

SECTION 15651 – REFRIGERATION (SPLIT SYSTEMS)**PART 1 - GENERAL****1.1 SCOPE**

- A. Work required under this Specification shall include furnishing all labor and materials for the complete installation of the refrigeration work as described herein and shown on the Drawings.
- B. The intent of the Plans and Specifications is not to show every item required for proper operation and service. No extras will be allowed for any item such as offsets, supports, valves, or thermometers which are required for operation and maintenance, but which may not be shown.
- C. The scope of the work shall include, but not be limited, to the furnishing and installing of the following:
 - 1. All transportation, storage, unloading, moving and rigging of the Contractor's equipment.
 - 2. Compressors/condensing units.
 - 3. Air cooling units.
 - 4. All valves, gauges, thermometers, oil reclamation devices, accessories, and all other equipment required for the complete installation of the refrigeration system.
 - 5. All piping listed below:
 - a) Refrigeration piping.
 - b) Air unit drain piping.
 - c) Gauge and control piping.
 - d) Oil piping.
 - e) Relief piping.
 - 6. Steel supports for all equipment and piping, including all hangers, brackets, stands, and guards.
 - 7. All motors and drives.
 - 8. Full charges of refrigerant and oil for all equipment.
 - 9. Shop painting, touch-up painting of equipment and piping and labeling.
 - 10. All refrigeration controls including float valves, level controllers, automatic valves, thermal operated valves, pressure switches, safety controls, thermostats and all other controls required for a complete operating system.
 - 11. Pipe insulation.
 - 12. Warranty.
- D. The following items are **NOT** included under this Specification.
 - 1. General construction of the building.
 - 2. All power and control wiring, switches and lighting, except as required for the Contractor's own use during construction.

1.2 INSTRUCTION MANUALS

- A. The Contractor shall furnish to the Owner four copies of an Instruction Manual. This manual shall include maintenance and operating instructions for the major equipment, lubrication instructions, wiring diagrams for all controls, and power wiring, etc., recommended spare parts and replacement parts list.
- B. The Contractor shall provide training for all equipment installed. Training must include emergency shut down of equipment and systems, start up of equipment and systems after emergency and normal shutdowns. Training shall be conducted for each shift personnel.

1.3 REVIEW OF MATERIALS AND SUBMITTALS

- A. The Contractor shall submit copies of Shop Drawings to the Engineer for review before installation for items listed in the Plans and Specifications. Each Shop Drawing shall be certified as being checked and approved by the Contractor before being submitted to the Engineer.
- B. The Contractor shall submit to the Owner one copy of Record Drawings showing all changes made during construction.

PART 2 - MATERIALS**2.1 AIR UNITS (CENTRIFUGAL FAN)**

- A. Units shall be furnished complete with rear horizontal centrifugal fans, motor and drive, finned coil, electric bayonet heaters, and unit casing.
- B. Fans shall be galvanized steel, forward curved, squirrel cage, centrifugal blower and shall be mounted on a steel fan shaft with self-aligning, sealed ball bearings. Motor shall be mounted on top of fan section and shall be factory wired to a NEMA 1, non-fused disconnect located on the fan casing. Electric heaters (both pan and coil) shall be factory wired to a NEMA 1, non-fused disconnect located on the fan casing.
- C. Coils shall be tested at 300 psig under water.
- D. Drain pan shall be heavy gauge mill galvanized steel interior & exterior, electric heated, double-pan construction with 2" thick closed cell polyurethane insulation between pans. Drain pans shall be factory mounted and unit supplied with 24" long mounting legs for penthouse application.
- E. Casing shall be heavy gauge mill galvanized steel. Removable access panels shall be provided to facilitate inspection and service. Discharge duct flanges shall be provided.
- F. All bearings and moving parts shall be factory lubricated for operation in the indicated ambient, and lubrication instructions shall be furnished with the units. Lubrication points shall be easily accessible.
- G. Blowers shall be V-belt drive selected for a minimum 150% of motor nameplate horsepower. Motor mounting assemblies shall be fabricated from mill galvanized steel. Drive assemblies shall be equipped with adjustable motor sheave with split taper-lock hubs and removable belt guards. Blowers shall be dynamically balanced as an assembly at the rated CFM.

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- H. Each unit shall comply with the following requirements:
1. Duty: +34° F. Cooler
 2. Quantity: Four (AU-1 thru AU-4)
 3. Refrigerant: R-404A
 4. Capacity: 16,067 BTUH/° F. temperature difference (19.5 TR @ 14.6° F. TD)
 5. Air Flow: 26,820 CFM
 6. Face Velocity: 600 FPM @ 0.25" WG Total Static Pressure
 7. Fin Spacing: 4 Fins Per Inch
 8. Coil Depth: 8 Rows
 9. Coil Construction: Copper Tubes with Aluminum Fins
 10. Coil Circuiting: Direct Expansion
 11. Motors: One, 7 1/2 HP, 1750 RPM, 460/3/60 VAC, ODP, 1.15 S.F.
 12. Fan Size: (2) 25" Diameter
 13. Defrost Method: Electric (coil and pan)
 14. Arrangement: Two Left Hand, Two Right Hand
 15. Model: Century Model VPC-447-8-4-TL/RH-EDL, McCormack, Krack, or Approved Equal.

2.2 SPLIT SYSTEM COMPRESSOR/CONDENSER

- A. Compressor/condenser unit shall be complete with one semi-hermetic motor-compressor, air cooled condenser, charge of oil, factory wired electrical control enclosure, liquid line filter-drier with sight glass, suction-liquid heat exchanger, suction filter and accumulator all factory assembled, piped and mounted on a steel base requiring only refrigeration piping connections and wiring connections.
- B. Compressor shall be of the discus reciprocating type with motor overload protection and shall have suction and discharge line vibration eliminators and shall be mounted on the steel base. Compressor shall have an oil sight glass and a crankcase heater factory installed and wired.
- C. Compressor unit shall have factory supplied and mounted suction and discharge back-seating service valves, moisture indicating liquid sight glass and replaceable core type liquid filter-drier.
- D. Air-cooled condenser shall be supplied with seamless copper tube with aluminum plate fin coils. Coil frames and tube sheets shall be galvanized steel. Fan motors shall be industrial duty, 1140 RPM, ball bearing, weather resistant, three phase with inherent overload protection. Fans shall be draw through vertical discharge type. Fan blades shall be heavy gauge steel with a corrosion resistant coating. Fan guards shall be steel with corrosion resistant coating.
- E. Liquid receiver shall be ASME stamped, oversized to provide complete system pump-down capacity with low ambient condenser flooding valves. Receiver shall be equipped with inlet and outlet service valves, gauge port and pressure relief valves.

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- F. Compressor control enclosure shall be of heavy gauge galvanized steel and shall have high-low pressure controls, manual pump-down switch, suction, discharge and oil pressure gauges, oil failure switch, magnetic contactors for compressor, condenser fans, defrost heaters and air unit fans, transformers, anti-short cycle timers, electric defrost timers and control circuit breakers, all mounted and wired requiring only one, three wire, 460 volt feeder to the control enclosure. The enclosure cover latch shall be interlocked with the main disconnect to remove power from the enclosure when the cover is removed.
- G. Each compressor/condenser/air unit system shall be furnished with a liquid refrigerant solenoid valve (with pilot light), a room thermostat, and a flow control valve with bulb well tee for field installation.
- H. Each compressor package shall comply with the following requirements:
 - 1. Duty: +34° F. Cooler
 - 2. Quantity: Four (CU-1 thru CU-4)
 - 3. Refrigerant: R-404A
 - 4. Saturated Suction Conditions: +20° F./55.7 PSIG
 - 5. Saturated Discharge Conditions: + 115° F./291.8 PSIG
 - 6. Ambient Conditions: + 95° F.
 - 7. Capacity: 274,746 BTUH
 - 8. Refrigerant capacity: 212 lbs.
 - 9. Compressor Nominal HP: 35 HP
 - 10. Electrical Power: 460/3/60 VAC
 - 11. Control Power: 120/1/60 VAC
 - 12. Model: Century DS35H4, KeepRite KVS035M8, Krack ICUSD35H4M, or Approved Equal.

2.3 MOTORS

- A. All motors shall be of the electrical characteristics specified.
- B. Motors shall have adequate torque characteristics for the duty required and shall be of the type and frame construction suitable for the application.
- C. Motors shall conform to the standards of the AIEE and NEMA for their respective classes in accordance with manufacturer's nameplates, and shall conform to the requirements of the local Power Company and all applicable codes.

2.4 SHEET METAL WORK AND AIR OUTLETS

- A. General
 - 1. Air distributing ductwork from the penthouse air units shall be furnished and installed as shown on the Drawings, including flexible connections at air units, straightening vanes and duct turns. All sheet metal work shall be true to the dimensions indicated on the Drawings and be straight and smooth on the inside. Sheet metal work shall be properly supported in an approved manner and completely free of vibration under all conditions of operation.

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B. Materials and Workmanship

1. All sheet metal, ducts, partitions, casing, plenums, etc., with sizes as indicated shall be constructed from prime galvanized sheet steel and shall be in accordance with standards set forth in the latest issue of ASHRAE Guide and Duct Manual of Sheet Metal and Air Conditioning Contractors National Association, Inc., covering (for Rectangular Low Pressure Ducts) gauges of materials, workmanship, method of fabrication and erection. All galvanizing shall be clean and free from white oxidation.
2. All square elbows and tees shall have approved turning or straightening vanes of same gauge as the fitting and with leaving edges extended to insure parallel flow of air.
3. Joints and transformations shall be made in accordance with the latest issue of the ASHRAE Guide, or in a manner specifically approved by the Engineer. All laps shall be made in the direction of air flow. All edges and slips must be hammered down so as to leave a smooth finish inside the ducts. All button or bolt connections in the standing seams shall be spaced at fixed centers, not greater than 4" spacing, unless otherwise shown, and shall be at the same center lines throughout the entire length of duct.

C. Cross Breaking of Ducts

1. All duct panels shall be cross-broken in accordance with ASHRAE Guide recommendations to a sufficient center height to assure rigidity in the duct section.

D. Size and Support

1. Ducts shall be the same size as the fan opening on the air units unless noted otherwise. The duct size must remain constant throughout the length of the duct unless noted otherwise on the Drawings.
2. The duct shall be run as shown on the Drawings and shall extend a minimum distance to the wall of the penthouse to prevent air short cycling.
3. Ducts shall be supported using galvanized sheet steel bands attached to the structural steel under the penthouse. Supports shall be complete so as to provide a firm, rigid support. Ducts and baffles may be attached to the floor grating by bolting or welding.
4. The Contractor shall be responsible for accurately sizing, locating, cutting and reinforcing all openings for ducts in the penthouse floor grating.

2.5 CONTROLS

A. General

1. Control valves shall be as supplied by the compressor/ condenser unit manufacturer. Companion flanges shall be the same size as the adjacent pipe size unless noted otherwise.

B. Solenoid Valves

1. Solenoid valves shall be of the packless, normally closed type with 120 volt, single phase, 60 cycle, molded watertight solenoid coil, manual jacking stem with NEMA 4 watertight pilot light assembly with long life L.E.D. light. Each solenoid valve shall be preceded by a close coupled 60 mesh strainer complete with socket weld companion flanges.

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- C. Thermostatic Expansion Valves
 - 1. Contractor shall furnish and install thermostatic expansion valves as shown on the Drawings.
 - 2. Contractor shall carefully install thermal valves, taking into account actual pressure drop across coil and distributor, static head, line drop, variable discharge pressure and amount of subcooling.
 - 3. The Contractor shall mount thermal bulb and equalizer line as required.
- D. Thermometers
 - 1. Thermometers shall be provided where shown and/or where required for proper operation of the system. Ranges shall be suitable for the service intended.
 - 2. Thermometers shall be provided with separable stainless steel well sockets. On insulated piping, sockets shall have necessary extension neck.
 - 3. Thermometers shall be located with due regard for ease of reading and non-interference with working space and measured fluid flows.
 - 4. Dial thermometers shall be Trerice 5" dial, bi-metal type, stainless steel case and stem, or Approved Equal.
- E. Gauges
 - 1. Gauges shall be provided where shown and/or where required for proper operation of the system. Ranges shall be suitable for the service intended. All gauges in refrigerant lines shall have appropriate refrigerant temperature- pressure scales. All gauges shall be designed for refrigeration, water, or as required. All gauges shall be no less than 3-1/2" in size and may be mounted locally. All gauges shall be installed with a Hansen long neck shutoff valve upstream of the gauge. Gauges shall be Ashcroft, or Approved Equal.
- F. Strainers
 - 1. All refrigerant strainers shall be Type ST with 60 mesh stainless steel screens as manufactured by Hansen Technologies, or Approved Equal.

2.6 THERMOSTATS (ROOM)

- A. Single stage (SPDT) 120/1/60 VAC integral bulb thermostats shall be as furnished by the Compressor/condenser manufacturer.
- B. Thermostat set point: make @ +35° F., break @ +32° F.

2.7 FLUID CHARGES

- A. Refrigerant
 - 1. The Contractor shall furnish and install a complete charge of R-404A refrigerant. The Contractor shall replace all refrigerant lost due to leaks caused by his work during the first 90 days of operation.
- B. Oil Charges
 - 1. The Contractor shall furnish and install complete charges of compressor lubricating oil.

2. Compressor lubricating oil shall be as supplied by the compressor package manufacturer, or Approved Equal.

2.8 EQUIPMENT SUPPORTS

- A. The Contractor shall furnish and install all necessary steel supports for air units and condensing units supplied under this contract. Supports shall be complete so as to provide a firm, rigid support for all equipment mounted thereon.
- B. The Contractor shall be responsible for accurately sizing, locating and cutting and patching all openings for refrigerant piping.
- C. If the Contractor installs approved equipment by manufacturers other than specified, he shall be responsible for any extras required to modify the supporting steel.

2.9 PIPING SYSTEMS

A. Refrigerant and Oil Piping

1. General

- a) The Contractor shall furnish and install all necessary refrigerant piping as shown on the Drawings, complete with all valves, fittings and hangers.
- b) It is extremely important that any foreign matter shall not enter the system, and that **NO STRAINS ARE IMPOSED ON THE SYSTEM MACHINERY BY PIPING CONNECTIONS**. When connections are made, piping strains shall be checked by removing flange bolts at equipment which shall be loose and readily removed. **ANY PIPING MIS-ALIGNMENT EVIDENCED BY BOUND BOLTS SHALL BE CORRECTED AT NO COST TO THE OWNER**.
- c) The Owner's representative will witness the final leveling of equipment and the proper alignment of all piping and flanges.

2. Copper Piping

- a) Copper tubing shall be hard drawn type ACR copper tubing (ASTM B280). Fittings shall be wrought copper or forged brass (ASTM B16.22).

3. Joints

- a) All joints in copper refrigerant tubing shall be brazed using an inert atmosphere inside tubing to avoid heat scaling of tubing. Joints shall be made with a brazing filler metal AWS Classification BCuP-5, in accordance with AWS Specification A5.8.

4. Valves

- a) All valves shall be of the globe or angle seal cap type as shown on the Plans, designed for the refrigerant in the system and as specified. Solder end valves may be used in all sizes. Valves shall be Superior, or Approved Equal.
- b) All valves shall be of the back seating type to permit repacking under pressure, except small forged steel angle valves, 1/4" to 1/2", used in gauge lines.
- c) Valves shall be installed with stems horizontal, unless otherwise shown on Drawings. All valves shall have flow through the seat toward the stem, unless otherwise noted on the Drawings. Valves shall not be installed with stems vertically down.

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B. Condensate Drain Piping

1. The Contractor shall furnish and install all condensate drain piping from air units as shown on the Drawings, and as required to complete the system. Drain piping shall be schedule 40 galvanized pipe with screwed joints. Fittings shall be 150 psi galvanized malleable iron.
2. Condensate drains must be pitched 1/4" per foot, and must be provided with plugged tees for cleanout at **EVERY** change of direction.
3. Provide wet traps as indicated on the Drawings.
4. All threads cut on galvanized steel pipe shall be spray painted with ZRC zinc paint.
5. Drains and traps shall be insulated and heated as noted on the Drawings and where ambient conditions, both interior and exterior, necessitate.
6. Drain line heating cable shall be stainless steel braided and grounded, furnished and installed in the air unit drain lines where required.
7. Drain line heating cable shall be Auto Trace, Self-Limiting Heating Cable as manufactured by Raychem Corp., or Approved Equal. Cable shall be rated at 6W/foot, 120 volt, with a maximum length/section of 100 feet.

2.10 PIPE INSULATION

A. General

1. All refrigeration piping requiring pipe insulation shall be insulated with flexible synthetic elastomer type insulation.

B. Materials

1. Flexible synthetic elastomer pipe insulation shall be closed cell foamed synthetic elastomer with a thermal conductivity of 0.27 or better at 75°F mean temperature, and shall have a permeability of not greater than 0.2 perminches.
2. Insulation shall be AP/Armaflex as manufactured by Armacell, or Approved Equal.

C. Pipe Insulation Finish

1. All piping insulated with flexible synthetic elastomer pipe insulation shall be finished with two coats of white WB/Armaflex finish, as manufactured by Armacell, or Approved Equal.

D. Heat Tracing

1. All piping, fittings and valves requiring heat tracing shall be insulated using flexible synthetic elastomer pipe insulation as previously specified, and shall be finished as previously specified.

E. Insulation Accessories

1. Adhesive for sealing joints shall be a rubber base contact adhesive and shall be Armaflex #520 adhesive, or Approved Equal.

2.11 INSULATION PROTECTION SADDLES

- A. Insulation protection saddles shall be provided and installed by the Contractor at all pipe hangers and supports for insulated lines. All insulation protection saddles shall be rolled with a true radius to suit the insulation OD Prime galvanized sheet metal shall be used for all saddles. The saddles shall be sized to wrap the insulation in an arc between 120 degrees and 180 degrees. The saddles shall be anchored to the pipe insulation with no less than two bands per saddle. Bands shall be stainless steel or galvanized steel.
- B. All insulation saddles shall be a minimum of 12" long and shall be fabricated of minimum 14 gauge material.

2.12 PIPE HANGERS AND SUPPORTS

- A. Contractor shall furnish and install all pipe hangers and supports for all piping installed by the Contractor.
- B. Pipe hangers shall be of the trapeze type or clevis type equal to Grinnell Fig. 260. Chain, perforated and flat steel strip hangers will not be acceptable. Sway bracing shall be provided to minimize vibration, particularly on discharge and liquid lines.
- C. Care shall be taken to insure that bracing and supports will not restrain expansion and contraction or set up excessive stresses at the joints and equipment.
- D. Pipe hangers for pipe shall be spaced not greater than shown in schedule below:

<u>PIPE SIZE IN INCHES</u>	<u>COPPER TUBING</u>
1/2" to 1"	4 ft.
1-1/4"	5 ft.
1-1/2"	6.5 ft.
2"	8 ft.
2 1/2"	9 ft.
3"	10 ft.
4" and larger	11 ft.

- E. Additional supports shall be provided for tubing, valves, fittings, and accessories. In all cases, a hanger shall be placed not over two feet from a change in direction of any piping.
- F. All hangers supplied for insulated lines shall be sized for the outside diameter of the applied insulation. Contractor shall provide temporary wooden blocks, properly sized for insulation thickness, which will accurately center the pipe in the hanger. If hanger adjustment allows, hangers may be raised to support piping in final position, so that insulating contractor may lower each hanger to install insulation for required density and thickness as indicated on the Drawings.
- G. All hangers, rods, angles, roof stands, clevis, etc., shall be **galvanized** steel.

2.13 PIPE AND CONDUIT PENETRATIONS

- A. All **NON-INSULATED PIPE** which penetrate an **INSULATED WALL** shall be insulated with a **MINIMUM** of 3/4" thick pipe insulation. Insulation shall project a minimum of 30" on the warm side and 6" on the cold side of the wall. Insulation shall be sealed on both ends to the pipe.

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- B. For **INSULATED PIPE** penetrations which penetrate an **INSULATED WALL**, refer to the details provided on the Drawings.
- C. All penetrations through exterior walls must be rain and wind tight.
- D. It is the responsibility of the Refrigeration Contractor to cut openings in **INSULATED** panels for pipe penetrations and install the pipe. It is the responsibility of the Insulation Contractor to reseal all openings in the insulated panels to assure vapor barrier continuity is maintained.

PART 3 - INSTALLATION**3.1 GENERAL**

- A. All work shall conform to the requirements of the American National Standard B31.5, Code for Pressure Piping: Refrigeration Piping, latest edition.
- B. Pipe shall be cut accurately to measurement established at the site and shall be worked into place without springing or forcing.
- C. All piping shall be installed with sufficient flexibility to adequately provide for expansion and contraction due to temperature fluctuation inherent in its operation.
- D. No piping shall be run concealed in walls or partitions nor underground or under the floor, except as shown. Where pipe passes through building structure, pipe joints shall not be concealed, but located where they may be readily inspected.
- E. All pipes to be insulated shall be run as shown and as required with sufficient clearance to permit application of insulation. Any burrs on the pipe due to cutting or other causes shall be completely removed by reaming prior to installation.
- F. Screw joints shall be made with uniform tapered threads properly cut with sharp clean dies. Screw joints shall be made perfectly tight with a thread compound suitable for the fluid involved. Threads of fittings shall not be coated with compound.
- G. Flanged joints shall be used only where necessary for normal maintenance and where required to match valves and equipment. Flanges shall be faced true and made up perfectly square and tight.
- H. Surfaces for soldering shall be cleaned and free from paint, oil, rust, and other foreign matter. Surfaces to be soldered shall be aligned as accurately as is practical within existing commercial tolerances. All gaskets, packing and thread compounds shall be suitable for the fluid for which they are used.
- I. All piping shall be fabricated, installed, supported and tested in accordance with the latest edition of the American National Standard Code for Pressure Piping ANSI B31.5.
- J. All piping shall be run essentially as shown and detailed on the Drawings, care being taken to avoid interference with other piping, conduit or equipment. Except where specifically shown otherwise on the Drawings, piping shall run straight and parallel to walls and ceilings. Trapping of lines shall not be permitted without the approval of the Engineer except where shown on the Plans.

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- K. To avoid loss of time, damage to equipment, and start-up difficulties, each section of pipe, fittings and valves shall be thoroughly cleaned and positively free of all foreign matter before installation. Prior to erection, each piece of pipe shall be thoroughly cleaned of loose scale and foreign matter and then swabbed. Open ends of mains shall be PLUGGED OR CAPPED during all non-working periods. Lines shall not be left open at any place where any foreign matter might accidentally enter pipe.
- L. Roof is to be fully protected by the Contractor. Protective sheets are to be laid under each cutting and soldering area. Hot soldering materials must not be dropped on the roof. All precautions are to be taken against potential fire hazards. Oil of any type must not come in contact with rubber roof membranes.

3.2 INSULATION

- A. General
 - 1. Surfaces to receive insulation shall in all cases be free of rust, scale or dust, clean and dry. All insulation must be installed prior to refrigeration system pulldown.
 - 2. Insulation shall be applied with tightly butted joints, free of voids and gaps. Overall appearance of work shall be subject to Engineer's approval. All insulation must be sealed to the pipe a minimum of six (6") inches from any termination of such insulation.
- B. Pipe Insulation
 - 1. Flexible synthetic elastomer pipe insulation shall be slipped onto pipe whenever possible. Where this method is impractical, the insulation shall be longitudinally slit and placed on the pipe. All slits and end joints shall be completely sealed using the specified contact adhesive to provide a perfect vapor seal. Contact adhesive shall be applied to both surfaces to be joined and shall dry to a light touch before joining surfaces to assure proper seal and adhesion.
- C. Insulation Application
 - 1. All air unit condensate drain lines shall be insulated using 3/4" thick flexible synthetic elastomer.
 - 2. Insulation shall be installed on all refrigerant suction lines. Insulation shall be flexible synthetic elastomer and shall be 1 1/2" thick.

3.3 PIPING TESTS

- A. Refrigerant
 - 1. All refrigerant piping shall be tested before pipe insulation is applied.
 - 2. Refrigerant relief valves shall be removed prior to pressure testing and shell openings plugged. After system is tested and found to be completely tight, relief valves shall be reinstalled prior to system evacuation.
 - 3. Halogen refrigerant systems shall be pressure tested with dry nitrogen. **COMPRESSED AIR MAY NOT BE USED.** Leaks shall be repaired by removing and remaking the defective joint. No caulking will be permitted. After repair of leaks, system shall be retested and proved tight.

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4. Refrigerant piping shall be tested at a minimum of 300 PSIG. Suggested procedure is as follows:
 - a) Charge system with dry nitrogen or dried compressed air to pressure of 100 PSIG. Make a soap bubble test of all joints. Mark all leaks, blow down and repair all leaks.
 - b) After above test and repair, charge with refrigerant to a pressure of 45 PSIG. Make a rapid leak check at this pressure using an electronic leak detector. If no leaks are found, raise pressure to 300 PSIG using dry nitrogen.
 - c) Let mixture set overnight to permit mixing by diffusion. Check diffusion and leak tester operation by venting a flange or valve stem. Make a thorough leak test. If leaks are found, blow down, repair, and retest. Continue this procedure until entire system is proved to be absolutely tight.
5. After the refrigerant piping has been pressure tested and proven tight and before pipe insulation is applied, the entire system shall be evacuated with a vacuum pump to remove air and moisture. Evacuation shall be performed with all spaces containing refrigerant piping or equipment at no less than 50°F.
6. All manual valves except those open to atmosphere shall be opened and all controls such as solenoids and back pressure regulators shall be jacked open. Any gauges or pressure controls which could be damaged by a deep vacuum shall be valved off. All seal caps on valves shall be in place and tight. Any valves open to atmosphere shall be closed and plugged.
7. The entire system shall be double evacuated to 1500 microns.
 - a) When vacuum pump is started, vacuum should pull down fairly rapidly to 25,000 microns. If vacuum does not pull down below 25,000 microns, obviously there are leaks in the system and leak test procedure must be repeated.
 - b) At approximately 10,000 microns, evaporation of free water in the system will be rapidly accelerated and vacuum will tend to remain constant as evaporation rate begins to equal vacuum pump capacity. Depending on amount of water, ambient temperature and vacuum pump capacity, it may take several hours to make any noticeable decrease in vacuum below 10,000 microns. During this period, apply heat to any low points or suspected points of moisture. Feel pipes for cold spots and apply heat.
 - c) Continue evacuation until a pressure of 1,500 microns minimum is reached, then break the vacuum and pressurize to 10 PSIG with dry nitrogen as holding charge until ready for charging.
 - d) When ready for charging, vent nitrogen holding charge to atmosphere and re-evacuate down to a minimum of 1,500 microns. Break vacuum with refrigerant gas. Do not use liquid refrigerant.

3.4 START UP OF SYSTEMS

- A. After testing and evacuating, and after pipe insulation is complete, the systems shall be charged and started. The Contractor shall operate the refrigeration system until the rooms are down to design conditions and held at design conditions for a minimum of seven days. The defrost systems shall be operated during this period. During this period the Contractor shall calibrate and adjust all operating and safety controls.
- B. During start up, all strainers shall be cleaned. **EXTREME** care shall be taken to keep air out of the system during the cleaning operation.

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- C. Prior to acceptance, the Contractor shall clean all strainers, purge all air, and **RECHECK THE ENTIRE SYSTEM FOR LEAKS.**
- D. Proper operation of all equipment, safety controls, and automatic controls shall be demonstrated to the Owner prior to acceptance.

3.5 PAINTING

- A. After all systems are ready for operation, the Contractor shall touch-up factory finish on all equipment, installed under this Specification, which has become marred during shipment or installation. Particular care shall be taken to repair any damaged finish on air units and condensing units.

3.6 FINAL INSPECTION

- A. Proper operation of all equipment, safety controls, and automatic controls in accordance with the Specifications shall be demonstrated to the Owner prior to acceptance.
- B. The Engineer's final inspection will not be made until the Contractor has complied with the start-up procedure and not until his clean-up work has progressed to the point where the plant is in condition to turn over to the Owner's operators. The time shall be mutually agreed upon with the Owner.

3.7 WARRANTY

- A. All refrigeration equipment must be warranted in writing (both parts and labor) for a period of one year from date of acceptance by Owner.

END OF SECTION