236000 – R744 (CO_2) REFRIGERATION INSTALLATION SPECIFICATIONS

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.

B. Refrigeration, Architectural, Controls, and Fixture drawings and specifications shall be considered part of, and used in conjunction with, these Specification Sections.

C. Contractual terms and conditions applicable to the installation of the refrigeration system shall apply to this Section.

1.2. SUMMARY

A. This Section includes specifications for the installation of a complete and operational CO_2 refrigeration system. Refrigeration system will include, but may not be limited to, Compressors, Condensers, Gas Coolers, Heat Exchangers, Coils, refrigerated Display Cases, Cooler and Freezer Boxes, and other parts and accessories required to operate the refrigeration system.

B. The contractor shall provide coordination, equipment, and manpower for receiving, installing, and constructing all owner supplied refrigeration equipment as outlined in the construction drawings and Refrigeration Schedules/Tables.

C. All technicians performing this installation, maintenance, service, repair or disposal must be EPA (US Environmental Protection Agency) certified for the type of equipment on which they are working.

D. Contractor to install all refrigeration pipe, tubing, fittings, hand shut off valves, refrigerant, oil, hangers, oil traps, risers and double risers as required by the Refrigeration Schedules and Construction Drawings. Contractor must verify which components will be shipped loose and provided by the OEM. **[Spec Editor – add site specific details and information as required]**

E. The Contractor to provide all labor and obtain all permits required by Local, State, and Federal jurisdictions to complete the installation as outlined in these specifications. It is the responsibility of the Contractor to insure all work and materials are in compliance with applicable codes, regulations, and industry standards.

F. Contractor to “start-up” and prove performance of the Refrigeration system. Operation and functionality of all components and equipment shall be according to these specifications and the manufacturers recommendation and are considered part of the Contractors contractual responsibilities.

1.3. SUBMITTALS

A. Submit manufactures cut-sheets and specifications to the owner and project Architect showing compliance with the associated Drawings and Specifications for the items that follow.

1. Piping and insulation (type, grade, brazing, welding materials)
2. Insulation type and manufacturer
3. Hangers and piping supports
4. All contractor supplied valves and devices
5. Type, manufacturer and amount of Oil
6. Type, grade, supplier, and amount of CO_2
7. Letter of Warranty
8. Letter of Certification

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

1. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, Gas Cooler, Heat Reclaim and length of piping to ensure proper operation and compliance with warranties of connected equipment.

1.4. INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control test reports.

C. EPA certifications

D. Type, grade and name of CO_2 supplier/manufacturer

1.5. CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

B. Field quality-control test reports.

C. Start-up/Commissioning Forms

1.6. QUALITY ASSURANCE

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

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

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7. PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

B. The Contractor shall be responsible for receiving, storage, and labor to properly unload, deliver, uncrate, provide general safekeeping, set and assemble all refrigeration equipment and cases. Provide crane service to hoist units directly from truck to ground or roof as applicable. Contractor to Coordinate with the General Contractor for timing and location of storage, delivery, unloading, and setting of all refrigeration equipment and display cases.

C. The Contractor shall check each piece of refrigeration equipment as it arrives at the store and if any of it arrives in damaged condition or shortages, the Contractor shall:

1. Note damages on the bill of lading and obtain legible signature from the carrier.

2. Notify Owner immediately and include photographic evidence.

3. Make no repairs until authorized to do so.

D. Contractor shall be responsible for failure to note freight damage and shortages at time of receipt of equipment. Concealed damage to equipment within undamaged packaging shall be notified to the Supplier and Owner within 15 days of receipt of delivery.

1.8. COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations with General Contractor.

B. Coordinate the location and timing of electrical requirements and terminations with General and Electrical contractor.

C. Startup and commissioning of refrigeration system and associated components shall be coordinated with the General Contractor and EMS/BMS/Controls Contractor.

D. Refrigeration contractor will coordinate with Commissioning Contractor to correct any deficiencies found and out of functional operating parameters as outlined in the Construction Drawings and these Specifications.

PART 2. - PRODUCTS

2.1. PIPE, TUBE, AND FITTINGS

A. All system components provided by Contractor shall meet the system design pressures and requirements of R744 refrigerant (CO_2).

B. Unless otherwise specified, all refrigeration piping shall be Mueller, or approved equal, "Nitrogenized" ® refrigeration grade Type L hard drawn, cleaned, dehydrated and capped (ACR Grade) to avoid contamination prior to installation. If type K tubing is required, it must be cleaned and capped per ASTM B280. Copper water tubing Type M is not permitted.

C. For pipe-work systems operating above the maximum allowable working pressures of standard copper only stainless steel, or high pressure copper Muller XHP-120, Wieland K65 or equivalent, is acceptable. Carbon Steel may be used when following the requirements outlined as part of these specifications. This will typically be applicable for pipping on the discharge side of the systems such as to/from gas cooler and heat reclaim systems. See Refrigeration Schedule included in the Construction Drawings for size and type of pipe to be installed.

D. Copper Pipe for Liquid and Suction: **[Spec Editor's Note – Designer, contractor and OEM should be in agreement and aware of the various pressure ratings for piping]**

   a. Line sizes 3/8, 1/2, 5/8 – ACR Type K

   b. Line sizes 7/8, 1-1/8, 1-3/8 – ACR Type K *Streamline 700 psi* (Mueller) or approved equal.

   c. 1-5/8 to 2-5/8 (if used) – ACR Type K *Streamline 700 psi* (Mueller) or approved equal.

E. Wrought-Copper Fittings: ASME B16.22. Exception, XHP-120 allowed with approval of owner

F. Solder Filler Metals: ASTM B 32. Use 95-5 Tin Antimony or Alloy HB solder to join copper socket fittings on copper pipe.

G. Brazing Filler Metals: AWS A5.8.

2.2. STEEL PIPE AND FITTINGS

A. All refrigeration piping requiring stainless steel per Construction Drawings and Refrigeration Schedules shall be in stainless steel ASTM A312 schedule 40 pipe or stainless seamless steel tube ASTM A213. If stainless pipe is used all fittings shall be in stainless steel ASTM A182. Stainless tubing or piping to be welded by approved pressure ticketed welder or automated welding system according to local code using approved procedures.

B. Steel Pipe: Stainless steel shall be per ASTM A312 or ANSI/ASME B36.19.

C. All refrigeration piping requiring Carbon steel per Construction Drawings and Refrigeration Schedules shall be carbon steel schedule 80 ASTMA SA 333 grade 6 seamless, carbon steel pipe. NPS 1-1/2 and under may be either hot finished or cold drawn. NPS 2 and larger shall be

hot finished unless otherwise specified. Pipe shall arrive at the job site capped, chemically cleaned and coated or "pickled" with "Passivation".

D. Where Carbon Steel is used, pipe shall be painted (paint color to match surrounding area when installed in exposed areas). When Carbon Steel pipe is used for "cold" liquid lines and all suction lines it should be wrapped with a Petrolatum Tape to prevent corrosion. Remove all loose scale, rust or other foreign matter before applying tape or primer. Apply a thin film of Denso Paste to serve as a primer. Spirally wrap the tape with a minimum 1" (25 mm) overlap.

E. Different types of steel pipe shall not be mixed within the refrigeration systems.

2.3. INSULATION MATERIALS

A. All insulation provided shall comply with ASTM C 534, Type I for tubular material and Type II for sheet materials.

B. Contractor shall provide Armacell Armaflex II, Aeroflex USA Inc. Aerocel or Rubatex R-180FS insulation where specified in these specifications and the associated drawings.

2.4. ADHESIVES

A. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Aeroflex USA Inc.; Aeroseal.
   b. Armacell LCC; 520 Adhesive.
   c. Foster Products Corporation, H. B. Fuller Company; 85-75.
   d. RBX Corporation; Rubatex Contact Adhesive.

2.5. VALVES AND SPECIALTIES

A. Valves shall be suitable for operation with R744. All valves shall have name and pressure rating marked on body.

B. Joining of all special fittings such as Shut-off valves, driers, solenoid valves etc., that may warp, shall be made in such a manner to contain the heat in the immediate area of the joint providing necessary precautions are taken to prevent moisture and steam from being drawn into the joint.

C. There are two (2) pressure "high side" conditions within most CO2 systems - High pressure (Low temperature system compressor discharge, Gas Cooler, and transcritical) and Intermediate Pressure (typically, at the Flash tank and downstream of the Flash Tank, up to Booster/Low Temperature Compressor suction).

D. Diaphragm Packless Valves:

1. All hand shut-off valves shall be the same port size as the lines in which they are installed. They shall be nonferrous ball valves with seal cap or angle valves. Any isolation valves added to a CO2 refrigeration system, which are not factory installed, are to have a check

valve installed to relieve potentially "trapped refrigerant" and allow flow of expanding refrigerant in the direction pressure relief valve.

2. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
3. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
4. Operator: Rising stem and hand wheel.
5. Seat: Nylon.
6. End Connections: Socket.
7. Working Pressure Rating: High Side 1885 psi (130 Bar), Intermediate Pressure 1015 psi (70 nBar).
8. Maximum Operating Temperature: -40°F - 240°F (-40°C - 115°C).

E. Packed-Angle Valves:

1. Body and Bonnet: Forged brass, cast bronze, or steel.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: High Side 1885 psi (130 Bar), Intermediate Pressure 1015 psi (70 nBar).
8. Maximum Operating Temperature: -40°F - 240°F (-40°C - 115°C).

F. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. End Connections: Socket (ODS sweat)..
6. Maximum Opening Pressure: 0.50 psig.
7. Working Pressure Rating: High Side 1885 psi (130 Bar), Intermediate Pressure 1015 psi (70 nBar).
8. Maximum Operating Temperature: -40°F - 240°F (-40°C - 115°C).

G. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Brass or Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Extended socket
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location.
6. Working Pressure Rating: High Side 1885 psi (130 Bar), Intermediate Pressure 1015 psi (70 nBar).
7. Maximum Operating Temperature: -40°F - 240°F (-40°C - 115°C).

H. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.

2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: High Side 1885 psi (130 Bar), Intermediate Pressure 1015 psi (70 nBar).
5. Maximum Operating Temperature: -40°F - 240°F (-40°C - 115°C).

I. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. End Connections: Socket or flare.
4. Working Pressure Rating: High Side 1885 psi (130 Bar), Intermediate Pressure 1015 psi (70 nBar).
5. Maximum Operating Temperature: -40°F - 240°F (-40°C - 115°C).

J. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket (ODS sweat)
6. Working Pressure Rating: High Side 1885 psi (130 Bar), Intermediate Pressure 1015 psi (70 nBar).
7. Maximum Operating Temperature: -40°F - 240°F (-40°C - 115°C).

K. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless steel screws, and neoprene gaskets.
2. Filter Media: XX micron, pleated with integral end rings; stainless steel support.
3. Desiccant Media: shall be designed or CO2 applications.
4. End Connections: Socket.
5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
6. Working Pressure Rating: High Side 1885 psi (130 Bar), Intermediate Pressure 1015 psi (70 nBar).
7. Maximum Operating Temperature: -40°F - 240°F (-40°C - 115°C).

L. Permanent Filter Dryers: Comply with ARI 730.

1. Body and Cover: Bronze or Painted-steel shell.
2. Filter Media: 10 microns, pleated with integral end rings; stainless steel support.
3. Desiccant Media: Shall be compatible with CO_2.
4. End Connections: Socket.
5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
6. Working Pressure Rating: High Side 1885 psi (130 Bar), Intermediate Pressure 1015 psi (70 nBar)
7. Maximum Operating Temperature: -40°F - 240°F (-40°C - 115°C).

2.6. REFRIGERANTS

A. Manufacturers and suppliers: Subject to compliance with requirements, provide products by one of the following:
   1. Air Gas
   2. Praxair
   3. Other suppliers allowed with owner approval

B. The installing Contractor shall supply Coleman Instrument Grade CO_2, or equivalent, only for the refrigeration system. CO_2 shall be 99.99% pure with less than 20ppm of water. No "capped" cylinders with other inert gases shall be allowed.

2.7. OIL

A. Contractor shall become familiar with the type and quantity of compressor oil used in the system and supplied by Rack OEM. Additional oil used in the system shall match the exact type as recommended by the compressor manufacturer and Rack OEM.

B. The Rack OEM is responsible for shipping the correct oil type and quantity for each Rack system. The Refrigeration Contractor shall be responsible for furnishing additional oil required and charging of each system with the correct oil type and amount to bring the level of each reservoir up to the center of the sight glass. This procedure must be continued until the oil level stabilizes, following at least (21) days of operation. Use only oil that is approved by Compressor Manufacturer. All oil must be delivered to the job in factory sealed, unopened containers. The Refrigeration Contractor must use extreme caution during oil handling to prevent the ingress of moisture laden air

C. Before operating any motor or other moving parts, the parts are to be lubricated with the proper oil or grease as necessary.

D. Do not add refrigeration oil while the system is short of refrigerant unless oil level is dangerously low. Where oil has been added during charging, carefully check the compressor crankcase sight glass after reaching a normal operating condition to be sure the system does not contain an excessive amount of oil.

PART 3. - EXECUTION

3.1. The piping shall be planned and arranged to keep the number of fittings at a minimum and to keep the runs as short as possible. Arrange the piping to allow for normal inspection and servicing of the compressors and other equipment and replacement access is not hindered. Do not run tubing from one system through a case connected to another system. All pipe routes are to be reviewed and approved by Owners representative and General Contractor.

3.2. VALVE AND SPECIALTY APPLICATIONS

A. Install Electronic Expansion Valves as close as possible to evaporators.

   1. Install pressure transducers and temperature sensors as specified by valve manufacturer.

2. Install strainers or filter dryers in liquid line ahead of Electronic Expansion Valves in an accessible location.

B. Install safety relief valves where shown on plans and according to OEM Rack installation recommendations.

C. Contractor to follow the Rack OEM recommendations, specifications, and piping diagram showing the Relief Valve Piping and associated components. Any discrepancies between codes and industry best practice and what is designed by the consulting engineer and/or provided by the Rack OEM, shall be brought to the attention of the owner and/or their representative for resolution.

3.3. PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. All individual circuits shall have circuit isolation valves. All isolation valves shall have a bypass and check valve to allow flow in the direction of a Pressure Relief Valve. Under no circumstances should a section of the piping and refrigeration system have complete isolation of CO_2 gas or liquid without relief to the atmosphere. All field piping and valves installation shall provide for CO_2 relief in the case of power loss or system failure. It shall be brought to the attention of the Owner or their representative any OEM provided equipment, component, or length of piping that could potentially trap CO_2 liquid.

C. Install refrigerant piping according to ASHRAE 15.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Install piping adjacent to machines to allow service and maintenance.

H. Install piping free of sags and bends.

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

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Refrigerant piping installed belowground shall be installed in a protective conduit per details provided in the construction drawings or per industry standards when no detail is provided. Particular consideration should be taken regarding pipe slope, sealing conduit water tight, depth below ground, backfill material, and proper compaction of soil.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward toward the compressor at a rate of one inch (1") per twenty feet (20') of pipe.
3. Install traps and double risers to entrain oil in vertical runs. Due to lower velocities of the CO_2, where vertical risers of more than two (2) feet occur in a DX suction line, the riser shall be trapped at the bottom (inverted P trap). Install an additional trap for each Ten Feet (10') of riser.
4. Liquid "overfeed" systems do not require traps in the risers.
5. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties.

Q. Before installation of steel refrigerant piping, verify pipe and fittings are clean and free of dirt debris, and other contaminants using the following procedures:

1. All piping material shall be delivered to the job site "capped" and clean.
2. Non-stainless steel pipe shall be "pickled and coated" when it arrives.
3. Contractor to verify all piping is clean and free of debris and dirt before installation occurs.

R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

S. Contractor to identify refrigerant piping and valves to install, and/or provide, according to the Refrigeration Schedule contained in the Construction Drawing set.

T. Install PVC sleeves for piping penetrations shall be provided for all refrigeration lines passing through walls, ceilings, and floors, walk-in box panels and case partitions that do not have pre-fabricated access holes provided. Sleeves and pipe shall be sealed with insulated foam and silicone on both sides of fixtures. Contractor to seal openings with fire rated calking where required by codes and local inspectors. Refrigeration piping is to enter refrigerated case through the manufacturer intended penetration. Refrigeration piping entering fixture through a case end panel or other penetration not intended by the equipment manufacture is not permitted. Any display case end panel which is altered to allow piping penetration will be replaced at refrigeration contractors expense.

U. Install sleeve seals for piping penetrations of concrete walls and slabs shall be done in PVC. Underground lines shall be run in PVC sleeves terminating in a PVC elbow and brought above ground under the fixture with a tee in the riser at the other end. PVC pipe and lines to be flush with finish concrete. No inaccessible underground joints in the pipe will be permitted. All underground to be inspected and approved by owner or their representative before backfilling. Trenching and backfill floor underground lines by General Contractor, Seal ends prior to setting cases.

V. Install escutcheons for piping penetrations of walls, ceilings, and floors.

W. All condensate drains, including final connections, shall be by Refrigeration Contractor. All cases shall have a drain line and trap. The line shall be the same size as the fixture drain outlet connection but shall not be smaller than ¾". Case drains should be installed with PVC or ABS if approved by local codes. Copper pipe should be used for drains where under case return is utilized. Any un-used case drain outlets shall be securely sealed and capped. Note that pooling of condensate water in the bottom of the case will not be permitted. All drains shall be installed to provide a minimum continuous fall of 1 inch in 8 feet. All case drains will terminate by gravity into a main drain hub (provided by others). An air gap must be provided between the case drain pipe and the hub drain. All case drains shall have screens to prevent product ingress.

3.4. PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

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

C. Fill pipe and fittings with nitrogen during brazing or welding, to prevent scale formation. During all of the brazing operations, dry nitrogen must be bled through the piping at 2 psig to prevent oxidation and scaling.

D. Soldered Joints: Use a solder with at least forty–five percent (45%) silver content on all copper to steel, brass to steel, or steel-to-steel joints.

E. Brazed Joints: All joints in the system discharge, suction and liquid lines shall be brazed with a suitable high temperature silver solder alloy containing not less than 15 percent (15%) silver. At any copper to brass joint where damage could occur from excess heat use 35% silver, but must utilize a heat wrap in brazing process. For CO_2 systems, brazing alloy and flux must not contain zinc or zinc chloride.

1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

F. Welded Joints: Construct joints according to AWS D10.12/D10.12M.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5. HANGERS AND SUPPORTS

A. Hangers or straps shall be installed so as to adequately prevent vibration or undue strain on any pipe or fitting. Clamp all lines in compressor room with Hydrazorb cushion clamp assemblies on 1 5/8" coated "Unistrut" or equivalent.

B. Cushion all pipes on minimum 4" flat metal hangers or with curved sheet metal sections glued around the Armaflex, on intermediate supports where pipe is not clamped. Optional "pipe saddles and shields", *Insugaurd* or equivalent, can be used and installed per manufacturers recommendations. Where the clamps are applied directly onto copper or steel lines, Hydrazorb cushion clamp assemblies shall be used with 1-5/8" width steel channel. Steel clamp parts must not touch or rub the pipe. Secure all lines supported by trapezes but not clamped, with nylon zip-ties.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

D. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
8. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
9. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2 inch.

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

1. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
2. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
3. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
4. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.

F. Support multi-floor vertical runs at least at each floor.

3.6. FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports. Pipe testing and Evacuation:

1. Contractor shall notify the Owner 24 hours in advance when one or more systems will be ready to test so the Owner and/or manufacturer's representative may be present for the test, if desired. Failure to notify the Owner may result in having to repeat test.
2. Comply with requirements of local codes if higher test pressures are required. Refrigeration piping will not be acceptable unless it is gas tight. If leaks are found, isolate leaks, discharge gas and repair leaks, and then repeat test. When testing has been completed, release pressure using safe procedure.

B. Refrigerant Pipe testing and Refrigerant Piping Evacuation Procedures

1. Contractor to follow these procedures and best practices, to ensure that the refrigeration equipment is leak-free when installed. Always adhere to testing procedures required by local codes, and do not exceed system design pressures. Make sure pressure used is in compliance with local codes and that you meet all local code requirements for rough-in inspection. **Always follow safety standards. Ensure proper ventilation at all times.**
2. Before beginning the leak check procedures, carry out the following pre-check:
    a. Visually inspect refrigerant lines and joints for proper piping assembly and installation.
    b. Ensure proper bracing.
    c. Ensure that there are no metal to metal contact points.
    d. Manually verify that all mechanical joints are tight.
    e. Ensure tightness of all electrical connections.
    f. Check phase monitor for correct polarity.
3. Contractor shall isolate any and all components not suitable for the pressure levels contained in these Guidelines. Warning: some components are not suitable for high pressure levels, including, but not limited to, some compressors, pressure transducers, and safety relief valves. Check with the component manufacturer if any doubt exists as to whether certain components should be isolated from the rest of the system during pressure tests.
4. Open all valves, either manually or by energizing the solenoids, including the following:
    a. Ball valves to circuits, branches, satellites, condenser, heat reclaim, receiver, etc.
    b. Main liquid line solenoid valve
    c. Suction stop EPR valves
    d. Both sides of condenser and heat reclaim piping
    e. De-energize the solenoid valves (which are normally open)
5. Contractor shall fully Pressure Testing for leaks. Before beginning the pressure test, ensure all defrost heaters are disconnected or by-passed. Charge system with regulated dry nitrogen and the appropriate tracer gas to bring system pressure up to 300 psig minimum. Do not use of fluorinated refrigerants (all CFCs including R-12, all HCFCs including R-22, HFCs) as tracer gases. CFCs and HCFCs may not be used due to the harm they cause to the earth’s ozone layer.
    a. Check system access points to verify pressurization. Note: Branches may be tested in segments to reduce the time needed to locate leaks and associated wasted test gas. However, for the final test, all valves must be open.

b. If leak is found, carry out the following procedure: o isolate leak from rest of system;
    i. Repair leak
    ii. Retest area to verify leak has been repaired
    iii. Re-pressurize the area to 300 psig; and
    iv. Before continuing, make sure all valves that were closed to isolate the leak are opened again after the leak has been repaired.
c. After system has been checked for leaks and all leaks have been repaired and retested, the system must stand, unaltered, for 24 hours with no more than a +/- 1 pound pressure change from 300 psig, using the same gauge. Ambient air temperature changes may lead to a slight increase or decrease in pressure.
d. If system does not drop below 300 psig within the 24 hours, the system is then ready to be evacuated.
e. Release the nitrogen charge to the atmosphere (make sure you have adequate ventilation).

6. Prior to Evacuation of the systems, the contractor shall ensure the system is prepared accordingly. Nitrogen, air, and moisture can remain in the system if the system is not properly evacuated. Moisture causes expansion valve ice blockage, wax build up, and acid in the oil. Before beginning the evacuation process, make sure you observe the following:
    a. Ensure system is completely depressurized.
    b. Plan procedures so breaking the vacuum with refrigerant does not introduce contaminates into the system.
    c. The evacuation pump should be connected to three points on the rack, unless the system is small (if the system is small, the evacuation pump may only need to be connected at 2 points). The 3/8 inch flare ports are ideal for these connections.
    d. Copper lines are preferred over hoses, and if any hoses are used, they must be special vacuum hoses, as standard pressure hoses tend to collapse under high vacuum and increase the time required to fully evacuate the system.
    e. Vacuum pumps should be rated at 8 cfm or larger. Pumps should be connected to several branch circuits to access all components of the system.
7. Be sure each pump is tested prior to use and vacuum sensors are in working order. The pump must be able to achieve a vacuum of at least 300 microns. Test vacuum gauges and vacuum sensors according to manufacturer's instructions. Only vacuum pumps manufactured for this specific purpose shall be used and/or allowed for the purposes outlined in this specification.
    a. Use clean vacuum pump oil as recommended by the pump manufacturer.
    b. Make sure electrical connections to the pump are secure and uninterrupted.
    c. Check all vacuum pump connections for leaks.
    d. Monitor the pump for signs of normal operation (e.g. "vapor" from the pump exhaust early in the procedure that tapers off).
8. Use only copper lines or hoses that are suitable for vacuum duty and rated for this purpose. Use only packless valves.
    a. One large vacuum pump can be used, if a header is connected to three different points on the system.

b. All schrader valve caps need to be properly tightened and checked. Check the condition of o-ring in Schrader valve caps.
c. All access valves need to be properly tightened and o-rings intact. In a deep vacuum, the stems will draw in and cause a loss of vacuum. This will not be noticed during a pressure test.

9. Before beginning evacuation, calibrate the Micron vacuum gauge (digital, analog, LED) per manufacturer's instructions.
   a. Verify with a gauge that the vacuum pump can pull a vacuum of at least 300 microns.
   b. Measure vacuum at a minimum of two locations. These two locations must be at the most extreme positions of the system.
10. Contractor shall pull a system vacuum down to at least 1000 microns (+/- 50 microns) and close the vacuum header valves. If the system cannot pull a vacuum at any step and returns to atmospheric pressure, which is an indication of a leak, test for and repair the leak using the previously described procedure with tracer gas. Once the 1000 micron vacuum holds for 30 minutes, break the vacuum with dry nitrogen to a pressure of 2 psig ∗

    Do not exceed micron gauge transducer limits or transducer will be damaged!
    a. Install system suction and liquid drier cores.
    b. Pull a second vacuum to a minimum of 500 microns.
    c. Close vacuum header valves.
    d. If the 500 micron vacuum holds for a minimum of 30 minutes, then break the vacuum with the refrigerant to be used in the system to a pressure of 2 psig.
    e. Pull a third vacuum to a minimum of 300 microns.
    f. Close vacuum header valves and allow system to stand for a minimum of 24 hours.
    g. Once the 300 micron vacuum holds for 24 hours with a maximum drift of 100 microns over the 24 hour period, then the system is ready to be charged with refrigerant.
    h. Break the vacuum with the refrigerant to be used in the system and charge the system with refrigerant.
    i. Add oil to the compressors, oil separator and oil reservoirs, if equipped.
11. Now that the system is operational, conduct a complete walk-through of the system with a leak detector to make sure no leak

3.7. SYSTEM CHARGING

A. Refrigeration contractor shall supply complete refrigerant charge as part of scope of work. Refrigeration contractor to secure all refrigerant cylinders on site to wall using steel chain or other owner approved method.

B. When the system has been successfully evacuated, the contractor shall fit to the system calibrated pressure gauges and thermometers for use during the charging and commissioning procedure.

C. After final evacuation, the vacuum should be broken with R744 vapor. Refrigeration Contractor to verify with General Contractor that permanent power has been established and available before charging the system with CO2. Always begin with vapor CO_2 only, until the pressure rises above 75 psig. Do not introduce liquid CO_2 until pressure across the entire refrigeration system is greater than 75 psig to avoid the formation of dry ice in the refrigeration system. Charging may then continue with liquid refrigerant. When charging the CO_2 refrigerant to a new system follow OEM procedures. During refrigerant charging oil heaters on low pressure side vessels should be energized, if fitted. Only one container of refrigerant should be connected to the system at a time. The connecting point will depend on the type of system and the chosen method of charging i.e. gas or liquid charging. Care must be taken to ensure that liquid refrigerant does not enter the compressor.

D. When changing containers during the charging procedure, care must be taken not to trap liquid refrigerant between isolating valves.

E. When sufficient refrigerant has been charged into the system and there is suitable heat load to maintain operation, the compressor should be started in order to reduce the low side pressure and hence enable the charging process to be completed.

F. If the container pressure drops too low for further efficient charging, the pressure may be increased by standing the container in a bath of warm water or by applying some other gentle heat. On no account shall a flame be used, the container shall not be heated over 100°F.

G. During this procedure the operation of the compressor shall be monitored, and shall be shut off if any signs of abnormal operation are observed or heard. Extra care shall be taken during the initial phase of the charging process as, until there is an adequate charge of refrigerant in the system, the compressor must not be allowed to operate outside its normal range of temperatures and pressures. The system shall not be left unattended during the charging process.

H. The system should be fully charged, taking into account all operating conditions that can exist over the design range of ambient temperatures. When completed, the total weight of refrigerant charged into the system shall be recorded and posted on the control panel door,

3.8. ADJUSTING

A. Refrigeration contractor to verify all control set-points and programing for refrigeration operation and defrost setting specifications shall be provided by owner, Rack OEM, or Controls OEM. Contractor to verify all points have been individually set and checked for proper operation of each fixture per OEM specifications. Refrigeration contractor to verify all electronic expansion valve superheat and valve base opening settings have been individually set for proper operation of each fixture.

B. Verify and reset superheat, as necessary, after cases and walk-ins have been loaded with product, and temperature and humidity levels have been reached.

C. Change liquid line filter dryers, oil system dryers, suction filter dryers, and oil separator filters after 24 hours of run time or as recommended by rack manufacturer. Filters to be rated for wax removal.

D. The refrigeration Contractor shall ensure that all defrost schedules are satisfactory. Refrigeration contractor to verify and adjust any/all defrost termination and fan delay set points. Defrost Schedules must be set in accordance with case/rack manufacturer, or if available customer, specifications. The refrigeration Contractor shall confirm that all evaporator defrost cycles are terminating at proper time or temperatures based on manufacturers recommendations.

E. Refrigeration contractor to perform store power failure simulation test once refrigeration system is operational but before perishable product arrives at store. Contractor to verify that system performs as designed in this situation. Any issues or concerns need to be documented and presented to the Owner and equipment OEM.

3.9. START-UP

A. The Contractor shall give the Owner or his representative and refrigeration system manufacturer minimum 2 weeks' notice prior to scheduled start-up.

B. Refrigeration system start-up shall be in accordance with these Specifications and procedure as laid out by the system manufacturer. Start-up reports will form part of the refrigeration completion documentation which will be issued to Owner by the Contractor.

C. Coordinate Work of this Section with energy management system contractor, refrigeration contractor, mechanical contractor, and rack Manufacturer for installation dates, testing dates, and completion dates.

D. The rack Manufacturer or his representative shall provide assistance for system startup. The Contractor shall perform the startup, which shall include a check of proper installation, system check-out, adjustment, and complete start-up. The startup will occur only when system Manufacturer and Owners representative have signed off that the refrigeration system is complete and ready to start.

E. The Contractor shall complete installation and startup checks according to manufacturer's written instructions and shall include the following as a minimum:

   a. Shipping, blocking, and bracing removed.

   b. Inspection for visible damage to all components.

   c. Clearances have been provided for servicing.

   d. Electrical connections are tightened.

   e. Controls are connected and operable.

   f. Lines purged with OFN.

   g. Start-up completed according to manufacturer's written instructions.

h. Completion of startup sheets.

i. Inspection and record of interlocks and protective devices performance; verification of sequences documented.

j. Unit operation for run-in period recommended by manufacturer.

k. Inspection of control valves for proper operation.

l. Inspection of controls for correct sequencing for normal and emergency shutdown.

m. Measurement and record of operating conditions, temperatures and amperage.

n. Verification of functional performance of system simulating conditions on the sequence of operations.

o. Verification of Refrigeration Equipment operation.

F. Notify Equipment Manufacturer of malfunctioning components that do not pass tests and inspections. Equipment Manufacturer shall remove and replace malfunctioning components and retest as specified above.

G. Equipment Manufacturer shall notify Owner on any major issues regarding equipment and startup.

H. After compressors are started, continue charging until system has sufficient refrigerant for proper operation. Do not overcharge. During start-up, do not leave compressor operating unattended and unmatched until system is properly charged with refrigerant and oil.

I. Do not add refrigerant oil while system is short of refrigerant unless oil level is dangerously low. If oil has been added during charging, carefully check compressor crank case sight glass after reaching normal operating condition to ensure it does not contain excessive amount of oil which can cause slugging or loss or refrigeration capacity.

J. The case manufacturer shall provide assistance during the startup of the refrigeration system to support the Contractor with case operation and performance.

K. The Contractor shall be responsible for documenting and reporting all case operating problems to the case manufacturer and Owner.

3.10. WARRANTY

[SPEC EDITORS NOTE, NTE: Insert customer's warranty requirements for Refrigeration Systems and components. It is strongly recommended to include labor, workmanship, and parts language to the warranty section.]

PART 4. - REFRIGERATION INSTALLATION

4.1. EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install all equipment according to manufacturer recommendations and installation guidelines.

B. Install equipment level, plumb, parallel, and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated. Install units firmly anchored in locations indicated; maintain manufacturer's recommended clearances and following any seismic mounting code requirements.

C. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations.

D. Install equipment to allow right of way for piping installed at required slope.

4.2. COMPRESSOR RACK

A. COMPRESSOR RACK EXAMINATION

1. Before rack installation; examine roughing-in for locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting rack performance, maintenance, and operations.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. COMPRESSOR RACK INSTALLATION

1. Follow Rack OEM guidelines and specification for receiving and setting the racks.
2. Coordinate with General Contractor in regards to timing and equipment required to install the rack.

CONTROL SYSTEM **[SPEC EDITORS NOTE, NTE: These specifications are not intended to cover the scope and directives for the install or supply of a controls and/or energy management system. A separate, standalone, control/EMS system specification should be developed outside of these specifications. Add reference to control specifications number and name.]**

C. COMPRESSOR RACK PIPING CONNECTIONS

1. Route piping adjacent to rack in a manner that will allow clearance for service and maintenance.
2. Connect to suction, liquid, and condenser piping.

END OF SECTION 236000