

**SECTION 22 62 00**  
**VACUUM SYSTEMS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Vacuum Systems: This section describes the labor, equipment, and services necessary for and incidental to the installation of piped vacuum systems and vacuum. Vacuum shall be installed started, tested, and ready for use. The scope of work shall include all necessary piping, fittings, valves, rough ins, gages, alarms including low voltage wiring, vacuum pumps, electric motors and starters, receivers, and all necessary parts, accessories, connections and equipment.
- B. The contractor shall provide all elements and accessories required for a complete system according to the most recent edition of NFPA 99C, Gas and Vacuum Systems.
- C. All necessary connections to owner furnished equipment shall be made as indicated on the documents. A separate construction isolation valve shall be made at the point of connection to an existing vacuum system.
- D. Electrical power and control wiring for vacuum pump(s), ceiling columns, alarms wiring from equipment to alarm panels, and modular accessories associated with the system(s) shall be included.
- E. Pressure testing, cross connection testing and final testing per NFPA 99 most recent edition and using procedures shall be performed.

**1.2 RELATED WORK**

- A. Section 07 84 00, FIRESTOPPING: Sealing around pipe penetrations to maintain the integrity of time rated construction.
- B. Section 07 92 00, JOINT SEALANTS: Sealing around pipe penetrations through the floor to prevent moisture migration.
- C. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: General requirements and items common to more than one section of Division 22.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit.
- E. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Control wiring.
- F. Section 26 27 26, WIRING DEVICES: Electrical wiring and accessories.
- G. Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT: Electric motors.
- H. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS: Motor starters.
- I. Section 10 25 13, PATIENT BED SERVICE WALLS: Prefabricated bedside patient units.

J. Section 22 63 00, GAS SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES:  
Laboratory and Healthcare Gases and Vacuum Alarms.

K. SECTION 22 63 00, GAS SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES:  
Laboratory and Healthcare Gas Piping and Equipment:

### **1.3 QUALITY ASSURANCE**

- A. Installation and Start-up: The manufacturer will provide factory authorized representatives to review installation and perform initial start up of system.
- B. Contractor shall include with submittals an affidavit attesting to compliance with all relevant paragraphs of NFPA 99 most recent edition. Personnel assembling vacuum shall meet NFPA 99 5.1.10.10.11 "Qualification of Installers" and hold medical gas endorsements as under ASSE 6010. The Contractor shall furnish documentation attesting that all installed piping materials were purchased cleaned and complied with the requirements of NFPA 99 5.1.10.1 and 5.1.10.2. Electrical Control systems and vacuum Alarms are to be UL listed as assemblies with label affixed. Vacuums are to be wired in accordance with NEC.
- C. Equipment Installer: The equipment installer shall show documentation proving that the personnel installing the equipment meet the standards set by the American Society of Sanitary Engineers (ASSE) 6010 Professional Qualification Standards for Medical Gas System Installers. Show technical qualifications and previous experience in installing medical gas equipment on three similar projects. Submit names and addresses of referenced projects. The equipment install shall perform the following coordination functions:
  - 1. Coordinate with other trades to ensure timely installations and avoid conflicts and interferences.
  - 2. Work with the metal stud partition installer and/or mason to ensure anchors, sleeves and similar items are provided in sufficient time to avoid delays; chases and openings are properly sized and prepared.
  - 3. Coordinate with VA to ensure medical vacuum inlets, whether owner supplied or contractor supplied, in walls, ceiling and all equipment is provided by the same Vacuum Equipment Manufacturer satisfactory to the owner.
  - 4. The contractor shall coordinate with the Vacuum System Verifier to deliver a complete, tested medical gas installation ready for owner's use.

- D. Equipment Supplier: The Equipment supplier shall demonstrate evidence of installing equivalent product at three installations similar to this project that has been in satisfactory and efficient operation for three years. Names and addresses where the product is installed shall be submitted for verification.
- E. Names of three projects where testing of vacuum systems has been performed by the testing agency shall be provided. The name of the project, names of such persons at that project who supervised the work for the project owner, or who accepted the report for the project owner, and a written statement that the projects listed required work of similar scope to that set forth in this specification shall be included in the documentation.
- F. The testing agency's detailed procedure which will be followed in the testing of this project shall be submitted. In the testing agency's procedure documentation, include details of the testing sequence, procedures for cross connection tests, outlet function tests, alarm tests, purity tests, etc., as required by this specification. For purity test procedures, data on test methods, types of equipment to be used, calibration sources and method references shall be submitted.
- G. Installation and Start-up: The manufacturer shall provide factory authorized representatives to review the installation and perform the initial startup of the system. The factory authorized representatives shall submit a report to the construction administrator and to the Contractor. The Contractor shall make all corrections identified by the factory authorized representative.
- H. Certification: The Final inspection documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and a certification that all results of tests were within limits allowed by this specification.
- I. The installing contractor shall maintain as-built drawings of each completed phases for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings shall be provided, and a copy of them on Auto-Cad version (R-14 or later) provided on compact disk.

#### **1.4 SUBMITTALS**

- A. Submit as one package in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Manufacturer's Literature and Data:

1. Complete specifications for the product intended to be installed, dimensional drawings, and wiring schematics.
  2. Package drawing indicating package style, dimensions when complete, method of disassembly and sizes of subsections for rigging and installation.
  3. Piping.
  4. Valves.
  5. Inlet and outlet cocks
  6. Valve cabinets.
  7. Gages.
  8. Station inlets, and rough in assemblies.
  9. Ceiling services.
  10. Alarm controls and panels.
  11. Vacuum switches.
  12. Vacuum bottle brackets.
  13. Vacuum pump systems (Provide certified pump test data at start up):
    - a. Pumps: Manufacturer and model.
    - b. Pump performance curves.
    - c. Pump operating speed (RPM).
    - d. Capacity: Free air exhaust from 65 and 80 kPa (19 and 24 inches Hg.) gage vacuum (L/s) (SCFM).
    - e. Capacity: Expanded air capacity at 65 and 80 kPa (19 and 24 inches Hg.) gage vacuum (L/s) (SCFM).
    - f. Type of bearing in pump.
    - g. Type of lubrication.
    - h. Type and adjustment of drive.
    - i. Electric motors: Manufacturer, frame and type.
    - j. Speed of motors (RPM).
    - k. Current characteristics and horsepower of motors.
    - l. Receiver capacity and rating.
    - m. Silencers: Manufacturer, type and model.
- C. Certification: The completed systems have been installed, tested, purged and analyzed in accordance with the requirements of this specification.
- D. A notarized affidavit from the verifier stating that the verifier undertakes to verify this project and thus agrees to disqualify themselves from supplying any equipment which will be included in the

scope of their verification. No verifier who supplies equipment shall be permitted to verify that equipment. Statement declaring that the vacuum system manufacturer has no fiduciary interest in the verifier and that the verifier is not an agent or representative of the vacuum system manufacturer.

#### **1.5 TRAINING**

- A. The services of a competent instructor shall be provided for not less than two four-hour periods for instructing personnel in the operation and maintenance of the vacuum systems, on the dates requested by COTR.
- B. The other training requirements specified in Section 01 00 00, GENERAL REQUIREMENTS shall be coordinated with the above paragraph

#### **1.6 APPLICABLE PUBLICATIONS**

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the test by the basic designation only.
- B. American National Standards Institute (ANSI):
  - A13.1-2007.....Scheme for Identification of Piping Systems
  - B16.22-01 (R2005).....Wrought Copper and Bronze Solder-Joint Pressure Fittings
  - B40.1-(2006)..... Pressure Gauges and Gauge Attachments
- C. American Society for Testing and Materials (ASTM):
  - B819-00.....Standard Specification for Seamless Copper Tube for Medical Gas Systems
- D. American Society of Mechanical Engineers (ASME):
  - Section IX-04.....Welding and Brazing Qualifications
- E. American Welding Society (AWS):
  - AWS A5.8/A5.8M-2004.....Brazing Filler Metal
  - AWS B2.2-91.....Standard for Brazing Procedure and Performance Qualification (Modified per NFPA 99)
- F. Compressed Gas Association (CGA):
  - P-9-92.....Inert Gases Argon, Nitrogen and Helium
- G. National Electrical Manufacturers Association (NEMA):
  - ICS-6-(1993, R 2006)....Industrial Controls and Systems Enclosures
- H. National Fire Protection Association (NFPA):
  - 70 (2007).....National Electric Code
  - 99-2005.....Health Care Facilities with 2005 errata
- I. United States Pharmacopoeia XXI/National Formulary XVI (USP/NF)

J. Manufacturing Standardization Society (MSS):

MSS-SP-72-99.....Ball Valves With Flanged or Butt Welding For  
General Purpose

MSS-SP-110-96.....Ball Valve Threaded, Socket Welding, Solder  
Joint, Grooved and Flared Ends

MSS-SP-73-03.....Brazing Joints for Copper and Copper Alloy  
Solder Pressure Fittings

**1.7 WARRANTY**

- A. Warranty will be expressly complete, include all components of the system and be the responsibility of the vacuum system manufacturer of record only. Warranties limiting the responsibility of the vacuum system for any system component or which pass through to another manufacturer are not acceptable.
- B. Warranties shall include on site repairs including travel, labor and parts. Warranties requiring return of equipment for adjustment are not acceptable.

**1.8. MAINTENANCE SUPPORT**

- A. The vacuum equipment manufacturer shall demonstrate a national factory direct service capability able to perform major overhauls. The vacuum equipment manufacturer shall offer factory direct preventative maintenance contract for the owner's consideration. The vacuum equipment manufacturer shall offer formal maintenance training courses.

**PART 2 - PRODUCTS**

**2.1 GENERAL PRODUCT REQUIREMENTS**

- A. One Vacuum Equipment Manufacturer shall supply the vacuum system(s) and equipment to include valves and gauges, valve boxes, alarm panels and manifolds, vacuum.

**2.2 PIPING**

- A. Copper Tubing: Copper tubing shall be type "K" or "L", ASTM B819, seamless copper tube, hard drawn temper, with wrought copper fittings conforming to ANSI B16.22 or brazing fittings complying with MSS SP-73. The copper tubing size designated reflects nominal inside diameter. All tubing and fittings shall be labeled MV.
- B. Brazing Alloy: The brazing alloy shall comply with AWS A5.8, Classification BCuP, greater than 537 °C (1000 °F) melting temperature. Flux shall be strictly prohibited for copper to copper connections.
- C. Screw Joints: Screw joints shall use polytetrafluoroethylene (teflon) tape.

- D. Galvanized Steel: Galvanized steel shall only be used for the discharge from the vacuum producer. The galvanized steel vacuum discharge pipe and fittings shall comply with the following:
  - 1. Pipe: The galvanized steel pipe shall comply with ASTM A53, standard weight.
  - 2. Fittings: The fittings shall comply with the following
    - a. Flexible groove, malleable iron, ASTM A47, or ductile iron, ASTM A536.
    - b. Malleable iron screwed, ANSI B16.3.
- E. Memory metal couplings shall have temperature and pressure ratings not less than that of a brazed joint.
- F. Piping identification labels shall be applied at time of installation in accordance with current NFPA. Supplementary color identification shall be in accordance with CGA Pamphlet C-9.
- G. Special Fittings: The following special fittings shall be permitted to be used in lieu of brazed joints:
  - 1. Memory-metal couplings having temperature and pressure ratings joints not less than that of a brazed joint.
  - 2. Listed or approved metallic gas tube fittings that, when made up, provide a permanent joint having the mechanical, thermal, and sealing integrity of a brazed joint.
  - 3. Dielectric fittings where required by the manufacturer of special medical equipment to electrically isolate the equipment from the piping distribution system.
  - 4. Axially swaged, elastic strain preload fittings providing metal to metal seal having pressure and temperature ratings not less than that of a brazed joint and when complete are permanent and non-separable.

### **2.3 EXPOSED VACUUM PIPING**

- A. Finished Room: Use full iron pipe size chrome plated brass piping shall be used for exposed laboratory and healthcare vacuum piping connecting fixtures, casework, cabinets, equipment and reagent racks when not concealed by apron including those furnished by the Government or specified in other sections.
  - 1. Pipe: Fed. Spec. WW-P-351, standard weight.
  - 2. Fittings: Fittings shall comply with ANSI B16.15 cast bronze threaded fittings with chrome finish, (125 and 250).
  - 3. Nipples: Nipples shall comply with ASTM B 687, Chromium-plated.

4. Unions: Unions shall comply with Mss SP-72, SP-110, Brass or Bronze with chrome finish. Unions 65 mm (2-1/2 inches) and larger shall be flange type with approved gaskets.
5. Valves: Valves shall comply with Mss SP-72, SP-110, Brass or bronze with chrome finish.

#### **2.4 VALVES**

A. Ball: Ball valves shall be in line, other than zone valves in cabinets.

1. Sixty five millimeter or DN65 (2 1/2 inches) and smaller: Ball valves shall be bronze/ brass body, Fed. Spec. MSS SP72 & SP 110 , Type II, Class 150, Style 1, with tubing extensions for brazed connections, full ported, three piece or double union end connections, teflon seat seals, full flow, 4125 kPa (600 psi) WOG minimum working pressure, with locking type handle.
2. Eighty millimeter or DN80 to 100 millimeter or DN100 (3" to 4" inches): Ball valves shall be bronze/ brass body, Fed. Spec. MSS SP72 & SP 110, Type II, Class 150, Style 1 with tubing extensions brazed to flanges, full ported, three piece, double seal, teflon seals, full flow, 4125 kPa (600 psi) WOG minimum working pressure, with locking type handle.

B. Check:

1. Check valves eighty millimeters (DN80) (3 inches) and smaller: brass and Bronze body, straight through design for minimum pressure drop, spring loaded, self aligning with teflon cone seat, vibration free, silent operation, supplied NPT female threads at each end with flow direction arrow permanently cast into, 2750 kPa (400 psi) WOG minimum working pressure.
2. One hundred millimeter or DN100 (4 inches) and larger check valves shall be iron body, bronze trim, swing type, vertical or horizontal installation, flange connection, 1025 kPa (150 psi) WSP.

#### **2.5 GAGES**

A. Vacuum Gages:

1. For vacuum line adjacent to source equipment the vacuum gages shall comply with ANSI B40.1, vacuum gage type, size 115 mm (4-1/2 inches), gage listed for vacuum, accurate to within 2-1/2 percent, with metal case. The vacuum gage range shall be 0 to-100 kPa (0-30 inches Hg). Dial graduations and figures shall be black on a white background, or white on a black background. Label shall be for



vacuum service. A gage cock shall be installed. Compound gages shall be installed for Vacuum system.

2. For vacuum service upstream of main shutoff valve: A 40 mm (1-1/2 inch) diameter gage shall be provided with steel case, bourdon tube and brass movement, dial range 0 to -100 kPa (0-30 inches Hg).

Compound gages shall be provided for Vacuum system.

## 2.6 STATION INLET ROUGH-IN

- A. Station inlet rough in shall be Flush mounted, and protected against corrosion. Rough in shall be anchored securely to unit or wall construction.
- B. The modular cover plate shall be constructed from die cast plate, two piece .85 mm (22 gage) stainless steel or 1.6 mm (16 gage) chromium plated metal, secured to rough in with stainless steel or chromium plated countersunk screws. The latch mechanism shall be designed for one handed, single thrust mounting and one handed fingertip release of secondary equipment.
- C. Cover Plate for Prefabricated Bedside Patient Units (PBPUs) shall be One piece with construction and material as indicated for modular cover plate.
- D. Permanent, metal or plastic, identification plates shall be provided securely fastened at each inlet opening, with inscription for appropriate service using color coded letters and background. Metal plates shall have letters embossed on baked on enamel background. Color coding for identification plates is as follows:

SERVICE LABEL	IDENTIFICATION PLATE COLORS
VACUUM	Black letters on white background

## 2.7 CEILING SERVICES

- A. Column accessories:
  1. Equip each utility column with flush type quick coupler gas service station outlets, except nitrogen outlets shall be DISS, as specified under Article, STATION OUTLETS. Provide the following outlets, mounted on the utility column: two oxygen, one medical air, and two vacuum inlets.
  2. Provide one 48 mm by 80 mm (1-7/8" by 3") blank and face plate for future installation of mass spectrometer inlet tubing and wiring.
  3. Provide spacing to allow for future installation of up to three monitoring receptacles.

4. Provide four single, NEMA 5-20R, hospital grade receptacles rated at 20 amps, 125 volts, 2 pole, 3 wire; two grounding receptacles. Coordinate with Section 26 27 26, WIRING DEVICES.
5. Equip column with four I.V. hooks.
6. Provide one 48 mm by 80 mm (1 7/8" x 3") blank face plate for computer connection.

## **2.8 VACUUM SWITCHES**

- A. Vacuum switches shall be general purpose, contact or mercury type, allowing both high and low set points, with contact type provided with a protective dust cover. The vacuum switch shall have an adjustable range set by inside or outside adjustment. Vacuum switches shall activate when indicated by alarm requirements. One orifice nipple (or DISS demand check valve) shall be used for each sensor switch.

## **2.9 VACUUM BOTTLE BRACKET**

- A. Vacuum bottle bracket shall be single plate of one piece, .85 mm (22 gage) stainless steel or 1.6 mm (16 gage) chromium plated metal or aluminum, finish matching cover of adjoining vacuum inlet. All components shall be of same material as plate and assembly anchored securely. The bracket shall be provided and plastic vacuum bottle holder for each vacuum wall inlet.

## **2.10 VACUUM PUMP SYSTEMS**

- A. Provide a complete vacuum package, complying with NFPA 99 5.1.3.6 in all respects, as specified and scheduled on the drawings. All components shall be factory packaged (pre-wired and prepiped), on a steel base, or tank mounted. All package piping shall be type L or type K rigid copper. Provide discharge separator/silencer.
- B. All components shall be duplexed and valved (or check valved as permitted NFPA-99) to allow service to any component without interrupting vacuum service to the facility during any maintenance operation or any condition of single fault failure. The design load shall be met with the largest single unit out of service. Each pump exhaust shall be isolated by a union fitting permitting capping for service removal.
- C. A complete plant shall be furnished consisting of pumps, receiver and controls capable of providing the scheduled capacity with one pump out of service. All capacities will be indicated in SCFM at 19 inches HG and 24 inches HG.

- D. System shall be completely factory assembled, requiring only interconnection between modules on site. Systems requiring on site assembly other than interconnection are not acceptable (replacement of components removed for shipping is permitted).
- E. Motor and Starter: Maximum 40 °C (104 °F) ambient temperature rise, close coupled to a NEMA rated, High Efficiency, TEFC motor with a service factor of 1.15, ball bearings, for operation with current, voltage, phase and cycle specified in Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT. Motor shall be of such capacity that brake horsepower required by driver equipment at normal rated capacity will not exceed nameplate rating of the motor. Provide each motor with automatic, fully enclosed, magnetic starter of type specified in Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.
- F. Each pump will include inlet and outlet flex connectors supplied by the medical vacuum equipment manufacturer.
- G. Programmable Logic Controllers (PLC) will be used to implement operating logic. PLC shall have integral memory and EPROM backup. PLC shall control the automatic alternation of the vacuum pumps with provisions for simultaneous operation if required, and automatic activation of reserve or lag unit if required. A lag alarm on control cabinet and contacts for the master alarm shall be provided.
- H. The complete control system and all electrical components shall be NEMA ICS-6, type 12 and UL labeled. The control system shall provide:
  - 1. Automatic lead/lag sequencing including self adjusting minimum run timers which adaptively optimize the number of pump starts based on demand.
  - 2. Circuit breaker disconnects for each vacuum pump with external operators. Units with fuses instead of circuit breakers in motor circuit are not acceptable. The control system shall include an automatic minimum run time adjustment to automatically adjust run time based on demand.
  - 3. Full voltage motor starters with overload protection.
  - 4. Redundant 120 volt control circuit transformers.
  - 5. Visual and audible reserve unit alarm with isolated contacts for remote alarms and audio cancel.
  - 6. Control cabinet shall have lighted HOA selector switches
  - 7. Panel mounted vacuum gauge, external visual lights indicating on/off status, audible and visual signals for thermal overload, oil

- discharge filter differential pressure or back pressure alarm, and alarm silence button.
8. Contacts for external oil discharge filter differential pressure or back pressure alarm
  9. If silence has been pressed, audible and visual signal would be reactivated upon second alarm condition. Alarm shall be reset upon correction of original signal.
  10. Runtime hour-meter for each pump.
- I. The vacuum pumps shall be oil free, single stage, positive displacement, and non pulsating liquid ring type. The vacuum pump shall be fitting with mechanical seals. Each vacuum pump shall be all iron construction with bronze or stainless steel rotor and carbon steel shaft. The medical vacuum pump design shall require 360 days between maintenance intervals. Fresh seal water shall be minimal under operation and shall include a reservoir of sufficient capacity for 96 hours of operation without a fresh water supply.
- J. The complete vacuum system and all electrical components shall be factory tested prior to shipment by the medical vacuum equipment manufacturer
- K. Controls:
1. Automatic: Adjustable, vacuum operated, automatic, electric switch to start and stop motor at receiver vacuum indicated. Provide heavy duty alternator, automatic, operating on a timed basis, to alternate the pumps by time forced alternation.
  2. Control panel: Housed in a NEMA ICS-6, Type 12, listed, dust proof enclosure; prewired to include all specified electrical, electronic and electro pneumatic devices. Include wiring diagrams and operating descriptions in the cabinet. Include the following:
    - a. Circuit breakers for each control and motor circuit.
    - b. Hand off automatic selector switch for each pump.
    - c. Hour meter for each pump.
    - d. Control circuit transformers.
    - e. One magnetic motor starter for each pump.
    - f. Provide panel with external visual (lights, red for running, green for off) and audible (horn/buzzer) signals. The signals provided include:
      - 1) Pump in operation (visual only).
      - 2) Thermal overload shutdown (visual and audible).

- 3) Oil discharge filter differential pressure or back pressure alarm (visual), with contacts for external signal. Wire to master alarm panel.
  - 4) Cancel button, which will silence an audible alarm, reactivate should a second alarm occur while the horn is silenced, and reset automatically upon correction of the original signal.
- L. Receiver Tank: The receiver tank shall be welded galvanized steel, in compliance with ASME Section VIII, 850 kPa (125 psi) working pressure stamped and certified. The receiver tank shall be equipped with vacuum gage and gage glass. The receiver tank shall be of sufficient capacity to ensure practical on/off operation of pumps.
- M. Bio-Hazard Safety Statement: "BIOHAZARD CAUTION: Fluid and waste material inside vacuum pipelines and vacuum equipment may be contaminated with blood and other potentially infectious material. Construction and service personnel should use PERSONAL PROTECTIVE EQUIPMENT and practice UNIVERSAL PRECAUTIONS when opening or servicing vacuum systems."

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION**

- A. All installation shall be performed in strict accordance with NFPA 99 5.1.10. Brazing procedures shall be as detailed in NFPA 99 5.1.10.5. Brazing shall be performed only by brazers qualified under NFPA 99 5.1.10.10.11. Where piping runs underground, the installation shall be made in accordance with NFPA 99 5.1.10.10.5.
- B. Contractor shall furnish 4 inch high concrete housekeeping pads. The contractor shall furnish inertia bases in lieu of housekeeping pads where the equipment installed is not factory isolated by the manufacturer. Anchor bolts shall be cast into bases
- C. Cast escutcheon shall be installed with set screw at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.
- D. Open ends of tube shall be capped or plugged at all times or otherwise sealed until final assembly.
- E. Piping shall be cut square and accurately with a tube cutter (sawing not permitted) to measurements determined at place of installation. the tubing shall be reamed to remove burrs, being careful not to expand tube, and so no chips of copper remain in the tube. The tubing shall be worked into place without springing or forcing. The tubing shall be

bottomed in socket so there are no gaps between tube and fitting. Care shall be exercised in handling equipment and tools used in cutting or reaming of tube to prevent oil or grease from being introduced into the tubing. Where contamination has occurred, material shall be no longer suitable for vacuum service and new, sealed tube sections used..

- F. Piping shall be supported with pipe trays or hangers at intervals as shown on the drawings or as defined in NFPA 99 Table 5.1.10.10.4.5. Piping shall not be supported by other piping. Isolation of copper piping from dissimilar metals shall be of a firm, positive nature. Duct tape is not acceptable as an isolation material..
- G. Valves and other equipment shall be rigidly supported to prevent strain on tube or joints.
- H. Piping exposed to physical damage shall be protected.
- I. During any brazing operation, the interior of the pipe shall be purged continuously with oil free, dry nitrogen NF, following the procedure in NFPA 99 5.1.10.5.5. At the completion of any section, all open pipe ends shall be capped using an EXTERNAL cap. The flow of purged gas shall be maintained until joint is cool to touch. The use of flux is prohibited when making of joints between copper to copper pipes and fittings.
- J Threaded joints in piping systems shall be avoided whenever possible. Where unavoidable, make up the male threads with polytetrafluorofethylene (such as Teflon) tape. Liquid sealants shall not be used.
- K. Tubing shall not be bent. Fittings shall be used in all change of direction or angle.
- L. After installation of the piping, but before installation of the outlet valves, blow lines clear using nitrogen NF.
- M. Pressure and vacuum switches, transmitter and gauges shall be installed to be easily accessed, and provide access panel where installed above plaster ceiling. Pressure switch and sensors shall be installed with orifice nipple between the pipe line and switches/sensors.
- N. Pipe labeling shall be applied during installation process and not after installation is completed. Size of legend letters shall be in accordance with ANSI A13.1.
- O. After initial leakage testing is completed, the piping shall be allowed to remain pressurized with testing gas until testing agency performs final tests.

P. Penetrations:

1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoked partitions, or floors, fire stopping shall be installed that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING, Clearances between raceways and openings with the fire stopping material shall be completely filled and sealed..
2. Water proofing: At floor penetrations, clearances shall be completely sealed around the pipe and made watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS.

Q. A vacuum gage 40mm (1 1/2 inch) diameter line shall be installed downstream of each zone valve in cabinets.

R. Piping shall be labeled with name of service, identification color and direction of flow. Where non-standard pressures are piped, pressure shall be labeled. Labels shall be placed at least once every 20 feet of linear run or once in each story (whichever is more frequent). A label shall additionally be placed immediately on each side of all wall or floor penetrations. Pipe labels shall be self adhesive vinyl type or other water resistant material with permanent adhesive colored in accordance with NFPA 99 Table 5.1.11 and shall be visible on all sides of the pipe. Each master alarm signal shall be labeled for function after ring out. Each zone valve shall be labeled and each area alarm labeled for the area of control or surveillance after test. Labels shall be permanent and of a type approved by the VAMC

S. Alarms and valves shall be labeled for service and areas monitored or controlled. Coordinate with the VAMC for final room or area designations. Valves shall be labeled with name and identification color of the gas and direction of flow

**3.2 INSTALLER TESTING**

A. Prior to declaring the lines ready for final verification, the installing contractor shall strictly follow the procedures for verification as described in NFPA 99 5.1.12.2 and attest in writing over the notarized signature of an officer of the installing company the following;

1. That all brazing was conducted by brazers qualified to ASSE 6010 and holding current medical gas endorsements.
2. That all brazing was conducted with nitrogen purging. (Procedure per NFPA 99 5.1.10.5.5).

3. That the lines have been blown clear of any construction debris using oil free dry nitrogen or air are clean and ready for use. (Procedure per NFPA 99 5.1.12.2.2).
  4. That the assembled piping, prior to the installation of any devices, maintained a test pressure 1 1/2 times the standard pressures listed in NFPA 99 Table 5.1.11 without leaks. (Procedure per NFPA 99 5.1.12.2.3).
  5. That after installation of all devices, the pipeline was proven leak free for 24hours at a pressure 20% above the standard pressures listed in NFPA 99 Table 5.1.11. (Procedure per NFPA 99 5.1.12.2.2.6)
  6. That the systems have been checked for cross connections and none were found. (Procedure per NFPA 99 5.1.12.2.4)
  7. That the manufacturer has started up all air compressors and that they are in operating order.
- B. Four originals of the affidavit, shall be distributed; (1) to the engineer, (1) to the owners representative, (1) to the general contractor and (1) to the verifier.

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