility fuel oil piping, as listed in, but not limited to, the “Saudi Mechanical Code” SBC 501, and the standards listed below in this section; whichever is more stringent.

C. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

D. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

E. Pipe Welding Qualifications: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code.

1.2 PERFORMANCE REQUIREMENTS

A. Maximum Operating-Pressure Ratings: 3 psig (21 kPa).

B. Quality Standards:

1. ASME B31.9, "Building Services Piping," for fuel-oil piping materials, installation, testing, and inspecting.
2. UL 842 for fuel-oil valves, with "WOG" permanently marked on valve body.

1.3 MATERIALS

A. Piping Specialties:

1. Metallic flexible connectors.
2. Y-pattern strainers.
3. Manual air vents.

B. Manual Fuel-Oil Shutoff Valves:

1. One-piece, bronze ball valves with bronze trim.
2. Two-piece, regular full-port, bronze ball valves with bronze trim.

C. Specialty Valves:

1. Pressure relief valves.
2. Oil safety valves.
3. Emergency shutoff valves.
4. Mechanical leak detector.

D. Leak-Detection and Monitoring System: Cable sensor with probes and annunciator panel.

E. Fuel Oil:

1. Grade No. 2.

F. Labeling and Identifying: Detectable warning tape buried above tank and piping.

1.4 OUTDOOR PIPING SCHEDULE

A. Underground Fuel-Oil Piping: Rigid double-containment piping.

B. Underground Fuel-Oil-Tank Fill and Vent Piping: Steel, with protective coating where underground.

C. Containment Conduit: Steel with welded joints and protective coating.

D. Aboveground Fuel-Oil and Vent Piping:

1. NPS 2 (DN 50) and Smaller: Steel pipe with welded joints
2. NPS 2-1/2 (DN 65) and Larger: Steel pipe with welded joints

1.5 INDOOR PIPING SCHEDULE

A. NPS 1/2 (DN 15) and Smaller: Steel pipe with threaded joints

B. NPS 5/8 to NPS 2 (DN 18 to DN 50) and Smaller: Steel pipe with welded joints

C. NPS 2-1/2 (DN 65) and Larger: Steel pipe with welded joints

END OF SECTION 231113

SECTION 231126 – LPG PLANT AND FACILITY GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.
6. LPG Storage Tanks.
7. Transport truck unloading facility specialties.
8. Vaporizers.
9. Flare Stack.
10. Air Compressor

11. Concrete bases.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. LPG: Liquefied-petroleum gas.

E. Design values of gas are as follows:

- LPG and air mixture percentages: 45 % air & 55 %LPG
- LPG composition: 70 % butane & 30% propane
- LPG calorific Value: 3060 btu/ft^3
- LPG gas specific gravity: 1.6
- LPG liquid specific gravity: 0.566

1.4 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification for LPG piping systems, as listed in, but not limited to the “Saudi Mechanical Code” SBC 501, and the standards listed below in this section; whichever is more stringent.

C. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.5 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. For Piping and valves Containing Only Vapor:

   a. Piping and Valves: 125 psig (862 kPa) unless otherwise indicated.

2. For Piping Containing Liquid:

   a. Piping and Valves: 350 psig (2413 kPa) unless otherwise indicated.

B. Delegated Design: Design restraints and anchors for LPG piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

C. Seismic Performance: Vaporizers and storage container supports shall withstand the effects of earthquake motions determined according to SEI/ASCE 7 .

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.6 GENERAL REQUIREMENTS

A. Welding: Piping shall be welded in accordance with qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME Boiler and Pressure Vessel Code: Section IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. The Engineer shall be furnished with a copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record.

B. Standard Products: Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Asbestos or products containing asbestos shall not be used. Manufacturer's descriptive data and installation instructions shall be submitted

for approval for compression-type mechanical joints used in joining dissimilar materials and for insulating joints. Valves, flanges and fittings shall be marked in accordance with MSS SP-25.

1.7 TESTING AND COMMISSIONING

A. Testing and commissioning shall be performed by a third party specialist agency with a minimum 10 years of experience in testing and commissioning of LPG systems to perform the testing and commissioning activities of LPG system along with leak detection, testing and commissioning and interface with fire alarms and PLC based Process control system (PCS).

B. Installer Qualifications: Submit names and qualifications of the specialist agency. Submit information on 3 recently completed projects. Submit list of proposed equipment

C. Report: Provide complete signed and certified testing and commissioning report to the Engineer showing all test measurements, calculations and list of instruments used.

1.8 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Piping specialties.
2. Corrugated stainless-steel tubing with associated components.
3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
4. Pressure regulators. Indicate pressure ratings and capacities.
5. Dielectric fittings.
6. LPG Storage Tanks
7. Vaporizers.
8. Flare Stack.
9. Air Compressor

B. Shop Drawings: For facility LPG piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1. Shop Drawing Scale: 1/4 inch per foot (1:50).
2. Detail mounting, supports, and valve arrangements for service meter assembly and pressure regulator assembly.

C. Delegated-Design Submittal: For LPG piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of seismic restraints.
2. Design Calculations: Calculate requirements for selecting seismic restraints.

1.9 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and details, drawn to scale, on which LPG piping is shown and coordinated with other installations, using input from installers of the items involved.

B. Site Survey: Plans, drawn to scale, on which LPG piping is shown and coordinated with other services and utilities.

C. Qualification Data: For qualified professional engineer.

D. Seismic Qualification Certificates: Submit certification that vaporizer, air mixer, storage container supports, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Welding certificates.

F. Field quality-control reports: Indicate and interpret test results for compliance with performance requirements.

1.10 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For LPG equipment and accessories to include in emergency, operation, and maintenance manuals specified in Division 1.

1.11 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. ANSI Standard: Comply with ANSI Z223.1, "National Fuel Gas Code."

E. FM Standard: Provide components listed in FM's "Fire Protection Approval Guide" if specified to be FM approved.

F. IAS Standard: Provide components listed in IAS's "Directory of A. G. A. and C. G. A Certified Appliances and Accessories" if specified to be IAS listed.

G. UL Standard: Provide components listed in UL's "Gas and Oil Equipment Directory" if specified to be UL listed.

1.12 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing LPG piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store pipes and tubes with protective PE coating to avoid damaging coating and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.13 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing LPG Service: Do not interrupt LPG service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of LPG supply according to requirements indicated:

1. Notify Engineer no fewer than two days in advance of proposed interruption of LPG service.
2. Do not proceed with interruption of LPG service without Engineer's written permission.

1.14 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Section 083113 "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40 and 80, Type S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

a. Material Group: 1.1.
b. End Connections: Threaded or butt welding to match pipe.
c. Lapped Face: Not permitted underground.
d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground, and stainless steel underground.

5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

6. Mechanical Couplings:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1) Dresser Piping Specialties; Division of Dresser, Inc.

2) Smith-Blair, Inc.

b. Stainless-steel flanges and tube with epoxy finish.
c. Buna-nitrile seals.
d. Stainless-steel bolts, washers, and nuts.
e. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
f. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

B. PE Pipe: ASTM D 2513, SDR 11.

1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type S, Grade B.
3. Anodeless Service-Line Risers: Factory fabricated and leak tested.

a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.
b. Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B with corrosion-protective coating covering. Vent casing aboveground.
c. Aboveground Portion: PE transition fitting.
d. Outlet shall be threaded or flanged or suitable for welded connection.
e. Tracer wire connection.
f. Ultraviolet shield.
g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

4. Transition Service-Line Risers: Factory fabricated and leak tested.

a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
b. Outlet shall be threaded or flanged or suitable for welded connection.
c. Bridging sleeve over mechanical coupling.
d. Factory-connected anode.
e. Tracer wire connection.
f. Ultraviolet shield.
g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

5. Steel Mechanical Couplings: Capable of joining plain-end PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

1) Dresser Piping Specialties; Division of Dresser, Inc.
2) Smith-Blair, Inc.

b. Stainless-steel flanges and tube with epoxy finish.
c. Buna-nitrile seals.
d. Stainless-steel bolts, washers, and nuts.
e. Factory-installed anode for steel-body couplings installed underground.

2.2 PIPING SPECIALTIES

A. Flexible Piping Joints:

1. Approved for LPG service.
2. Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
3. Minimum working pressure of 350 psig (2413 kPa) and 250 deg F (121 deg C) operating temperature.
4. Flanged- or threaded-end connections to match equipment connected and shall be capable of minimum 3/4-inch (20-mm) misalignment.
5. Maximum 36-inch (914-mm) length for liquid LPG lines.

B. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 40-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 350 psig (2413 kPa).

C. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 40-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: : 350 psig (2413 kPa).

D. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 40-mesh startup strainer and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig (5170 kPa).

E. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for LPG.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M.

2.4 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. Metallic Valves, NPS 2 (DN 50) and Smaller for Liquid Service: Comply with ASME B16.33 and UL 842.

1. CWP Rating: : 350 psig (2413 kPa) minimum
2. Threaded Ends: Comply with ASME B1.20.1.
3. Socket ends for brazed joints.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Listing by CSA or agency acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
6. Valves 1-1/4 inch (32 mm) and larger shall be suitable for LPG service, with "WOG" indicated on valve body.

C. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller for Vapor Service: Comply with ASME B16.33.

1. CWP Rating: 125 psig (862 kPa) minimum for LPG network
2. CWP Rating: 350 psig (2413 kPa) minimum for LPG plant
3. Threaded Ends: Comply with ASME B1.20.1.
4. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
5. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
6. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
7. Service Mark: Valves 1-1/4 inch (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.

D. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with ASME B16.38.
1. CWP Rating: 125 psig (862 kPa) minimum for LPG network
2. CWP Rating: 350 psig (2413 kPa) minimum for LPG plant
3. Flanged Ends: Comply with ASME B16.5 for steel flanges.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Service Mark: Initials "WOG" shall be permanently marked on valve body.

E. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

    a. BrassCraft Manufacturing Company; a Masco company.
    b. Conbraco Industries, Inc.; Apollo Div.
    c. Lyall, R. W. & Company, Inc.
    d. McDonald, A. Y. Mfg. Co.
    e. Perfection Corporation; a subsidiary of American Meter Company.

2. Body: Bronze, complying with ASTM B 584.
3. Ball: Chrome-plated brass.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Separate packnut with adjustable-stem packing threaded ends.
7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
8. CWP Rating: 600 psig (4143 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for LPG service with "WOG" indicated on valve body.

F. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

    a. BrassCraft Manufacturing Company; a Masco company.
    b. Conbraco Industries, Inc.; Apollo Div.
    c. Lyall, R. W. & Company, Inc.
    d. McDonald, A. Y. Mfg. Co.
    e. Perfection Corporation; a subsidiary of American Meter Company.

2. Body: Bronze, complying with ASTM B 584.
3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
8. CWP Rating: 600 psig (4143 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for LPG service with "WOG" indicated on valve body.

G. Bronze Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

    a. Lee Brass Company.
    b. McDonald, A. Y. Mfg. Co.

2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig (862 kPa) for LPG network
7. Pressure class: 350 psig (2413 kPa) for LPG plant
8. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for LPG service with "WOG" indicated on valve body.

H. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

    a. McDonald, A. Y. Mfg. Co.
    b. Mueller Co.; Gas Products Div.
    c. Xomox Corporation; a Crane company.

2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with LPG.
6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig (862 kPa) for LPG network

9. Pressure class: 350 psig (2413 kPa) for LPG plant
10. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
11. Service: Suitable for LPG service with "WOG" indicated on valve body.

I. Cast-Iron, Lubricated Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

    a. Flowserve.
    b. Homestead Valve; a Division of Olson Technologies, Inc.
    c. McDonald, A. Y. Mfg. Co.
    d. Milliken Valve Company.
    e. Mueller Co.; Gas Products Div.
    f. R&M Energy Systems; a subsidiary of Robbins & Myers, Inc.

2. Body: Cast iron, complying with ASTM A 126 Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with LPG.
6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig (862 kPa) for LPG network
9. Pressure class: 350 psig (2413 kPa) for LPG plant
10. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
11. Service: Suitable for LPG service with "WOG" indicated on valve body.

J. PE Ball Valves: Comply with ASME B16.40.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

    a. Kerotest Manufacturing Corp.
    b. Lyall, R. W. & Company, Inc.
    c. Perfection Corporation; a subsidiary of American Meter Company.

2. Body: PE.
3. Ball: PE.
4. Stem: Acetal.
5. Seats and Seals: Nitrile.
6. Ends: Plain or fusible to match piping.
7. Pressure Class: 125 psig (862 kPa) for LPG network
8. Pressure class: 350 psig (2413 kPa) for LPG plant
9. Operating Temperature: Minus 20 to plus 140 deg F (Minus 29 to plus 60 deg C).
10. Operator: Nut or flat head for key operation.
11. Include plastic valve extension.
12. Include tamperproof locking feature for valves where indicated on Drawings.

K. 3Way valve:

1. Manufacturers: Subject to compliance with requirements, provide products by approved suppliers listed in this document.
2. Body: brass.
3. Ball: Chrome plated brass.
4. Stem seals: PTFE with double O-ring.
5. Ball seats: PTFE energized with O-ring backing.

6. Handle: Plated steel with vinyl grip.
7. Ends: Plain, threaded or fusible to match piping.
8. Pressure class: 350 psig (2413 kPa) for SNG plant
9. Operating Temperature: Minus 20 to plus 140 deg F (Minus 29 to plus 60 deg C).
10. Include plastic valve extension.

L. Pressure Gauge:

1. Manufacturers: Subject to compliance with requirements, provide products by approved suppliers listed in this document.
2. Accuracy: ± 0.5% of span.
3. Ball: Chrome plated brass.
4. Wetted Parts: 316 Stainless Steel.
5. Case: Fiberglass reinforced thermoplastic.
6. Window: Acrylic, Buna-N gasket, removable.
7. Case-to-socket: Viton O-ring.
8. Dial: Aluminum.
9. Pointer: Black aluminum, adjustable under window.
10. Dial Layout: Number every 1 PSI, tick marks every 0.1 PSI.
11. Media Temperature: 100 degree Celsius.
12. Ambient Temperature: -40 to 60 degree Celsius.

M. Sight Flow Indicator:

1. Manufacturers: Subject to compliance with requirements, provide products by approved suppliers listed in this document.
2. Material: Carbon steel.
3. Type: Plain, double window.
4. Connection: Flanged.
5. Pressure: 350 psi.
6. Glass: temp Borosilicate.
7. Seals: neoprene / suitable for LPG use.

N. Valve Boxes:

1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches (125 mm) in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head and with stem of length required to operate valve.

2.5 MOTORIZED GAS VALVES

A. Hydrostatic Relief Valves: Comply with NFPA 58.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Engineered Controls International, Inc.; RegO Products.
b. Fisher Control Valves and Regulators; Division of Emerson Process Management.
c. Murray Equipment, Inc.
d. Sherwood; a division of Harsco Corporation.

2. Operating Pressure: [350 psig (2413 kPa)] <Insert pressure>.
3. Body: Brass.
4. Spring: Stainless steel.
5. Disc and Seat: Nitrile.
6. Brass body and stainless-steel, spring-operated valve with resilient rubber disc seat and protective cap.
7. Factory set and tested.
8. Listing: Valves listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Valve shall reseat after relieving pressure.

B. Automatic Gas Valves: Comply with ANSI Z21.21.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved:

    a. ASCO.
    b. ASCO Power Technologies, LP; Division of Emerson.
    c. ASCO Valve Canada; Division of Emerson Electric Canada Limited.
    d. Dungs, Karl, Inc.
    e. Eaton Corporation; Controls Div.
    f. Eclipse Combustion, Inc.
    g. Honeywell International Inc.
    h. Johnson Controls.

2. Body: Brass or aluminum.
3. Seats and Disc: Nitrile rubber.
4. Springs and Valve Trim: Stainless steel.
5. Normally closed.
6. Visual position indicator.
7. Mechanical operator for actuation by appliance automatic shutoff device.

C. Electrically Operated Valves: Comply with UL 429.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

    a. ASCO.
    b. ASCO Power Technologies, LP; Division of Emerson.
    c. Dungs, Karl, Inc.
    d. Eclipse Combustion, Inc.
    e. Goyen Valve Corp.; Tyco Environmental Systems.
    f. Magnatrol Valve Corporation.
    g. Parker Hannifin Corporation; Climate & Industrial Controls Group; Skinner Valve Div.
    h. Watts Regulator Co.; Division of Watts Water Technologies, Inc.

2. Pilot operated.
3. Body: Brass or aluminum.
4. Seats and Disc: Nitrile rubber.
5. Springs and Valve Trim: Stainless steel.
6. [120-V] [220-V] ac, [50] [60] Hz, Class B, continuous-duty molded coil, replaceable.
7. NEMA ICS 6, Type 84, coil enclosure.
8. Normally closed.
9. Visual position indicator.

2.6 PRESSURE REGULATORS

A. General Requirements:

1. Single or multi stage and suitable for LPG.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

B. Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

   a. Actaris.
   b. American Meter Company.
   c. Fisher Control Valves and Regulators; Division of Emerson Process Management.
   d. Invensys.
   e. Richards Industries; Jordan Valve Div.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet pressure: 350 psig (2413 kPa) for LPG plant

2.7 SERVICE METERS

A. Turbine Meters: Comply with ASME MFC-4M.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

   a. American Meter Company.
   b. Invensys.

2. Housing: Cast iron or welded steel.
3. Connection Threads or Flanges: Steel.
4. Turbine: Aluminum or plastic.
5. Turbine Bearings: Self-lubricating.
6. Compensation: Continuous temperature and pressure.
7. Meter Index: Liters.
8. Tamper resistant.
9. Remote meter reader compatible.
10. Maximum Inlet Pressure: 100 psig (690 kPa).
11. Accuracy: Maximum plus or minus 2.0 percent.

B. Service-Meter Bars:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Actaris.
b. American Meter Company.
c. Lyall, R. W. & Company, Inc.
d. McDonald, A. Y. Mfg. Co.
e. Mueller Co.; Gas Products Div.
f. Perfection Corporation; a subsidiary of American Meter Company.

2. Malleable- or cast-iron frame for supporting service meter.
3. Include offset swivel pipes, meter nuts with o-ring seal, and factory- or field-installed dielectric unions.
4. Omit meter offset swivel pipes if service-meter bar dimensions match service-meter connections.

C. Service-Meter Bypass Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Lyall, R. W. & Company, Inc.
b. Williamson, T. D., Inc.

2. Ferrous, tee, pipe fitting with capped side inlet for temporary LPG supply.
3. Integral ball-check bypass valve.

2.8 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Capitol Manufacturing Company.
b. Central Plastics Company.
c. Hart Industries International, Inc.
d. Jomar International Ltd.
e. Matco-Norca, Inc.
f. McDonald, A. Y. Mfg. Co.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
h. Wilkins; a Zurn company.

2. Description:

a. Standard: ASSE 1079.
b. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Capitol Manufacturing Company.
b. Central Plastics Company.
c. Matco-Norca, Inc.

d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
e. Wilkins; a Zurn company.

2. Description:

a. Standard: ASSE 1079.
b. Factory-fabricated, bolted, companion-flange assembly.
c. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.

2. Description:

a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: 150 psig (1035 kPa).
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

2.9 LPG STORAGE TANKS

A. Description: Factory fabricated for underground installation with backfill, complying with requirements in NFPA 58 and ASME Boiler and Pressure Vessel Code and bearing the ASME label. Tanks shall be rated for 350 psig (2413-kPa) minimum working pressure.

B. Design: Storage cylinder / tanks, equipment and ancillary fittings to be tested and approved by a recognized laboratory and bear the label “complying with NFPA 54 & 58”.

All design must comply NFPA 54, NFPA 58and NFPA 59. And loading facility to consider Class 1, Group D, Zone 1 locations and NFPA 58 requirements.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

a. American Welding & Tank.
b. Hanson, Roy E. Jr. Mfg.
c. Trinity Industries, Inc.
d. United Industries Group, Inc.
e. Trans Tech Energy, Inc.
f. Ely Energy.
g. Algas SDI.

2. Construction: Welded, fine grain, high strength, normalized steel plate of 434 MPa to 517 MPa tensile strength and 276 MPa minimum yield strength. Tank nozzles and accessories

shall be best quality drop forged steel. Tank to be shot blasted and painted at factory with 1 coat anti-corrosion primer and 2 coats flat white machine epoxy enamel.

3. Inspection: Welds shall be X-ray controlled. Tank shall be inspected by official, government recognized inspectors for raw material, manufacturing operations, X-raying and final hydrostatic and pneumatic tests. Test certificate shall be submitted with tank.
4. Liquid outlet and vapor inlet and outlet connections shall have shutoff valves with excess-flow safety shutoff valves and bypass and back-pressure check valves with smaller than 0.039-inch (1-mm) drill-size hole to equalize pressure. Liquid-fill connection shall have backflow check valve.

    a. Connections: Color-code and tag valves to indicate type.

        1) Liquid fill and outlet, red.
        2) Vapor inlet and outlet, yellow.

5. Level gage shall indicate current level of liquid in the container. Gages shall also indicate storage container contents; e.g., "Butane," "50-50 LPG Mix," or "Propane."
6. Pressure relief valves, type and number as required by NFPA 58, connected to vapor space and having discharge piping same size as relief-valve outlet and long enough to extend at least 84 inches (2130 mm) directly overhead. Identify relief valves as follows:

    a. Discharge pressure in psig (kPa).
    b. Rate of discharge for standard air in cfm (L/s).
    c. Manufacturer's name.
    d. Catalog or model number.

7. Container pressure gage.
8. Regulators: Tank shall be supplied complete from the factory with first and second stage regulators. Regulators to be sized for tank capacity and shall; be provided with necessary strainers and vents and securely mounted to tank.
9. For outdoor installation, exposed metal surfaces mechanically cleaned, primed, and painted for resistance to corrosion.
10. Protection: Filler valve, service valve, and pressure gage shall have a special hood to protect them from mechanical damage. Other components and accessories shall be protected at the factory against damage during shipment or installation.
11. Stainless-Steel Nameplate: Attach to aboveground storage container or to adjacent structure for underground storage container.

    a. Name and address of supplier or trade name of container.
    b. Water capacity in gallons and liters.
    c. Design pressure in psig (kPa).
    d. Statement, "This container shall not contain a product having a vapor pressure in excess of 350 psig (2413 kPa) at 100 deg F (37.8 deg C)"
    e. Outside surface area in sq. ft. (sq. m).
    f. Year of manufacture.
    g. Shell thickness in inches (mm).
    h. Overall length in feet (m).
    i. OD in feet (m).
    j. Manufacturer's serial number.
    k. ASME Code label.

12. Painted-steel support for accumulator. Corrosion protection required at container-to-felt contact.
13. Tie straps for each tank.
14. Straps and anchors for tie-down slab.
15. Asphalt-based coating for corrosion protection.
16. Thermometer well.
17. Container connections and valves protected in manway at top of storage container.
18. Cofferdam with bolt-on extension and hinged covers equipped with ventilation louvers.

19. Vessel access manway
20. Sacrificial anodes.
21. storage tank should include minimum the following trim items and any other items required by the standards:
    a. Liquid fill valves.
    b. Liquid outlet port valves.
    c. Vapor space valves.
    d. Pressure gauges.
    e. Thermometers.
    f. Pressure Relief valves.
    g. Excess flow valves.
    h. 85% values.
    i. Internal Valves.
    j. Rotary level gauges.

2.10 TRANSPORT TRUCK UNLOADING FACILITY

A. Description: Comply with requirements in NFPA 58. To consider Class 1, Group D, Zone 1 locations and shall meet all current NFPA 58 requirements.

B.

1. Liquid-fill and vapor-return, quick-disconnect fittings.
2. Liquid and vapor shutoff valves with hydrostatic relief valves mounted between the quick-disconnect fittings and shutoff valves.
3. Excess-flow safety shutoff valve in vapor-return line.
4. Backflow check valve in liquid-fill line.
5. Remote emergency shutoff valve station with underground cable to the vapor emergency shutoff valve.

2.11 VAPORIZERS

A. Description: Factory-fabricated, assembled, and tested vaporizer with heat exchanger sealed pressure-tight, built on a steel base; including insulated jacket, flue-gas vent, liquid fuel supply and vapor connections, and controls/control panel explosion proof type. Assembly shall be FMG labeled and comply with NFPA 58 and NFPA 70

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:

    a. Algas-SDI.
    b. Alternate Energy Systems, Inc.
    c. Ely Energy, Inc.
    d. Ransome Manufacturing; a division of Meeder Equipment Company.
    e. Trans Tech Energy, Inc.

B. Fabricate base and attachment to vaporizers with reinforcement strong enough to resist vaporizer movement during a seismic event when steel base is anchored to a concrete base.

C. Casing:

1. Mineral-fiber insulation, a minimum of 2 inches (50 mm) thick, surrounding the heat exchanger.
2. Integral one-piece skid with forklift access holes.
3. Lifting lugs on top of vaporizer.
4. Flue rain cap and bird screen.
5. Sheet metal jacket with screw-fastened closures and baked-enamel protective finish.

6. Mounting base to secure boiler to concrete base.
7. Control Compartment Enclosure: NEMA 250, Type 4, enclosure housing control panels for LPG-fired vaporizers. Explosion-proof control compartment construction required for electric vaporizers.

D. LPG Liquid and Vapor Circuit Specialties:

1. Y-type strainer with drain valve at inlet.
2. Vaporizer coil safety pressure relief valve.
3. Vaporizer coil blowdown valve.
4. Vapor outlet isolation valve.
5. Pressure gages, a minimum of 2-1/2 inches (63 mm) in diameter, at liquid inlet and vapor discharge. Gages shall have operating-temperature ranges so normal operating range is at approximately 50 percent of full range.
6. Inlet safety solenoid valve to close with off-normal operation alarm.
7. Backflow check valve in bypass around inlet safety solenoid valve.
8. Liquid carryover or float-type safety shutoff switch.
9. LPG Vapor Filter: Steel shell designed and manufactured per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1; factory mounted on vaporizer discharge. Shells larger than 5 inches (125 mm) shall be ASME "U" stamped. Fill with stainless-steel, woven-mesh coalescing element to remove 99 percent of particles larger than 10 microns. 250-psig (1723-kPa) minimum working pressure. Finish with corrosion-resistant coating for an exterior application. Include factory-mounted and -piped, differential pressure gage with gage cocks in and out, and minimum NPS 3/4 (DN 20) full-port, ball-type drain valve.
10. Low water level cutoff switch.
11. High waterbath temperature cutoff switch.
12. Low and high gas pressure cutoff switch.
13. Liquid carry over safety switch (or float shutoff).
14. Safety relief valve (for LPG coil; pre-set at 250 PSIG).
15. Electronic flame safeguard UV scanner.
16. Energy source gas fired burner.

E. Indirect-Type, Water-Bath Heat Exchanger:

1. Description: designed according to NFPA pamphlet 58 for gas fired water bath vaporizers, constructed to ASME pressure vessel code section VIII Division 1. The vaporizer shall be industrial duty fixed air force draft power burner that provides optimum exhaust stack temperatures and fast response to local changes. It shall be rated for 350 psig at temperature of 650 degree F.. Include the following:

   a. Water bath filled with water
   b. Water-bath, high- and low-level sight glasses.
   c. Low-water cutoff to stop heater and annunciate alarm.
   d. Water fill and vent fitting.
   e. Minimum NPS 3/4 (DN 20) hose-end drain valves.
   f. Operating high- and low-limit aquastat controllers.
   g. Water-bath temperature gage; a minimum of 2-1/2 inches (63 mm) in diameter. Gages shall have operating-temperature ranges so normal operating range is at approximately 50 percent of full range.

F. Capacities and Characteristics: as per design requirements.

1.

2.12 FLARE STACK

A. A Flare Stack should be used to safely burn LPG/Air mixtures and help in setting up the SNG Module operation.

B. The Flare Stack should:
   a. Safely burns LPG/Air mixtures.
   b. Be provided with high capacity flare stack complete with 2” or 3” flare base, flare head and controls.
   c. Be provided with electric ignition, with burner that ensures SNG mixtures are burned.
   d. Be provided with separate pilot supply to ensure stable pilot.
   e. Be with stainless steel burner head.

2.13 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored yellow.

B. Comply with requirements of Section 230553 "Identification for HVAC Piping and Equipment."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for LPG piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.3 PREPARATION

A. Close equipment shutoff valves before turning off LPG to premises or piping section.

B. Inspect LPG piping according to NFPA 58 and NFPA 54 to determine that LPG utilization devices are turned off in piping section affected.

C. Comply with NFPA 58 and NFPA 54 requirements for prevention of accidental ignition.

3.4 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 58 and NFPA 54 requirements for installation and purging of LPG piping.

B. Install underground, LPG piping buried with a minimum of 12 inches (300 mm) of cover below finished grade. The minimum cover shall be increased to 18 inches (460 mm) if external damage to the pipe from external forces is likely to result. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

   1. If LPG piping is installed with less than 12 inches (300 mm) cover below finished grade, install it in containment conduit.

C. Install underground, PE, LPG piping according to ASTM D 2774.

D. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
3. Replace pipe having damaged PE coating with new pipe.

E. Install fittings for changes in direction and branch connections.

F. Joints for connection to inlets and outlets on vaporizers, air mixers, regulators, and valves may be flanged or threaded to match the equipment.

G. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

3.5 VALVE INSTALLATION

A. Install underground valves with valve boxes.

B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

C. Install anode for metallic valves in underground PE piping.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full ID of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Ch. 22, "Pipe and Tube."

F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for LPG service. Install gasket concentrically positioned.

G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

H. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.7 HANGER AND SUPPORT INSTALLATION

A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).
5. NPS 4 (DN 100) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 5/8 inch (16 mm).

D. Install hangers for horizontal, drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1/2 and NPS 5/8 (DN 15 and DN 18): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 3/4 and NPS 7/8 (DN 20 and DN 22): Maximum span, 84 inches (2134 mm); minimum rod size, 3/8 inch (10 mm).
4. NPS 1 (DN 25): Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).

3.8 STORAGE CONTAINER INSTALLATION

A. Fill storage container to at least 70 percent capacity with LPG.

B. Install piping connections with swing joints or flexible connectors to allow for storage container settlement and for thermal expansion and contraction.

C. Ground containers according to NFPA 780.

D. Set storage containers in felt pads on concrete or steel saddles. Install corrosion protection at container-to-felt contact.

E. Install tie-downs over storage containers on saddles with proper tension.

F. Set concrete saddles on dowels set in concrete base. Anchor steel saddles to concrete base.

G. Set storage container on concrete ballast base large enough to offset buoyancy of empty storage container immersed in water.

H. Install tie-down straps over container anchored in ballast base and repair damaged coating.

I. Backfill with a minimum coverage for underground or mounded storage containers according to NFPA 58.

J. Backfill with pea gravel as required in Section 312000 "Earth Moving."

K. Install cathodic protection for storage container. Cathodic protection is specified in Section 264200 "Cathodic Protection."

3.9 VAPORIZER INSTALLATION

A. Install vaporizer with access space for periodic maintenance.

B. Set vaporizers on and anchor to concrete base.

C. Connect liquid line from pump set, and vapor supply to distribution piping.

D. Install backup connection from vapor space of container to inlet of pressure-regulating valve at vaporizer discharge to bypass the vaporizer during maintenance. Install shutoff valves to change source from vaporizer to storage container.

3.10 LABELING AND IDENTIFYING

A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches (305 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.11 PAINTING

A. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components with factory-applied paint or protective coating.

1. Alkyd System: MPI EXT 5.1D.

    a. Prime Coat: Alkyd anticorrosive metal primer.
    b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
    c. Topcoat: Exterior alkyd enamel (gloss).
    d. Color: Gray.

B. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.12 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (451-mm) centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Use 3000-psig (20.7-MPa), 28-day, compressive-strength concrete and reinforcement as specified in Section 033000 "Cast-in-Place Concrete."

3.13 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge LPG according to NFPA 58 and NFPA 54 and requirements of authorities having jurisdiction.

C. LPG piping will be considered defective if it does not pass tests and inspections.

D. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.

E. Verify capacities and pressure ratings of service meters, pressure regulators, valves, and specialties.

F. Verify correct pressure settings for pressure regulators.

G. Verify that specified piping tests are complete.

H. Prepare test and inspection reports.

3.14 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain LPG equipment.

3.15 OUTDOOR PIPING SCHEDULE

A. Underground LPG liquid piping shall be the following:

1. Schedule 40 steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

B. Aboveground LPG liquid piping shall be the following:

1. NPS 1 (DN 25) and Smaller: Schedule 40 steel pipe, malleable-iron threaded fittings and threaded and seal welded joints. Coat pipe and fittings with protective coating for steel piping.
2. NPS 1-1/4 (DN 32) and Larger: Schedule 40, steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.

C. Underground LPG vapor piping shall be the following:

1. PE pipe and fittings joined by heat-fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.

D. Aboveground LPG vapor piping shall bethe following:
1. Schedule 40, steel pipe with wrought-steel fittings and welded joints, or mechanical couplings.

E. Containment Conduit: Schedule 40, steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.16 UNDERGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.

B. Underground Vapor Piping:

1. PE valves.
2. NPS 2 (DN 50) and Smaller: Bronze, lubricated plug valves.
3. NPS 2-1/2 (DN 65) and Larger: Cast-iron, lubricated plug valves.

3.17 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Aboveground Liquid Piping:

1. Two-piece, full-port, bronze ball valves with bronze trim.

B. Valves for pipe NPS 2 (DN 50) and smaller at service meter shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full-port, bronze ball valves with bronze trim.
3. Bronze plug valve.

C. Valves for pipe NPS 2-1/2 (DN 65) and larger at service meter shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, nonlubricated plug valve.

D. Distribution piping valves for pipe NPS 2 (DN 50) and smaller shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full-port, bronze ball valves with bronze trim.
3. Bronze plug valve.

E. Distribution piping valves for pipe NPS 2-1/2 (DN 65) and larger shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, nonlubricated plug valve.

END OF SECTION 231126

SECTION 231213 - FACILITY FUEL-OIL PUMPS

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification for fuel oil pumps, as listed in, but not limited to the ”Saudi Mechanical Code” SBC 501, and the standards listed below in this section; whichever is more stringent.

1.2 PERFORMANCE REQUIREMENTS

A. Maximum Operating-Pressure Ratings: 3 psig (21 kPa).

1.3 PRODUCTS

A. Submersible Fuel-Oil Pumps: Turbine fuel-oil pumps with pump controller panel and interface controller with HVAC controls. Comply with UL 79, UL 87, and UL 343.

B. Multiplex Fuel-Oil Transfer Pump Sets: Packaged unit, skid mounted, with positive-displacement, rotary gear type, with direct, close-coupled drive and interface controller with HVAC controls. Comply with HI M109.

C. Fuel Maintenance System: Fuel-oil filtration with enclosure, filter, fuel-oil pump, multiple-tank manifold, programmable logic controller, and controls.

1. Interface controller with HVAC controls.

END OF SECTION 231213

SECTION 231313 - FACILITY UNDERGROUND FUEL-OIL STORAGE TANKS

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification for underground fuel storage tanks, as listed in, but not limited to, the “Saudi Mechanical Code” SBC 501, and the standards listed below in this section; whichever is more stringent.

C. Installer Qualifications: FRP tanks; trained and certified by the tank manufacturer.

D. Underground Fuel-Oil Storage Tanks: Comply with requirements of the EPA and of state and local authorities having jurisdiction, including recording fuel-oil storage tanks.

1.2 WARRANTY

A. Warranty Period: 30 years.

1.3 PERFORMANCE REQUIREMENTS

A. Maximum Operating-Pressure Ratings: 3 psig (21 kPa).

1.4 MATERIALS

A. FRP Fuel-Oil UST: Double wall, with integral hydrostatic, leak-detection and monitoring system.

B. Fuel-Oil UST Accessories:

1. Tank manholes.
2. Steel tank masonry supports.
3. Ladders.
4. Threaded pipe connections.
5. Striker plates
6. Lifting lugs.
7. Supply tube.
8. Sounding and gage tubes.
9. Containment sumps.
10. Sump entry boots.
11. Anchor straps.
12. Filter mat.
13. Overfill prevention valves.

C. Liquid-level gage systems with floats or other sensors and remote annunciator panel.

D. Leak-Detection and Monitoring System: Cable and sensor with probes or other sensors and remote annunciator panel.

E. Fuel Oil:

1. Grade No. 2.

F. Precast concrete manholes with cast-iron frame and cover.

END OF SECTION 231313

SECTION 232300 - REFRIGERANT PIPING

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification for refrigerant piping, as listed in the “Saudi Mechanical Code-”, SBC 501, and the standards listed below in this section; whichever is more stringent.

C. Retain "Welding Qualifications" Paragraph below if shop or field welding is required. If retaining, also retain "Welding certificates" Paragraph in "Informational Submittals" Article.

D. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

E. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

F. Comply with ANSI/ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

G. UL Standard: Provide products complying with UL 207, "Refrigerant-Containing Components and Accessories, Nonelectrical"; or UL 429, "Electrically Operated Valves."

H. Listing and Labeling: Provide products specified in this Section that are UL listed and labeled.

1.2 PERFORMANCE REQUIREMENTS

A. Quality Standards: ASHRAE 15 and ASME B31.5.

B. Line Test Pressure for Refrigerant R-134a:

1. Suction Lines for Air-Conditioning Applications: 115 psig (793 kPa).
2. Suction Lines for Heat-Pump Applications: 225 psig (1551 kPa).
3. Hot-Gas and Liquid Lines: 225 psig (1551 kPa).

C. Line Test Pressure for Refrigerant R-407C:

1. Suction Lines for Air-Conditioning Applications: 230 psig (1586 kPa).
2. Suction Lines for Heat-Pump Applications: 380 psig (2620 kPa).
3. Hot-Gas and Liquid Lines: 380 psig (2620 kPa).

D. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

1.3 PRODUCTS

A. Copper Tube and Fittings: Type K or L with brazed fittings.

B. Steel Pipe and Fittings: Schedule 40, black steel with wrought-steel fittings.

C. Stainless-steel bellows, flexible connectors.

D. Valves and Specialties:

1. Diaphragm packless valves.
2. Packed-angle valves.
3. Check valves.
4. Service valves.
5. Refrigerant locking caps.
6. Solenoid Valves: 24 120 208-V ac.
7. Safety relief valves.
8. Thermostatic expansion valves for 40 deg F (4.4 deg C) suction temperature; adjustable superheat.
9. Straight-type strainers.
10. Angle-type strainers.
11. Moisture/liquid indicators.
12. Replaceable-core filter dryers with activated alumina media, 2-psig (14-kPa) maximum pressure loss
13. Permanent filter dryers with activated alumina media, 2-psig (14-kPa) maximum pressure loss
14. Mufflers.
15. Receivers.
16. Liquid accumulators.

1.4 REFRIGERANTS

A. R-134a.

B. R-407C.

C. R-410A.

1.5 PIPING APPLICATION SCHEDULES

A. Piping Applications for Refrigerant R-134a: Maximum NPS 4 (DN 100).

1. Suction, Hot-Gas, and Liquid Lines: Copper with brazed joints.
2. Safety-Relief-Valve Discharge Piping: Schedule 40, black steel with welded joints

B. Piping Applications for Refrigerant R-407C: Maximum NPS 4 (DN 100).

1. Suction, Hot-Gas, and Liquid Lines: Copper with brazed or soldered joints.
2. Safety-Relief-Valve Discharge Piping: Schedule 40, black steel with welded joints

C. Piping Applications for Refrigerant R-410A: Maximum NPS 4 (DN 100).

1. Suction Lines for Conventional Air-Conditioning Applications: Copper.

2. Safety-Relief-Valve Discharge Piping:

a. NPS 2 (DN 50) and Smaller: Copper with brazed joints.
b. NPS 2-1/2 (DN 65) and Larger: Schedule 40, black steel with welded joints.
c. Schedule 40, black steel with welded joints.

END OF SECTION 232300

SECTION 233113 - METAL DUCTS

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification for Metal ducts, as listed in, but not limited to the “Saudi Mechanical Code-”, SBC 501, and the standards listed below in this section; whichever is more stringent.

C. Welding Qualifications: Qualify procedures and personnel in accordance with the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for duct joint and seam welding.

D. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," unless otherwise indicated.

E. Comply with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems," unless otherwise indicated.

F. Comply with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations," Chapter 3, "Duct System," for range hood ducts, unless otherwise indicated.

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

C. Mockups:

1. Before installing duct systems, build mockups representing static-pressure classes in excess of 500 Pa. Build mockups to comply with the following requirements, using materials indicated for the completed Work:
   a. Locate mockups in the locations and of the size indicated or, if not indicated, as directed by Engineer. Mockup may be a representative section of the actual duct system.
   b. Include the minimum number of each of the following features and fittings:
      1) Five transverse joints.
      2) One access door(s).
      3) Two typical branch connections, each with at least one elbow.
      4) Two typical flexible duct or flexible-connector connections for each duct and apparatus.
      5) Duct with internal duct liner
2. Perform leakage tests specified in "Field Quality Control" Article. Revise mockup construction and perform additional tests as required to achieve specified minimum acceptable results.
3. Obtain Engineer's approval of mockups before starting Work.
4. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
5. When directed, demolish and remove mockups from Project site.
   a.

6. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.2 MATERIALS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on static-pressure class.

B. Single-wall rectangular ducts and fittings.

C. Sheet Metal Materials:

1. Galvanized sheet steel complying with ASRM A653/A653M.

    a. Galvanized Coating Designation: Z275.
    b. Finishes for Surfaces Exposed to View: Mill phosphatized.
2. Factory-applied antimicrobial coating having a hardness of 2H minimum when tested in accordance with ASTM D3363.

    a. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

D. Duct Liner:

1. Flexible elastomeric: Preformed, cellular, non-hydroscopic, closed-cell, sheet materials complying with ASTM C534/C534M, Type II, Grade 1; and with NFPA 90A or NFPA 90B and NFPA 255 .

    a. Thermal Conductivity (k-Value) 0.034 (W/mK) at 24°C mean temperature.
    b. Density: 48-96 kg/m^3
    c. Water vapor permeability: 0.04 metric perm at 25 mm thickness.
    d. Noise Reduction (NRC): 0.5 at 25.4 mm.
    e. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
    f. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
    g. Duct Liner shall pass the test for:

        1) Mold Growth as per UL181
        2) Fungi Resistance as per ASTM G21/C1338
        3) Bacterial Resistance as per ASTM G22

    h. Liner hot surface performance shall shows no evidence of cracking, flaming, glowing, smoldering, delamination, melting or insulation collapse when tested according to ASTM C 411 at 105°C.

E. Sealant Materials:

1. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
2. Two-part tape sealing system.
3. Water-based joint and seam sealant.
4. Solvent-based joint and seam sealant.
5. Flanged joint sealant.
6. Flange gaskets.

7. Round duct joint O-ring seals.

1.3 SEISMIC-RESTRAINT DEVICES

A. Channel support system.

B. Galvanized-steel restraint cables.

C. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

1.4 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Clean the following items:

1. Air outlets and inlets.
2. Supply, return, and exhaust fans.
3. Air-handling units.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

1.5 DUCT SCHEDULE

A. All ducts shall be galvanized steel.+

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification for air duct accessories, as listed in, but not limited to the “Saudi Mechanical Code-”, SBC 501, and the standards listed below in this section; whichever is more stringent.

C. Installation Standards: NFPA 90A, NFPA 90B, and SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1.2 SUSTAINABILITY REQUIREMENTS

A. Comply with the requirements as specified in Section 0181134.14 “Sustainability Design Requirements.”

1.3 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 90A and NFPA 90B.

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

C. Comply with AMCA 500-D "Laboratory Methods of Testing Dampers for Rating" for dampers rating.

1.4 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90 (Z275).
2. Exposed-Surface Finish: Mill phosphatized.

B. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.

C. Extruded Aluminum: Comply with ASTM B221 (ASTM B221M), Alloy 6063, Temper T6.

1.5 PRODUCTS

A. Backdraft and Pressure Relief Dampers: Tested and rated in accordance with AMCA 511, multiple blade, parallel action, gravity balanced with return springs.

B. Barometric Relief Dampers: Horizontal or vertical mounting; multiple blade, parallel action, gravity balanced with return springs.

C. Manual Volume Dampers: Multiple and single blade, parallel- -blade design, with linkage outside airstream.

1. Standard, steel, manual volume dampers.
2. Standard, aluminum, manual volume dampers.
3. Low-leak, steel, manual volume dampers, tested and rated in accordance with AMCA 511.
4. Low-leak, aluminum, manual volume dampers, tested and rated in accordance with AMCA 511.

D. Control Dampers: Parallel blade design; galvanized-steel frame and blades, tested and rated in accordance with AMCA 511.

E. Fire Dampers: Static and dynamic, heat-responsive device, rated and labeled in accordance with UL 555 by an NRTL.

F. Combination Fire and Smoke Dampers: Static and dynamic heat-responsive device rated and labeled according to UL 555S by an NRTL.

G. Flange connectors.

H. Duct Silencers: Factory fabricated and tested, round or rectangular.

1. Compliant with ASHRAE 62.1 for surfaces in contact with airstream
2. Flame spread index not exceeding 25 and smoke-developed index not exceeding 50 according to ASTM E84.

I. Turning Vanes: Double-blade, galvanized sheet steel.

J. Duct-Mounted Access Doors: Double wall, rectangular, galvanized sheet steel with insulation in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels."

K. Pressure Relief Access Doors: Single wall Flexible Connectors: Indoor and outdoor in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels."

L. Duct accessory hardware.

END OF SECTION 233300

SECTION 233346 - FLEXIBLE DUCTS

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, and installation for flexible ducts, as listed in, but not limited to the “Saudi Mechanical Code-”, SBC 501, and the standards listed below in this section; whichever is more stringent.

C. Installation Standards: NFPA 90A, SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1," and ASTM E96/E96M.

1.2 SUSTAINABILITY REQUIREMENTS

A. Comply with the requirements as specified in Section 0181134.14 “Sustainability Design Requirements.”

1.3 PRODUCTS

A. Non-Insulated Flexible Ducts:

1. Complying with UL 181, Class1.
2. Two-ply flameproof vinyl film supported by helically wound, spring-steel wire.
3. Multiple layers of aluminum laminate supported by helically wound, spring-steel wire.

B. Insulated Flexible Ducts:

1. Complying with UL 181, Class1.
2. Two-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
3. Multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.

C. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action.
2. Non-Clamp Connectors: Adhesive, liquid adhesive plus tape, draw band, or adhesive plus sheet metal screws.

END OF SECTION 233346

SECTION 233416 - CENTRIFUGAL HVAC FANS

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification for centrifugal HVAC fans, as listed in the “Saudi Mechanical Code-”, SBC 501,”Saudi Energy Conservation Code” SBC 601 and the standards listed below in this section; whichever is more stringent.

C. Listing and Labeling: Provide electrically operated fixtures specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.

D. AMCA Compliance: Provide products that meet performance requirements and are licensed to use the AMCA Seal.

E. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

F. Local Certification: Fans should be certified by local authorities as applicable.

1.2 SUSTAINABILITY REQUIREMENTS

A. Comply with the requirements as specified in Section 0181134.14 “Sustainability Design Requirements.”

1.3 PERFORMANCE REQUIREMENTS

A. General

1. Performance data for all fans and spare parts shall be determined in accordance with the provisions of ASHRAE 51.
2. Sound pressure level ratings of ducted fans shall comply with AMCA 301 and shall be the result of tests made in accordance with AMCA 300.
3. Sound pressure level ratings of non-ducted fans shall comply with AMCA 301 and shall be the result of tests made in accordance with AMCA 300. Application of sound pressure level ratings shall conform to AMCA 302. Unit construction shall conform to applicable standards contained in AMCA 99 and to requirements specified.
4. Safety provisions for power transmission equipment and non-ducted inlets and outlets shall include guards and screens, unless other provisions are required, and shall be constructed in accordance with applicable provisions of ANSI B11.19. Installation shall be such that fan vibration-isolation provisions are not negated.
5. Fan wheels shall be statically and dynamically balanced at the factory.

B. Corrosion Protection: All steel shall be mill-galvanized, or phosphatized and coated with minimum two coats, corrosion resistant enamel paint. Manufacturers paint and paint system shall meet the minimum specifications of: ASTM D 1735 water fog; ASTM B 117 salt spray; ASTM D 3359 adhesion; and ASTM G 152 / ASTM G 153 weathermeter.

1.4 SQUARE IN-LINE CENTRIFUGAL FANS

A. Housing Material: Reinforced steel.

B. Housing Coating Hot-dip galvanized.

C. Drive: Direct or Belt driven.

D. Wheels: Aluminum airfoil blades welded to aluminum hub.

E. Motor Enclosure: Totally enclosed, fan cooled

1.5 TUBULAR IN-LINE CENTRIFUGAL FANS

A. Housing Material: Reinforced steel.

B. Housing Coating: Hot-dip galvanized.

C. Drive: Direct or Belt driven.

D. Wheels: Steel or Aluminum airfoil blades welded to aluminum hub.

E. Motor Enclosure: Totally enclosed, fan cooled

1.6 KITCHEN HOODS EXHAUST FANS (ECOLOGY UNIT)

A. Fan Unit: A package consisting of a backward inclined exhaust fan with heavy duty bearings, fan isolators, sound attenuation, two grease sheaves, filter and odor reducing sections.

B. Ecology unit shall be UL or ETL listed for kitchen grease exhaust and comply with NFPA – 96.

C. Ecology unit shall conform to ANSI/UL STD867 & UL STD 710 where applicable or approved equal.

D. Pre-filter Section: The pre filter section shall include 2 inch deep steel washable permanent filters according to ASHRAE 52-76 filters. Filter frames shall be constructed of steel.. All filters shall be removable without the use of tools through side access doors with lift and turn latches. Filters are to be cleanable with a water hose and soapy water.

E. Second stage filtration: 525 mm bag filter 90% ASHRAE 52-76 filters arranged in a v-bank configuration to increase filter area and reduce static pressure.

F. Third stage filtration: Absolute HEPA filter 305 mm DOP filter 99.97% ASHRAE 52-76 filters.

G. Fan: Single width, single inlet, airfoil centrifugal fan statically and dynamically balanced.

H. Fan Shaft: The fan shall be mounted on a heavy duty turned ground and polished steel shaft internally isolated. Pre-lubricated heavy duty bearings.

I. Motor: Squirrel cage, induction type with in-built thermal overload protection. Motor is to be class F insulation for motors outside air stream and class H insulation for motors inside airstream.

J. Odor Control Module: Odor control section shall be one of the following;

1. Pellets: The section consists of metal cells filled with activated alumna pellets impregnated with potassium permanganate. The odor is controlled through a combination of sorption and

a chemical modification of the gaseous contaminates. The odour media is non-toxic and non-flammable. The pellets are contained in perforated cells located in a separate odour reduction section normally located between the filter box and the tan box. All of the exhaust air is drawn over the pellets whenever the fan is operating. The cells are removed through a side access door on the odor section.

2. UV module: Self-cleaning inner surface. High output lamps designed to run for 13,000 hrs at optimum capacity. Ozone regulation technology shall control ozone production in line with cooking activity. Allows increases in air speed without significant effect on performance.
3. Rigid, bonded, activated carbon panels shall be furnished to remove both base and acid odor molecules. Carbon mass shall be applied at a minimum of 100 lbs. per 1,000 cfm (45.2 kg. per 472 l/s) of exhaust air volume. Panels shall be held in place by gasketed, extruded aluminum tracks arranged in a v-bank configuration.

K. Fan and Filter box Casing: 16 gauge steel, primed and painted suitably reinforced to ensure rigidity. An access door is provided to the exhaust fan motor and drive section. The casing is wrapped with 25mm sound attenuation insulation. The exhaust fan section shall be internally /externally spring isolated.

L. Fire Protection: Ecology unit shall be provided with an automatic fire suppression system; wet chemical type, or as recommended by the Ecology unit and fire suppression system manufacturers; ensuring protection of all the unit's sections and electrical components, and complying with requirements of NFPA-96 and NFPA 17A.

M. Control panel in stainless steel comprising on-off, PLC control, system status display, alarm buzzer, silencing button, control relays, and terminal strip for field wiring.

END OF SECTION 233416

SECTION 233423 - HVAC POWER VENTILATORS

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification for HVAC power ventlators, as listed in the “Saudi Mechanical Code-”, SBC 501,”Saudi Energy Conservation Code” SBC 601 and the standards listed below in this section; whichever is more stringent.

C. AMCA Certification for Fan Sound Performance Rating: AMCA 311.

D. AMCA Certification for Fan Aerodynamic Performance Rating: AMCA 211.

E. AMCA Certification for Fan Energy Index (FEI): AMCA 211.

F. UL Compliance: UL 705 and UL 762.

1.2 SUSTAINABILITY REQUIREMENTS

A. Comply with the requirements as specified in Section 0181134.14 “Sustainability Design Requirements.”

1.3 AXIAL ROOF VENTILATORS

A. Direct-drive or belt-driven axial type, with removable, spun-aluminum housing.

1. Fan Wheel: Steel.
2. Disconnect switch outside fan housing.
3. Bird screens.
4. Backdraft dampers.
5. Motorized dampers.
6. Galvanized-steel roof curbs with self-flashing without cant strip and with mounting flange prefabricated roof sound curb.

1.4 CEILING-MOUNTED VENTILATORS

A. Housing: Steel with acoustical insulation.

B. Backdraft Damper: Integral.

C. Grille: Plastic, louvered.

D. Accessories:

1. Variable-speed motor controller.
2. Manual starter switch.
3. Time-delay switch.
4. Motion sensor.
5. Ceiling radiation damper.

6. Washable aluminum filter.
7. Vibration isolators.
8. Roof jack or wall cap and transition fittings.

1.5 CENTRIFUGAL VENTILATORS - ROOF DOWNBLAST

A. Direct-driven or belt-driven centrifugal type, with galvanized-steel, mushroom-domed top; square, one-piece aluminum base with venturi inlet cone.

B. Fan Wheels: Aluminum hub and wheel with backward-inclined blades; spark proof construction.

C. Accessories:

1. Variable-speed motor controller.
2. Disconnect switch outside fan housing.
3. Bird screens.
4. Backdraft dampers.
5. Motorized dampers.
6. Galvanized-steel roof curbs with self-flashing without cant strip and with mounting flangePrefabricated roof sound curb.

1.6 CENTRIFUGAL VENTILATORS - ROOF UPBLAST OR SIDEWALL

A. Configuration: Direct-drive or belt-driven centrifugal roof upblast ventilator

B. Housing: Removable galvanized-steel, mushroom-domed top; square. One-piece aluminum base with venture inlet cone. Provide grease collector.

C. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.

D. Accessories:

1. Variable-speed controller.
2. Disconnect switch outside fan housing.
3. Bird screens.
4. Backdraft dampers.
5. Motorized dampers.
6. Galvanized-steel roof curbs with self-flashing without cant strip and with mounting flange built-in cant and mounting flange built-in raised cant and mounting flange vented curb for kitchen exhaust.
7. Grease Hood Kitchen Exhaust: UL 762 listed for grease-laden air.
8. NFPA 96 code requirements for commercial cooking operations.
9. Prefabricated roof sound curb.

1.7 SIDEWALL PROPELLER FANS

A. Direct-drive or belt-driven propeller type, with galvanized-steel housing and orifice ring.

1. Fan Wheels: Steel

B. Accessories:

1. Disconnect switch.
2. Gravity backdraft dampers.

3. Motorized dampers.
4. Motor-side back guard.
5. Wall sleeve.
6. Weathershield hood.
7. Weathershield front guard.

1.8 UPBLAST PROPELLER ROOF EXHAUST FANS

A. Direct-drive or belt-driven upblast propeller kitchen ventilator, with galvanized-steel housing. Provide grease collector.

1. Replaceable fan wheel with cast aluminum, airfoil blades.
2. Galvanized-steel roof curbs with self-flashing without cant strip and with mounting flange

B. Accessories:

1. Disconnect switch outside fan housing.
2. Bird screens.
3. Backdraft dampers.
4. Motorized dampers.
5. Galvanized-steel roof curbs with self-flashing without cant strip and with mounting flange.
6. Grease Hood Kitchen Exhaust: UL 762 listed for grease-laden air.
7. NFPA 96 code requirements for commercial cooking operations.
8. Prefabricated roof sound curb.

END OF SECTION 233423

SECTION 233433.13 - COMMERCIAL AIR CURTAINS

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification for air curtains, as listed in, but not limited to the “Saudi Energy Conservation Code-”, SBC 601, and “Saudi Mechanical Code” SBC 501, and the standards listed below in this section; whichever is more stringent.

C. Quality Standard for Fan Performance: AMCA 220.

D. Quality Standard for Air Curtains in Foodservice Establishments: NSF 37.

E. Quality Standard for Coils: AHRI 410.

1.2 SUSTAINABILITY REQUIREMENTS

A. Comply with the requirements as specified in Section 0181134.14 “Sustainability Design Requirements.”

1.3 WARRANTY

A. Materials and Workmanship: 24 months.

1.4 COMPONENTS

A. Housing Materials: Galvanized steel with epoxy-enamel, powder-coat finish.

1. Discharge Nozzles: Adjustable.

B. Air Intake: Grilles.

C. Fans: Direct drive, galvanized steel, centrifugal.

D. Motors: Single speed, totally enclosed, air over.

E. Filters: Washable panel type.

F. Controls:

1. Built-in thermostat.
2. Automatic door switch.
3. Start-stop, push-button switch.
4. Three-speed fan switch.
5. Time-delay relay to allow air curtain to operate from 0.5 seconds to 10 hours.
6. Motor-control panel.

G. Accessories:

1. Mounting brackets.
2. Discharge extension neck for ceiling-recessed installation.

END OF SECTION 233433.13

SECTION 233600 - AIR TERMINAL UNITS

1.1 QUALITY ASSURANCE

A. Products and equipment shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, and installation for air terminal units, as listed in, but not limited to, the “Saudi Building Code-” SBC 201, “Saudi Mechanical Code” SBC 501, and the standards listed below in this section; whichever is more stringent

C. Product Options: Drawings and schedules indicate requirements of air terminals and are based on specific systems selected. Other manufacturers' systems with equal performance characteristics may be considered. Refer to Division 1 Section "Product Requirements.”

D. Listing and Labeling: Provide electrically operated air terminals specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.

E. NFPA Compliance: Install air terminals according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

F. Comply with listed and labeled as defined in latest and relevant IEC standard, by a testing agency acceptable to the Engineer.

G. The maximum noise level for any ceiling mounted item shall not exceed NC 35. Units shall meet the airborne and radiated sound-power level (PWL) requirements scheduled, to attain the specified NC levels. An 18-dB space attenuation shall be assumed in all octave bands or as recommended by the manufacturer with consideration given to downstream duct construction and configuration in determining airborne NC levels. Sound levels shall be tested in accordance with ANSI/ASA S12.23.

1.2 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

1.3 PRODUCTS

A. Modulating, Single-Duct Air Terminal Units:

1. Description: Volume-damper assembly inside unit casing.
2. Casing: Galvanized steel.

a. Casing Lining: 13-mm- thick, neoprene or vinyl-coated fibrous glass insulation 24 kg/cu. m density complying with NFPA 90A requirements with UL 181 antimicrobial erosion-resistant coating with perforated metal liner.

3. Rating and Performance Certification: AHRI Industry Standards 880 I-P or 881 SI.

a. Maximum pressure drop: As shown on the drawings.
b. The inlet pressure should not be less than 374 Pa (1-1/2 inches water gage), unless shown otherwise on drawings. Provide terminal sound attenuators where necessary to comply with the noise criteria.

4. Volume Damper: Galvanized steel with flow-sensing ring and maximum damper leakage of 2 percent of nominal flow at 500 Pa inlet static pressure.
5. Attenuator Section: Absorptive, 1000 mm long, with casing material matching unit casing.
6. Controls: DDC; Damper operator, thermostat, and other devices compatible with temperature controls specified in other Sections.

B. Hangers and supports.

C. Seismic restraints.

1.4 SOURCE QUALITY CONTROL

A. AHRI 880 Certification: Test, rate, and label assembled air terminal units in accordance with AHRI 880.

B.

1.5 FIELD QUALITY CONTROL

A. Testing Agency: Contractor engaged.

END OF SECTION 233600

SECTION 233713.13 - AIR DIFFUSERS

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, and installation, for air diffusers, as listed in the “Saudi Mechanical Code-”, SBC 501, and the standards listed below in this section; whichever is more stringent.

C. Product Options: Drawings and schedules indicate specific requirements of diffusers and are based on the specific requirements of the systems selected. Other manufacturers' products with equal performance characteristics may be considered. Refer to Division 1 Section "Product Requirements."

D. NFPA Compliance: Install diffusers, according to NFPA 90A, "Standard for the Installation of Air-Conditioning and Ventilating Systems."

1.2 PRODUCTS

A. Round ceiling diffusers, fully adjustable.

B. Rectangular and square ceiling diffusers, fixed.

C. Linear bar diffusers with narrow core spacing arrangement.

D. Linear slot diffusers.

END OF SECTION 233713.13

SECTION 233713.23 - REGISTERS AND GRILLES

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, and installation, for air registers and grilles, as listed in the “Saudi Mechanical Code-”, SBC 501, and the standards listed below in this section; whichever is more stringent.

C. Product Options: Drawings and schedules indicate specific requirements of, registers, and grilles and are based on the specific requirements of the systems selected. Other manufacturers' products with equal performance characteristics may be considered. Refer to Division 1 Section "Product Requirements."

D. NFPA Compliance: Install, registers, and grilles according to NFPA 90A, "Standard for the Installation of Air-Conditioning and Ventilating Systems."

1.2 PRODUCTS

A. Registers: Adjustable with adjustable opposed-blade damper.

B. Grilles: Fixed

C. Linear bar grilles with grid face arrangement.

END OF SECTION 233713.23

SECTION 234100 - PARTICULATE AIR FILTRATION

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification for high efficiency particulate filters, as listed in, but not limited to the “Saudi Mechanical Code-”, SBC 501, “Saudi Energy Conservation Code” SBC 601, and the standards listed below in this section; whichever is more stringent.

C. Quality Standards: ASHRAE 62.1, ASHRAE 52.2, NFPA 90A, NFPA 90B, and UL 900.

D. Nameplates: Each filter shall bear a label or nameplate indicating manufacturer's name, filter size, rated efficiency, UL classification.

1.2 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance:

1. Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

B. Comply with NFPA 90A and NFPA 90B.

C. Comply with UL 900.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 and relevant IEC/EN standards, by a qualified testing agency, and marked for intended location and application.

1.3 PRODUCTS

A. Metal Panel Filters:

1. Description: Factory fabricated, flat panel type, cleanable air filters with holding frames. Initial pressure drop at a face velocity of 2.5 meter per second shall be 55 Pa. Average dust-spot efficiency shall be 18 percent and arrestance shall be 87 percent when filter is operated to a final pressure drop of 250 Pa. Under these circumstances, dust-holding capacity shall be 750 grams per square meter of face area.
2. Media: washable, constructed of non-woven synthetic-fabric-type, supported on rigid pleats of suitable grid material. Filter element shall be sealed into an enclosing 16 GA galvanized steel frame of rigid chipboard, providing a unit that will not rack.
3. Filter-Media Frame: Galvanized steel 18 GA minimum.

B. Flat Panel Filters:

1. Media: Interlaced glass or Cotton and synthetic fibers, coated with antimicrobial agent and nonflammable adhesive.
2. Filter-Media Frame: Cardboard frame with perforated metal retainer or Galvanized steel with metal grid on outlet side and steel rod grid on inlet side, hinged, with pull and retaining handles.

C. Extended-Surface, General

1. Use factory assembled air filters of the extended surface type with supported or non-supported cartridges for removal of particulate matter in air-conditioning, heating and ventilating systems. Filter units shall be of the extended surface type fabricated for disposal when the dust-load limit is reached as indicated by maximum (final) pressure drop.
2. Filter Classification: UL approved Class 1 or Class 2 conforming to UL Standard 900.
3. Filter Grades, Percent, Nominal Efficiency and Application:

    a. Grade A: 90-95 after-filter.
    b. Grade B: 80-85 after-filter.
    c. Grade C: 50-60 prefilter.
    d. Grade D: 25-30 prefilter.

4. Filter Media:

    a. Grade A, B and C Nonsupported (Bag) Type: Construct media of high-density glass fibers or other suitable fibers. Enclose or pocket each pleat in woven or non-woven backing material. Seal and fasten (stitch) to maintain pleat shape in a proper frame to insure no air leakage for life of filter. Staples and stays are prohibited.
    b. Grade A, B and C Supported (Rigid Pleated) Type: Media shall be composed of high-density glass fibers or other suitable fibers. Fastening methods used to maintain pleat shape, (metal backing or aluminum separators) shall be sealed in a proper enclosing frame to ensure no air leakage for life of filter. Staples and stays are prohibited.
    c. Grade D (Pleated) Type: Media shall be composed of synthetic/natural fibers. A metal grid backing shall be bonded to the air leaving side of the media to maintain uniform pleat shape and stability for proper airflow and maximum dust loading. The media frame shall be constructed of high strength moisture resistant fiber or beverage board. Bond the pleated media pack on all four edges to ensure no air leakage for the life of the filter. Staples and stays are prohibited.

5. Filter Efficiency and Arrestance: Efficiency and arrestance of filters shall be determined in accordance with ASHRAE 52.1 and ASHRAE 52.2. Atmospheric dust spot efficiency and synthetic dust weight arrestance shall not be less than the following:

    a. Grade A

        1) Percentage of Initial Efficiency: 75.4
        2) Percentage of Average Efficiency: 86.4
        3) Percentage of Average Arrestance: 99.0

    b. Grade B

        1) Percentage of Initial Efficiency: 58.0
        2) Percentage of Average Efficiency: 79.0
        3) Percentage of Average Arrestance: 98.0

    c. Grade C

        1) Percentage of Initial Efficiency: 25.0
        2) Percentage of Average Efficiency: 53.0
        3) Percentage of Average Arrestance: 97.0

    d. Grade D

        1) Percentage of Initial Efficiency: Less than 20.0
        2) Percentage of Average Efficiency: 22.0
        3) Percentage of Average Arrestance: 89.0

6. Maximum initial and final resistance, Pa (inches of water), for each filter cartridge when operated at 150 m/min (500 feet per minute) face velocity:

   a. Grade A (Bag)

      1) Initial Resistance: 130 (0.52)
      2) Final resistance: 250 (1.00)

   b. Grade A (Rigid Pleated)

      1) Initial Resistance: 185 (0.74)
      2) Final resistance: 250 (1.00)

   c. Grade B (Bag)

      1) Initial Resistance: 100 (0.40)
      2) Final resistance: 250 (1.00)

   d. Grade B (Rigid Pleated)

      1) Initial Resistance: 150 (0.60)
      2) Final resistance: 250 (1.00)

   e. Grade C (Bag)

      1) Initial Resistance: 70 (0.28)
      2) Final resistance: 200 (0.80)

   f. Grade C (Rigid Pleated)

      1) Initial Resistance: 85 (0.35)
      2) Final resistance: 200 (0.80)

   g. Grade D (2-inch deep)

      1) Initial Resistance: 80 (0.32)
      2) Final resistance: 175 (0.70)

   h. Grade D (4-inch deep)

      1) Initial Resistance: 65 (0.27)
      2) Final resistance: 175 (0.70)

7. Dust Holding Capacity: When tested to 250 Pa (l.00-inch water) at 150 m/min (500 fpm) face velocity, the dust holding capacity for each 600 mm by 600 mm (24 inches by 24 inches) (face area) filter shall be at least the values listed below. For other filter sizes the dust holding capacity shall be proportionally higher or lower to the face area.

   a. Grade A (Bag): 300 grams.
   b. Grade A (Rigid Pleated): 90 grams.
   c. Grade B (Bag): 430 grams.
   d. Grade B (Rigid Pleated): 175 grams.
   e. Grade C (Bag): 910 grams.
   f. Grade C (Rigid Pleated): 250 grams.
   g. Grade D (Bag): 150 grams.
   h. Grade D (Rigid Pleated): 300 grams.

8. Minimum Media Area: The minimum net effective media area in square meter (square feet) for each 600 mm by 600 mm (24 inches by 24 inches) (face area) filter at 150 m/min (500 fpm) face velocity shall be at least the values listed below. For other filter sizes the net effective media area shall be proportionally higher or lower.

    a. Grade A (Bag): 8.5 (91.0).
    b. Grade A (Rigid Pleated): 5.3 (57.0).
    c. Grade B (Bag): 8.5 (91.0).
    d. Grade B (Rigid Pleated): 5.3 (57.0).
    e. Grade C (Bag): 8.5 (91.0).
    f. Grade C (Rigid Pleated): 5.3 (57.0).
    g. Grade D (Bag): 1.4 (14.8).
    h. Grade D (Rigid Pleated): 2.1 (23.0).

D. Extended-Surface Disposable Pleated Panel Filters:

1. Media: Interlaced glass or Cotton and synthetic fibers, coated with antimicrobial agent, formed into deep V-shaped pleats held by self-supporting wire grid..
2. Filter-Media Frame: Cardboard frame with perforated metal retainer or Galvanized steel, fire-retardent, 19 mm particleboard with gaskets.

E. Extended-Surface Nonsupported Bag Filters:

1. Media: Fibrous material formed into tapered pleats and coated with antimicrobial agent.
2. Filter-Media Frame: Galvanized steel or Hard polyurethane foam.
3. Media Frames: Galvanized steel.

F. Front- and Back-Access Filter Frames: Aluminum framing with prefilters in a separate track, removable from front or back.

G. Side-Access Housings: Galvanized steel with disposable prefilters and access doors, with interior surface finish complying with ASHRAE 62.1.

H. Filter Gauges: Diaphragm or Manometer type.

END OF SECTION 234100

SECTION 236200 - PACKAGED COMPRESSOR AND CONDENSER UNITS

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification for packaged compressor and condenser units, as listed in, but not limited to the“Saudi Energy Conservation Code-”, SBC 601, “Saudi Mechanical Code” SBC 501, and the standards listed below in this section; whichever is more stringent.

C. Listing and Labeling: Provide electrically operated equipment specified in this Section that is listed and labeled.
The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.

D. Fabricate and label water-cooled condensers according to ASME Boiler & Pressure Vessel Code - Section VIII - Pressure Vessels Division 1.

E. Comply with UL 1995, “Heating and Cooling Equipment.”

1.2 SUSTAINABILITY REQUIREMENTS

A. Comply with the requirements as specified in Section 0181134.14 “Sustainability Design Requirements.”

1.3 PERFORMANCE REQUIREMENTS

A. Quality Standard: ASHRAE 15

1.4 WARRANTY

A. Warranty Period:

1. Failures include, but are not limited to, the following:

   a. Compressor failure.
   b. Condenser coil leak.

2. Warranty Period: Two years from date of Substantial Completion.
3. Warranty Period (Compressor, Motor and Bearings): Five years from date of Substantial Completion.

1.5 PRODUCTS

A. Air-Cooled Units, 1 to 5 Tons (3.5 to 17.6 kW):

1. Compressor: Scroll, hermetically sealed and isolated, two speed.
2. Refrigerant: R-407C or R-410A.
3. Condenser Coil: Copper-tube, aluminum-fin coil; circuited for integral liquid subcooler, with removable drain pan and brass service valves with service ports.

4. Condenser Fan: Direct-drive, metal propeller fan; with permanently lubricated, totally enclosed fan motor.
5. Accessories: Crankcase heater, cycle protector, electronic programmable thermostat, low-voltage thermostat and subbase, evaporator freeze thermostat, filter-dryer, high-pressure switch, liquid-line solenoid, low-ambient controller, low-pressure switch, plastic mounting base, precharged and preinsulated suction and liquid tubing, sound hood, thermostatic expansion valve, time-delay relay, reversing valve.
6. Unit Casing: Galvanized steel, finished with baked enamel.

B. Air-Cooled Units, 6 to 120 Tons (21 to 422 kW):
1. Compressor: Hermetic or semihermetic rotary-screw, withvariable-frequency controller .Refrigerant: R-407C or R-410A.
2. Condenser Coil: Seamless copper-tube, aluminum-fin coil, including subcooling circuit and backseating liquid-line service access valve. Factory-applied baked epoxy anti-corrosion coating to assembled coil.
3. Condenser Fan: Propeller type.
4. Controls: Factory mounted and wired.
5. Accessories: Electronic programmable thermostat,Low-voltage thermostat and subbase, low-ambient controller, gauge panel, hot-gas bypass kit, part-winding-start, timing relay, circuit breakers, and contactors, reversing valve, factory-mounted and wired non-fused disconnect switch, low-noise fans, 220 V ac convenience ground-fault circuit interrupter receptacle in weatherproof enclosure, vibration isolation, and security grilles.
6. Unit Casing: Galvanized or zinc-coated steel. Corrosion resistance.

1.6 SOURCE QUALITY CONTROL

A. Compressor and Condenser Units: Certify capacity performance in accordance with ARI 210/240/ARI 340/360.

B. Sound-Power Level Ratings: Factory test sound-power-level ratings in accordance with AHRI 270/AHRI 370.

END OF SECTION 236200

SECTION 237313.16 - INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

1.1 SUMMARY

A. Insulated, double-wall-casing, indoor, semi-custom, factory-assembled, air-handling units.

1.2 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification for HVAC units, as listed in, but not limited to, the “Saudi Green Construction Code” SBC 1001, the “Saudi Energy Conservation Code-”, SBC 601, and “Saudi Mechanical Code” SBC 501, and the standards listed below in this section; whichever is more stringent.

C. Quality Standards: AHRI 430, AHRI 1060, AHRI 260 or AMCA 311, AMCA 210, NFPA 70, and NFPA 90A.

D. NFPA Compliance: Central-station air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

E. UL/ETL Compliance: Electric coils, along with complete central-station air-handling unit, shall be listed and labeled by ETL in compliance with UL requirements.

F. AHRI Certification: Central-station air-handling units and their components shall be factory tested according to the applicable portions of ANSI/AHRI 430, "Performance Rating of Central-Station Air-Handling Units," and shall be listed and bear the label of the Air-Conditioning, Heating and Refrigeration Institute (AHRI) or equivalent relevant BS/EN standards.

G. Provide motors required as part of air-handling units that are listed and labeled by UL and comply with applicable NEMA standards or equivalent characteristics in accordance with applicable parts of IEC 60034.

H. Condensation: During first year guarantee period, if condensation forms on any section of air handler when unit is operating at design conditions, the Contractor shall replace or repair unit to correct the situation. Repairs shall not impair unit or component accessibility and future reparability and inherent access for maintenance. All repairs shall be subject to the Engineer’s approval.

I. Electrical Components, Devices, and Accessories: Listed and labeled as defined in latest and relevant IEC standard, by a testing agency acceptable to the Engineer.

J. Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.

K. Quality Standards: AHRI 430, AHRI 1060, AMCA 301 or AHRI 260, NFPA 70, and NFPA 90A.

1.3 SUSTAINABLE DESIGN REQUIREMENTS

A. Comply with the requirements as specified in Section 0181134.14 “Sustainability Design Requirements.”

B. Comply with ASHRAE 62.1 and ASHRAE/IES 90.1.

1.4 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 and relevant IEC/EN standards, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation, supports, and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

F. Structural Performance:

1. Casing Panels: Self-supporting and capable of withstanding positive/negative 133 percent internal static pressure indicated, without exceeding a midpoint deflection of L/200 where “L” is the unsupported span length within completed casings.
2. Floor and Roof Panels: Self-supporting and capable of withstanding 136-kg static load at midspan, without exceeding a midpoint deflection of 0.0042 mm/mm.
3. Roof Panels: Self-supporting and capable of withstanding a static snow load of 146 kg/sq. m, without exceeding a midpoint deflection of 0.0042 mm/mm.

G. Casing Leakage Performance: ASHRAE 111, Class 6 leakage or better at plus or minus 2000 Pa.

H. Provide fans and motors capable of stable operation at design conditions and at design cubic meters per minute (cubic feet per minute) and 110 percent pressure as stated above.

1. Lower than design pressure drop of approved individual components may allow use of a smaller fan motor and still provide the safety factor. When submitted as a deviation, a smaller motor may be approved in the interest of energy conservation. Such a deviation shall not qualify for any value engineering incentive claim or reward.

I. Select fan operating point to right hand side of peak static pressure point and near the peak of static efficiency.

J. Operating Limits: AMCA 99 or equivalent relevant BS/EN standards.

K. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified.
2. Component Importance Factor: 1.0.

L. Wind Performance: Air-handling units are to withstand the effects of wind determined in accordance with ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

1.5 COMPONENTS

A. Unit Casing:

1. Base Rail: Galvanized steel
2. Outside Casing: Galvanized steel
3. Outside Casing Finish: Manufacturer's standard.
4. Inside Casing: Galvanized steel solid; antimicrobial coating.
5. Floor Plate: Galvanized steel, antimicrobial coating.
6. Cabinet Insulation: Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071 or injected CFC free polyurethane foam insulation complying with NFPA 90A flame spread and smoke generation requirements, “Installation of Air Conditioning and Ventilating Systems,” for insulation; 50 mm thick.
7. Casing Panel R-Value: Thermal Conductance: Maximum 0.68 W/sq.mK.
8. Static-Pressure Classifications for Unit Sections Upstream of Fans: 750 Pa (3-inch wg), 1000 Pa (4-inch wg), or 1500 Pa (6-inch wg) as applicable as per equipment schedule and drawings.
9. Static-Pressure Classifications for Unit Sections Downstream and Including Fans: 750 Pa (3-inch wg), 1000 Pa (4-inch wg), or 1500 Pa (6-inch wg) as applicable as per equipment schedule and drawings.
10. Inspection access panels and access doors.
11. Condensate Drain Pans Double-wall, stainless steel, formed sections.

B. Centrifugal Fan Arrays:

1. Uniform airflow profile when measured 300 mm upstream of fan inlet and 1200 mm downstream of fan inlet.
2. Vibration isolated and balanced.
3. Airflow Measurement: Local indicating and remote monitoring.
4. Array Control: Remote.
5. Wheels: Aluminum, airfoil blades, aluminum hubs, and backplates.
6. Frames: Aluminum or galvanized steel.
7. Drives: Direct.
8. Inlet cone.
9. Motors: NEMA MG 1, electronically commutated.
10. Energy Efficiency: Complying with governing energy codes.
11. Fan sound silencing enclosures.
12. Backdraft dampers.
13. Protective screens.

C. Coils:

1. Coil Sections: Common or individual, insulated, galvanized-steel casings.
2. Cooling Coil: Refrigerant.

3. Refrigerant Coils: Designed for use with R-407C or R-410 refrigerant.

    a. Tubes: Copper.
    b. Fins: Aluminum
    c. Headers: Copper.
    d. Frames: Galvanized steel.

D. Prefilters:

1. UL 900.
2. Panel.

E. Final Filters:

1. UL 900.
2. Bag.

F. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2

Filter Access: Side.

Filter gauges.

G. Dampers:

1. Leakage Rate: Not to exceed 20 L/s per sq. m at 250 Pa and 40 L/s per sq. m at 1.0 MPa; AMCA 500.
2. Damper Operators: Electronic.
3. Zone Dampers: Two; single blade; galvanized steel.
4. Face-and-Bypass Dampers: Opposed blade; galvanized steel.
5. Low-Leakage, Outdoor-Air Dampers: Double skin; airfoil blade; galvanized steel, AMCA 511.
6. Outdoor- and Return-Air Dampers: Parallel blade; galvanized steel
7. Combination filter and mixing box.

H. Sound Attenuators:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials with flame-spread index not exceeding 25 and smoke-developed index not exceeding 50; ASTM E84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with ASHRAE 62.1.
4. Configuration: Straight or Elbow.
5. Shape: Rectangular.
6. Attenuation Mechanism: Acoustic glass fiber, inert and vermin proof; or, Packless.

I. UV-C Lamp System: Factory installed and pre-engineered.

1.6 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209M.

1.7 SOURCE QUALITY CONTROL

A. General:

1. AHRI or Eurovent certified AHUs: AHUs selected by the Engineer for testing shall be factory assembled and tested prior to shipment and shall be shipped prior to any untested units.
2. Non-AHRI certified AHUs: All units shall be factory assembled and tested.
3. Units specified to be tested shall be factory assembled and tested in accordance with specified Test Procedure to demonstrate compliance with required unit capacities, ensure correct fit of all components and minimize field assembly labor.

B. Air-handling units to be compliant with VDI 6022 Part 1, DIN 1946-4, and tested according to ISO 846 by an agency recognized and accepted by the local authorities having jurisdiction.

C. AHRI 430 Certification: Test, rate, and label air-handling units and their components in accordance with AHRI 430.

D. AHRI 1060 Certification: Test, rate, and label air-handling units that include air-to-air energy recovery devices in accordance with AHRI 1060.

E. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label in accordance with AHRI 260 or AMCA 311.

F. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.

G. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

H. Refrigerant Coils: Factory tested to minimum 450-psig (3105-kPa) internal pressure and to minimum 300-psig (2070-kPa) internal pressure while underwater, according to AHRI 410 and ASHRAE 33.

I. Approval:

1. Factory tests shall be witnessed by the Engineer’s and Employer’s representative. The team will comprise at least three persons from the Client’s side. All expenses to be borne by the Contractor . The Contractor shall provide the Engineer with a minimum two-week notice prior to proposed schedule test.
2. Failure of AHU to meet test requirements shall require correction of deficiency and re-testing of unit.
3. Submit written results of factory tests for approval prior to shipping.

1.8 INSTALLATION

A. Equipment Mounting: Install air-handling units on concrete bases with vibration isolation devices as shown on drawings

B. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers.

END OF SECTION 237313.16

SECTION 237343.16 - OUTDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

1.1 SUMMARY

A. Insulated, double-wall-casing, outdoor, semi-custom, factory-assembled, air-handling units.

1.2 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification for air-handling units, as listed in, but not limited to the “Saudi Energy Conservation Code-”, SBC 601, and “Saudi Mechanical Code” SBC 501, and the standards listed below in this section; whichever is more stringent.

C. Quality Standards: AHRI 430, AHRI 1060, AMCA 301 or AHRI 260, AMCA 210, NFPA 70, and NFPA 90A.

D. NFPA Compliance: Central-station air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

E. UL/ETL Compliance: Electric coils, along with complete central-station air-handling unit, shall be listed and labeled by ETL in compliance with UL requirements.

F. AHRI Certification: Central-station air-handling units and their components shall be factory tested according to the applicable portions of ANSI/AHRI 430, "Performance Rating of Central-Station Air-Handling Units," and shall be listed and bear the label of the Air-Conditioning, Heating and Refrigeration Institute (AHRI) or equivalent relevant BS/EN standards.

G. Provide motors required as part of air-handling units that are listed and labeled by UL and comply with applicable NEMA standards or equivalent characteristics in accordance with applicable parts of IEC 60034.

H. Condensation: During first year guarantee period, if condensation forms on any section of air handler when unit is operating at design conditions, the Contractor shall replace or repair unit to correct the situation. Repairs shall not impair unit or component accessibility and future reparability and inherent access for maintenance. All repairs shall be subject to the Engineer’s approval.

I. Electrical Components, Devices, and Accessories: Listed and labeled as defined in latest and relevant IEC standard, by a testing agency acceptable to the Engineer.

J. Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.

K. Quality Standards: AHRI 430, AHRI 1060, AMCA 301 or AHRI 260, NFPA 70, and NFPA 90A.

1.3 SUSTAINABLE DESIGN REQUIREMENTS

A. Comply with the requirements as specified in Section 0181134.14 “Sustainability Design Requirements.”

B. Comply with ASHRAE 62.1 and ASHRAE/IES 90.1.

1.4 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 and relevant IEC/EN standards, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation, supports, and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

F. Structural Performance:

1. Casing Panels: Self-supporting and capable of withstanding positive/negative 133 percent internal static pressure indicated, without exceeding a midpoint deflection of L/200 where “L” is the unsupported span length within completed casings.
2. Floor and Roof Panels: Self-supporting and capable of withstanding 136-kg static load at midspan, without exceeding a midpoint deflection of 0.0042 mm/mm.
3. Roof Panels: Self-supporting and capable of withstanding a static snow load of 146 kg/sq. m, without exceeding a midpoint deflection of 0.0042 mm/mm.

G. Casing Leakage Performance: ASHRAE 111, Class 6 leakage or better at plus or minus 2000 Pa.

H. Provide fans and motors capable of stable operation at design conditions and at design cubic meters per minute (cubic feet per minute) and 110 percent pressure as stated above.

1. Lower than design pressure drop of approved individual components may allow use of a smaller fan motor and still provide the safety factor. When submitted as a deviation, a smaller motor may be approved in the interest of energy conservation. Such a deviation shall not qualify for any value engineering incentive claim or reward.

I. Select fan operating point to right hand side of peak static pressure point and near the peak of static efficiency.

J. Operating Limits: AMCA 99 or equivalent relevant BS/EN standards.

K. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified.
2. Component Importance Factor: 1.0.

L. Wind Performance: Air-handling units are to withstand the effects of wind determined in accordance with ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

1.5 COMPONENTS

A. AHUs shall be entirely of double wall galvanized steel construction. Galvanizing shall be hot dipped conforming to A653/A653M and shall provide a minimum of 0.275 kg of zinc per square meter (0.90 oz. of zinc per square foot) (G90). Aluminum constructed units may be provided subject to the Engineer's approval and documentation that structural rigidity is equal or greater than the galvanized steel specified.

B. Gaskets: All door and panel gaskets shall be high quality which seal airtight and retain their structural integrity and sealing capability after repeated assembly and disassembly of bolted panels and opening and closing of hinged components. Bolted sections may use a more permanent gasketing method provided they are not disassembled.

C. Unit Casing:

1. Base Rail: Galvanized steel
2. Outside Casing: Galvanized steel.
3. Outside Casing Finish: Manufacturer's standard.
4. Inside Casing: Galvanized steel; solid; antimicrobial coating.
5. Floor Plate: Galvanized steel; antimicrobial coating.
6. Cabinet Insulation: Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071 or injected CFC free polyurethane foam insulation complying with NFPA 90A flame spread and smoke generation requirements, "Installation of Air Conditioning and Ventilating Systems," for insulation; 2 inches (50 mm) thick.
7. Casing Panel R-Value: Thermal Conductance: Maximum 0.68 W/sq.mK.
8. Static-Pressure Classifications for Unit Sections Upstream of Fans: 750 Pa (3-inch wg), 1000 Pa (4-inch wg), or 1500 Pa (6-inch wg) as applicable as per equipment schedule and drawings.
9. Static-Pressure Classifications for Unit Sections Downstream and Including Fans: 750 Pa (3-inch wg), 1000 Pa (4-inch wg), or 1500 Pa (6-inch wg) as applicable as per equipment schedule and drawings.
10. Inspection access panels and access doors.
11. Condensate Drain Pans: Double-wall, stainless steel, formed sections

D. Centrifugal Fan Arrays:

1. Uniform airflow profile when measured 300 mm upstream of fan inlet and 1200 mm downstream of fan inlet.
2. Vibration isolated and balanced.
3. Airflow Measurement: Local indicating and remote monitoring.
4. Array Control: Remote.
5. Wheels: Aluminum, airfoil blades, aluminum hubs, and backplates.
6. Frames: Aluminum or galvanized steel.
7. Drives: Direct.
8. Inlet cone.
9. Motors: NEMA MG 1, electronically commutated.
10. Energy Efficiency: Complying with governing energy codes.
11. Fan sound silencing enclosures.
12. Backdraft dampers.
13. Protective screens.

E. Coils:

1. Coil Sections: Common or individual, insulated, galvanized-steel casings.
2. Cooling Coil: Refrigerant.

3. Refrigerant Coils: Designed for use with R-407C or R-410 refrigerant.

a. Tubes: Copper.

b. Fins: Aluminum
c. Headers: Copper.
d. Frames: Galvanized steel.

F. Prefilters:

1. UL 900.
2. Panel.

G. Final Filters:

1. UL 900.
2. Bag.

H. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2

I. Filter Access: Side.

J. Filter gauges.

K. Dampers:

1. Leakage Rate: Not to exceed 20 L/s per sq. m at 1-inch wg 250 Pa and 40 L/s per sq. m at 1.0 MPa; AMCA 500.
2. Damper Operators: Electronic.
3. Zone Dampers: Two; single blade; galvanized steel.
4. Face-and-Bypass Dampers: Opposed blade; galvanized steel.
5. Low-Leakage, Outdoor-Air Dampers: Double skin; airfoil blade; galvanized steel, AMCA 511.
6. Outdoor- and Return-Air Dampers: Parallel blade; galvanized steel.
7. Combination filter and mixing box.

L. Sound Attenuators:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials with flame-spread index not exceeding 25 and smoke-developed index not exceeding 50; ASTM E84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with ASHRAE 62.1.
4. Configuration: Straight or Elbow.
5. Shape: Rectangular.
6. Attenuation Mechanism: Acoustic glass fiber, inert and vermin proof; or, Packless.

M. UV-C Lamp System: Factory installed and pre-engineered.

1.6 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.

2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209M.

1.7 SOURCE QUALITY CONTROL

A. General:

1. AHRI or Eurovent certified AHUs: AHUs selected by the Engineer for testing shall be factory assembled and tested prior to shipment and shall be shipped prior to any untested units.
2. Non-AHRI certified AHUs: All units shall be factory assembled and tested.
3. Units specified to be tested shall be factory assembled and tested in accordance with specified Test Procedure to demonstrate compliance with required unit capacities, ensure correct fit of all components and minimize field assembly labor.

B. Air-handling units to be compliant with VDI 6022 Part 1, DIN 1946-4, and tested according to ISO 846 by an agency recognized and accepted by the local authorities having jurisdiction.

C. AHRI 430 Certification: Test, rate, and label air-handling units and their components in accordance with AHRI 430.

D. AHRI 1060 Certification: Test, rate, and label air-handling units that include air-to-air energy recovery devices in accordance with AHRI 1060.

E. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label in accordance with AHRI 260 or AMCA 311.

F. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.

G. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

H. Refrigerant Coils: Factory tested to minimum 450-psig (3105-kPa) internal pressure and to minimum 300-psig (2070-kPa) internal pressure while underwater, according to AHRI 410 and ASHRAE 33.

I. Approval:

1. Factory tests shall be witnessed by the Engineer’s and Employer’s representative. The team will comprise at least three persons from the Client’s side. All expenses to be borne by the Contractor . The Contractor shall provide the Engineer with a minimum two-week notice prior to proposed schedule test.
2. Failure of AHU to meet test requirements shall require correction of deficiency and re-testing of unit.
3. Submit written results of factory tests for approval prior to shipping.

1.8 INSTALLATION

A. Equipment Mounting: Install air-handling units on concrete bases with vibration isolation devices as shown on drawings.

END OF SECTION 237343.16

SECTION 238123.11 – SMALL CAPACITY (6 TONS (21 KW) AND SMALLER), COMPUTER-ROOM AIR-CONDITIONERS, FLOOR-MOUNTED UNITS

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification for HVAC units, as listed in, but not limited to the “Saudi Energy Conservation Code-”, SBC 601, and “Saudi Mechanical Code” SBC 501, and the standards listed below in this section; whichever is more stringent.

1.2 SUSTAINABILITY REQUIREMENTS

A. Comply with the requirements as specified in Section 0181134.14 “Sustainability Design Requirements.”

1.3 WARRANTY

A. Materials and Workmanship for Compressors: Five years.

B. Materials and Workmanship for Humidifiers: Three years.

C. Materials and Workmanship for Control Boards: Three years.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Computer-room air conditioners shall withstand the effects of earthquake motions determined according to SBC 201 and ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 MANUFACTURED UNITS

A. Self-contained, factory assembled, prewired, and prepiped.

B. Cabinet and Frame: Welded tubular-steel frame with removable steel panels, insulated, and with baked-enamel finish with floor stand for downflow units.

C. Supply-Air Fan: Forward curved, centrifugal, belt driven.

D. Compressor: Digital scroll, variable capacity.

E. Refrigerant: R-407C or R-410A.

F. Evaporator Coil: Direct-expansion cooling coil of seamless copper tubes expanded into aluminum fins with stainless-steel drain pan having an automatic condensate pump if required.

G. Integral Water-Cooled Refrigerant Condenser: Brazed-plate type with water or glycol solution medium.

H. Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with propeller or centrifugal fan, direct or belt driven, as per design requirements.

I. Hydronic Cooling Coil: Copper tubes expanded into aluminum fins with modulating control valve with stainless-steel drain pan having an automatic condensate pump if required.

J. Hot-Water Reheat: Copper-tube, aluminum-fin coil with two-way, modulating control valve, and cleanable Y-strainer.

K. Remote Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet; copper-tube, aluminum-fin coil; direct-drive propeller fan; and single-phase motor.

L. Glycol-solution pump package containing centrifugal pump.

M. Electric-Resistance Heating Coil: Finned-tube electric elements.

N. Pre-Filter: 50 mm thick.

O. Filter: 50 mm thick.

P. Humidifier: Infrared.

Q. Disconnect Switch: Locking or Non-locking.

R. Control System: Microprocessor unit remote-mounted panel with solid-state temperature- and humidity-control modules.

END OF SECTION 238123.11

SECTION 238123.12 – LARGE CAPACITY (7 TONS (25 KW) AND LARGER), COMPUTER-ROOM AIR-CONDITIONERS, FLOOR-MOUNTED UNITS

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, installation, and identification for HVAC units, as listed in, but not limited to the “Saudi Energy Conservation Code-”, SBC 601, and “Saudi Mechanical Code” SBC 501, and the standards listed below in this section; whichever is more stringent.

1.2 SUSTAINABILITY REQUIREMENTS

A. Comply with the requirements as specified in Section 0181134.14 “Sustainability Design Requirements.”

1.3 WARRANTY

A. Materials and Workmanship for Compressors: Five years.

B. Materials and Workmanship for Humidifiers: Three years.

C. Materials and Workmanship for Control Boards: Three years.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Computer-room air conditioners shall withstand the effects of earthquake motions determined according to SBC 201 and ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 MANUFACTURED UNITS

A. Self-contained, factory assembled, prewired, and prepiped.

B. Cabinet and Frame: Welded steel, insulated, and baked-enamel finish with floor stand for downflow units.

C. Supply-Air Fan: Double inlet, forward curved, centrifugal, belt driven.

D. Compressors: Semihermetic or Scroll, variable capacity.

E. Refrigerant: R-407C or R-410A.

F. Evaporator Coil: Alternate-row or split-face-circuit, direct-expansion coil of seamless copper tubes expanded into aluminum fins with stainless-steel drain pan having an automatic condensate pump if required.

G. Integral, Water-Cooled Refrigerant Condenser: ASME-labeled, shell-and-tube or Coaxial tube-in-tube type with water or glycol solution medium.

H. Remote Air-Cooled Refrigerant Condenser: Copper-tube, aluminum-fin coils with internal overload protection and integral electric control panel and disconnect switch. Control capacity by modulating fan speeds or three-way refrigerant bypass with receiver and isolation valve.

I. Hydronic Cooling Coil: Copper tubes expanded into aluminum fins with modulating control valve with stainless-steel drain pan having an automatic condensate pump.

J. Glycol Cooling Coil: Copper tubes expanded into aluminum fins with three-way control valve with water or glycol solution medium.

K. Reheat: Copper-tube, aluminum-fin coil with three-way solenoid valve and refrigerant check valve for hot gas reheat.

L. Remote Air-Cooled Glycol-Solution Cooler: Corrosion-resistant cabinet; copper-tube, aluminum-fin coils; multiple direct-drive propeller fans; and single-phase motors.

M. Glycol-solution pump package containing one or two centrifugal pump(s).

N. Electric-Resistance Heating Coil: Enclosed finned-tube electric elements for minimum of three stages.

O. Pre-Filter: Pleated cotton fabric 50 mm thick and MERV 8.

P. Filter: Pleated cotton fabric 50 mm thick and MERV 13.

Q. Humidifier: Electrode or Ultrasonic steam.

R. Integral electrical controls with disconnect switch.

S. Control System: Microprocessor unit remote-mounted panel with solid-state temperature- and humidity-control modules.

END OF SECTION 238123.12

SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONERS

1.1 Quality Assurance:

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, and installation for split air-conditioners, as listed in, but not limited to, the“Saudi Energy Conservation Code-”, SBC 601, “Saudi Mechanical Code” SBC 501, and the standards listed below in this section; whichever is more stringent

C. ASHRAE Compliance:
1. Fabricate and label refrigeration system to comply with ASHRAE 15 and 34 Package, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2010, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

D. Efficiency of selected unit shall meet and exceed requirements of SBC 1001 and ASHRAE 90.1

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.2 SUSTAINABILITY REQUIREMENTS

A. Comply with the requirements as specified in Section 0181134.14 “Sustainability Design Requirements.”

1.3 COMPONENTS

A. Concealed Evaporator-Fan Components:

1. Galvanized-steel chassis and drain pan.
2. Insulated.
3. Copper-tube refrigerant coil.
4. Electric heating coil.
5. Forward-curved galvanized fan.
6. Multispeed motor.
7. Permanent filters.

B. Floor-Mounted, Evaporator-Fan Components:

1. Enameled-steel cabinet with discharge grille.
2. Insulated.
3. Copper-tube refrigerant coil.
4. Electric heating coil.
5. Centrifugal fan.
6. Multispeed motor.
7. Disposable filters.

C. Wall- or Ceiling-Mounted, Evaporator-Fan Components:

1. Enameled-steel cabinet.
2. Copper-tube refrigerant coil.
3. Electric heating coil.
4. Centrifugal fan.
5. Multispeed motor.
6. Disposable filters.

D. Air-Cooled, Compressor-Condenser Components:

1. Enameled-steel casing.
2. Hermetically sealed scroll compressor.
3. Copper-tube refrigerant coil.
4. Heat-pump components.
5. Aluminum-propeller fan.

E. Water-Cooled, Compressor-Condenser Components:

1. Enameled-steel casing.
2. Hermetically sealed scroll compressor.
3. Heat-pump components.
4. Copper-tube heat exchanger.

F. Accessories: Low-voltage thermostat.

END OF SECTION 238126

SECTION 238129 - VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS

1.1 QUALITY ASSURANCE

A. Products and materials shall demonstrate compliance with requirements specified in Section 016000 “Product Requirements.”

B. Comply with the applicable requirements and recommendations of local Saudi Building Code (SBC) and the latest applicable local regulations for materials, tests, and installation, for VRV systems, as listed in, but not limited to, the “Saudi Energy Conservation Code-”, SBC 601, “Saudi Mechanical Code” SBC 501, and the standards listed below in this section; whichever is more stringent.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of units and are based on the specific system indicated. Other manufacturers' systems with equal performance characteristics may be considered.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 , Article 100.

E. ASHRAE Compliance: Fabricate and label refrigeration system to comply with ASHRAE 15 AND 34 PACKAGE , “Safety Standards for Refrigeration Systems.”

F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

G. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

Paint finish shall be suitable for hot and humid climates. Unit shall be capable and suitable of working at outdoor ambient temperature of 50 deg. C**.** Sound-power-level, decibels reference, 10 to the minus 12 power watt, at the fan operating speed selected to meet the specified capacity. Sound level shall not exceed 40dBa at low speed and 48dBa at high speed.

H. Sound-power-level data or values for these units shall be obtained in accordance with the test procedures specified in AHRI standards. Sound-power values apply to units provided with factory-fabricated cabinet enclosures and standard grilles. Values obtained for the standard cabinet models will be acceptable for concealed models without separate tests provided there is no variation between models as to the coil configuration, blowers, motor speeds, or relative arrangement of parts. Each unit shall be fastened securely to the building structure.

I. Manufacturer Qualifications:

1. Nationally recognized manufacturer of VRF HVAC systems and products.
2. Shipped VRF HVAC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
3. VRF HVAC systems and products that have been successfully tested and in use on at least five completed projects.
4. Having complete published catalog literature, installation, and operation and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:

    a. Product research and development.
    b. Product and application engineering.
    c. Product manufacturing, testing, and quality control.
    d. Technical support for system installation training, startup, commissioning, and troubleshooting of installations.

e. Owner training.

J. Factory-Authorized Service Representative Qualifications:

1. Authorized representative of, and trained by, VRF HVAC system manufacturer.
2. Demonstrated past experience with products being installed for period within five consecutive years before time of bid.
3. Demonstrated past experience on five projects of similar complexity, scope, and value.

    a. Each person assigned to Project shall have demonstrated past experience.

4. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
5. Service and maintenance staff assigned to support Project during warranty period.
6. Product parts inventory to support ongoing system operation for a period of not less than five years after Substantial Completion.
7. VRF HVAC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

K. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.

1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
2. Installer certification shall be valid and current for duration of Project.
3. Retain copies of Installer certificates on-site and make available on request.
4. Each person assigned to Project shall have demonstrated past experience.

    a. Demonstrated past experience with products being installed for period within five consecutive years before time of bid.
    b. Demonstrated past experience on five projects of similar complexity, scope, and value.

L. Mockups: Build mockups to set quality standards for materials and execution.

1. Build mockups to show a finished installation for each of the following applications:

    a. For each different indoor unit type with exposed surfaces viewable by occupants.
    b. .

2. Mockups shall be operational.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

M. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.

1.2 SUSTAINABILITY REQUIREMENTS

A. Comply with the requirements as specified in Section 0181134.14 “Sustainability Design Requirements.”

1.3 SUMMARY

A. Section includes complete VRF HVAC system(s) including, but not limited to, delegated design and the following components to make a complete operating system(s) according to requirements indicated:

1. Indoor, ceiling-mounted units for ducting.
2. Indoor, concealed, floor-mounted units for ducting.
3. Indoor, exposed, wall-mounted units.
4. Indoor, suspended, ceiling-mounted units.
5. Indoor, dedicated outdoor air ventilation units.
6. System controls.
7. System refrigerant and oil.
8. System condensate drain piping.
9. System refrigerant piping.
10. Metal hangers and supports.
11. Metal framing systems.
12. Fastener systems.
13. Pipe stands.
14. Equipment stands.
15. Miscellaneous support materials.
16. Piping and tubing insulation.
17. System control cable and raceways.

1.4 WARRANTY

A. Direct-expansion (DX) VRF HVAC system(s) with variable capacity in response to varying cooling and heating loads. System shall consist of multiple indoor units, HRCUs, outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.

1. Two-pipe system design.
2. System(s) operation, air-conditioning as indicated on Drawings.
3. Each system with one refrigerant circuit shared by all indoor units connected to system.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. AHRI Compliance: System and equipment performance certified according to AHRI 1230 and products listed in AHRI directory.

D. ASHRAE Compliance:

1. ASHRAE 15: For safety code for mechanical refrigeration.
2. ASHRAE 62.1: For indoor air quality.
3. ASHRAE 135: For control network protocol with remote communication.
4. ASHRAE/IES 90.1 Compliance: For system and component energy efficiency.

E. UL Compliance: Comply with UL 1995.

1.5 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design complete and operational VRF HVAC system(s) complying with requirements indicated.

1. Provide system refrigerant calculations.

    a. Refrigerant concentration limits shall be within allowable limits of ASHRAE 15 and governing codes.
    b. Indicate compliance with manufacturer's maximum vertical and horizontal travel distances. Prepare a comparison table for each system showing calculated distances compared to manufacturer's maximum allowed distances.

2. Include a mechanical ventilation system and gas detection system as required to comply with ASHRAE 15 and governing codes.
3. System Refrigerant Piping and Tubing:

    a. Arrangement: Arrange piping to interconnect indoor units, HRCUs, and outdoor unit(s) in compliance with manufacturer requirements and requirements indicated.
    b. Routing: Conceal piping above ceilings and behind walls to maximum extent possible.
    c. Sizing: Size piping system, using a software program acceptable to manufacturer, to provide performance requirements indicated. Consider requirements to accommodate future change requirements.

4. System Controls:

    a. Network arrangement.
    b. Network interface with other building systems.
    c. Product selection.
    d. Sizing.

B. Service Access:

1. Provide and document service access requirements.
2. Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations. Avoid locations that are difficult to access if possible.
3. Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.
4. If less than full and unrestricted access is provided, locate components within an 18-inch (450-mm) reach of the finished assembly.
5. Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.
6. Comply with OSHA regulations.

C. System Design and Installation Requirements:

1. Design and install systems indicated according to manufacturer's recommendations and written instructions.
2. Where manufacturer's requirements differ from requirements indicated, contact Architect for direction. The most stringent requirements should apply unless otherwise directed in writing by Architect.

D. System Adaptability to Future Changes: Arrange and size system refrigerant piping to accommodate future changes to system without having to resize and replace existing refrigerant piping.

E. Isolation of Equipment: Provide isolation valves to isolate each HRCU, indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.

F. System Capacity Ratio: The sum of connected capacity of all indoor units shall be within the following range of outdoor-unit rated capacity:

1. Not less than 60 percent.
2. Not more than 130 percent.
3. Range acceptable to manufacturer.

G. System Turndown: Stable operation down to 20 percent of outdoor-unit capacity.

H. System Auto Refrigerant Charge: Each system shall have an automatic refrigerant charge function to ensure the proper amount of refrigerant is installed in system.

I. Outdoor Conditions:

1. Suitable for outdoor ambient conditions encountered.

a. Design equipment and supports to withstand wind loads of governing code and ASCE/SEI 7 <Insert requirement>.
b. Provide corrosion-resistant coating for components and supports where located in coastal or industrial climates that are known to be harmful to materials and finishes.

2. Maximum System Operating Outdoor Temperature: 55 C.
3. Minimum System Operating Outdoor Temperature: 0.

J. Seismic Performance: VRF HVAC system(s) shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. Component Importance Factor: 1.0.

K. Sound Performance: Sound levels generated by operating HVAC equipment shall be within requirements indicated.

1. Indoor: See Drawings. Within design guidelines of "2015 ASHRAE HANDBOOK- HVAC Applications."
2. Outdoor: See Drawings Within ordinance of governing authorities.

L. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.

M. Capacities and Characteristics: As indicated on Drawings.

1.6 INDOOR, CONCEALED, CEILING-MOUNTED UNITS FOR DUCTING

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

1.7 INDOOR, CONCEALED, FLOOR-MOUNTED UNITS FOR DUCTING

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

1.8 INDOOR, EXPOSED, WALL-MOUNTED UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1.9 INDOOR, RECESSED, CEILING-MOUNTED UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

1.10 INDOOR, SUSPENDED, CEILING-MOUNTED UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1.11 INDOOR, DEDICATED OUTDOOR AIR VENTILATION UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

1. Specially designed for up to 100 percent outdoor air entering unit.

1.12 SYSTEM CONTROLS

A. General Requirements:

1. Network: Indoor units, HRCUs, and outdoor units shall include integral controls and connect through a TIA-485A or manufacturer-selected control network.
2. Network Communication Protocol: open control communication between interconnected units.
3. Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:

a. Ethernet connection via RJ-45 connectors and port with transmission at 100 Mbps or higher.
b. Integration devices shall be connected to local uninterruptible power supply unit(s) to provide at least 5 minutes of battery backup operation after a power loss.
c. Integration shall include control monitoring scheduling change of value notifications

1.13 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect factory-assembled equipment.

END OF SECTION 238129