SECTION 220600 - MEDICAL GAS PIPING SYSTEMS

1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Conditions-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.

B. The Contractor shall provide all equipment and specialties complete with trim required and connect in a manner conforming to the NFPA and all other applicable codes.

C. The Contractor shall obtain exact centerline rough-in dimensions between partitions, walls, etc., as required for lay-out of his rough-in work. All work shall be roughed-in so that all exposed piping will be straight and true without bends or offsets.

D. All equipment and specialties shall be new unless otherwise indicated or specified. They shall also be of equivalent quality, dimensions, materials, etc., as those specified.

E. All equipment and specialties shall be installed as recommended by the manufacturer.

F. All equipment and specialties shall be installed in a neat and workmanlike manner. Unacceptable workmanship shall be removed and replaced at the installing Contractor's cost.

G. Refer to applicable Division 16 sections for wiring and power.

2. DESCRIPTION OF WORK

A. Extent of medical gas piping system work is indicated on the drawings and by requirements of this section.

B. NFPA Compliance: Comply with requirements of NFPA Standard 99 Gas and Vacuum Systems. All portions of each system shall be listed by and bear the seal of UL, Inc., where a standard has been established for such.

C. Comply with ANSI/AWS A5.8 - Specifications for Brazing Filled Metal regarding pipe joint make-up.

D. Central Medical Gas and Vacuum Systems: Consisting of Oxygen, Nitrous Oxide, Nitrogen, Medical Air, Vacuum and Anesthesia Evacuation Services as indicated on drawings; complete, ready for operation, including all necessary piping, fittings, valves, cabinets, station outlets and inlets, equipment connections, rough-Ins, ceiling services, gauges, alarms, headwall units, including low voltage wiring, nitrogen control panels, air compressors, vacuum pumps, electric motors and starters, receivers, air dryers, filters, pressure regulators, and all necessary parts, accessories, connections and equipment. Match station outlets and inlets.

E. Related Work

(1) Sealing around pipe penetrations to maintain the integrity of time rated construction.

(2) Sealing around pipe penetrations through the floor and roof to prevent moisture migration.
(3) Piping systems identification.

(4) Exposed piping and sleeves, and water piping, controls and accessories.

(5) Surgical service multi-purpose pendant.

(6) Alarm interface with main hospital alarm panel.

(7) Conduit.

(8) Control wiring.

(9) Electrical wiring and accessories.

(10) Electric motors.

(11) Motor starters.

(12) Prefabricated bedside patient units.

F. Quality Assurance

(1) Materials and Installation: In accordance with NFPA 99, and as specified.

(2) Equipment Installer: Show technical qualification and previous experience in installing medical gas equipment on three similar projects.

(3) Equipment Supplier: Show evidence of equivalent product installed at three installations similar to this project, that has been in satisfactory and efficient operation for three years.

(4) Independent Medical Gas System Testing Organization:

a. Testing agency that is financially independent of medical gas equipment manufacturer and supplier.

b. Provide names of three projects where testing of medical gases and systems has been performed by the testing agency. Include the name of the project, names of such persons at that project who supervised the work for the project owner, and a written statement that the projects listed required work of similar scope to that set forth in this specification.

c. Submit the testing agency's detailed procedure which will be followed in the testing of this project. Include details of the testing sequences, procedures for cross connection, tests, outlet function tests, ceiling column function tests, alarm tests, purity tests, etc., as required by this specification. For purity test procedures, include data on test methods, types of equipment to be used, calibration sources and method references.

(5) Certification: Provide documentation upon completion of the testing to 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 section.
3. DRAWINGS AND DESCRIPTIVE LITERATURE

The Contractor shall prepare and submit to the Architect and/or Engineer, seven (7) copies of shop drawings including, but not limited to, the following list:

A. Manufacturer's Literature and Data

   (1) Piping.

   (2) Valves.

   (3) Valve cabinets.

   (4) Station outlets, inlets, and rough-in assemblies.

   (5) Gauges.

   (6) Alarm controls and panels.

   (7) Switches (pressure and vacuum).

   (8) Vacuum bottle brackets.

B. Sample Outlets

   Provide a sample outlet of each type to the Engineer, so that the Owner may confirm the outlet type will work with the equipment they intend to connect to the outlet. Submit the sample outlets with the system shop drawings or before.

C. Station Outlets and Inlets

   Submit literature from manufacturer stating that outlets and inlets are designed and manufactured in compliance with latest NFPA 99 Gas and Vacuum Systems. Each outlet and inlet shall bear label of approval as an assembly, of Underwriters Laboratories, Inc., or Associated Factory Mutual Research Corporation. In lieu of the above labels, certificate may be submitted by a nationally recognized independent testing laboratory, satisfactory to the Contracting Officer, certifying that materials, appliances and assemblies conform to published standards, including methods of tests, of above organization.

D. Applicable Publications

   (1) The publications listed below form a part of this specification to the extend referenced. The publications are referenced in the test by the basic designation only.

   (2) Federal Specifications (Fed. Spec.):

          WW-V-35C.........................................................................................................................Valve, Ball

   (3) American National Standards Institute (ANSI):

          B16.22-89..........................................................................................................................Wrought Copper and Bronze
          Solder-Joint Pressure Fittings
4. MEDICAL GAS PIPING MATERIALS AND PRODUCTS

A. General

Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, and capacities as indicated on drawings. Provide materials and products complying with the
latest NFPA 99. Provide fittings of materials which match pipe materials used in medical gas piping systems including equipment connection.

(1) Piping shall be hard-drawn seamless medical gas tube, Type K or L (ASTM B819), and bear one of the following markings: OXY, MED, OXY/MED, ACR/OXY, or ACR/MED. Mains and branches in piping systems shall be not less than 1/2 in. nominal size. Runouts to area alarm panels shall be permitted to be 1/4 in. nominal size.

(2) Brazing Alloy: Provide brazing that complies with the latest NFPA 99 Gas and Vacuum Systems.

(3) Threaded Joints: Provide threaded joints that complies with the latest NFPA 99 Gas and Vacuum Systems.

(4) Identification: The gas content of medical gas piping systems shall be readily identifiable by appropriate labeling with the name of the gas contained. Such labeling shall be by the means of metal tags, stenciling, stamping or with adhesive markers in a manner that is not readily removable. Labeling shall appear on the piping at intervals of not more than 20 ft (6 m) and at least once in each room and each story traversed by the piping system. Where supplementary color identification of piping is used, it shall be in accordance with the gases and colors indicated in CGA Pamphlet C-9, Standard Color-Marking of Compressed Gas Cylinders Intended for Medical Use.

B. Basic Piping Specialties

(1) General

Provide piping specialties complying with the latest NFPA 99 in accordance with the following listing:

a. Pipe Escutcheons.

b. Pipe Sleeves.

c. Sleeve Seals.

C. Basic Supports, Anchors and Seals

(1) General

Provide supports, anchors and seals complying with Division 48 in accordance with the following listing:

a. Adjustable swivel pipe rings for horizontal piping hangers and supports.

b. Two-bolt riser clamps for vertical piping supports.

c. Concrete inserts, C-clamps, and steel brackets for building attachments.

5. MEDICAL GAS SYSTEM COMPONENTS

A. General
Furnish and install per latest NFPA 99 requirements a complete oxygen, vacuum, medical air nitrous oxide, nitrogen, vacuum system, carbon dioxide systems, etc., including, but not limited to, the following list:

(1) Station Outlets and Inlets (MG-#)

a. For All Services Except Nitrogen Systems: For designated service, consisting of a quick coupler and inlet supply tube. Provide coupler that is non-interchangeable with other services, and leakproof under three times normal working pressure. Equip each station outlet with an automatic valve and a secondary check valve to conform with the latest NFPA 99. Equip each station inlet with an automatic valve to conform with the latest NFPA 99. Place valves in the assembly to provide easy access after installation for servicing and replacement, and to facilitate line blow-out, purging, and testing. Fasten each outlet and inlet securely to rough-in to prevent floating and provide each with a capped stub length of 1/4-inch (3/8-inch outside diameter) tubing for connection to supply. Label stub tubing for appropriate service. Rough-in kits and test plugs for head wall units are furnished under this specification and installed per manufacturer of headwall unit recommendation before initial tests specified herein. Install completion kits (valve body and face plate) for the remainder of required tests.

b. Station Outlet and Inlet Rough-In

1) Flush mounted, protected against corrosion. Anchor rough-in securely to unit or wall construction.

2) Modular Cover Plate: Die cast plate, two-piece 22 gauge stainless steel or 16 gauge chromium plated countersunk screws.

3) Cover Plate for Prefabricated Bedside Patient Units (PBPU): One-piece with construction and materials as indicated for modular cover plate.

4) Provide permanent, metal or plastic, identification plates securely fastened at each outlet and 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:

<table>
<thead>
<tr>
<th>SERVICE LABEL</th>
<th>IDENTIFICATION COLOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>OXYGEN</td>
<td>White Letters On Green Background</td>
</tr>
<tr>
<td>OXYGEN (70 PSI)</td>
<td>White Letters On Green Background</td>
</tr>
<tr>
<td>MED AIR</td>
<td>Black Or White Letters On Yellow</td>
</tr>
<tr>
<td>MED VACUUM</td>
<td>Black Letters On White Background</td>
</tr>
</tbody>
</table>

c. Medical gas outlets and inlets shall be manufactured by Ohmeda, Puritan Bennett or equivalent. Outlets and inlets shall match the building existing equipment.

(2) Gauges

a. Pressure Gauges: Includes gauges temporarily supplied for testing purposes.
1) For Line Pressure Use Adjacent to Source Equipment: ANSI B40.1, pressure gauge, single, size 4-1/2", for compressed air, nitrogen and oxygen, accurate to within two percent, with metal case. Range shall be two times operating pressure. Dial graduations and figures shall be black on white background, or white on a black background. Gauge shall be cleaned for oxygen use, labeled for appropriate service, and marked "USE NO OIL." Install with gaugecock.

2) For All Services Downstream of Main Shutoff Valve: Manufactured expressly for oxygen use but labeled for appropriate service and marked "USE NO OIL," 1-1/2 inch diameter gauge with dial range 1-100 psig for oxygen, nitrous oxide and air, and 1-300 psig for nitrogen service.

b. Vacuum Gauges:

1) For vacuum line use adjacent to source equipment: ANSI B40.1, vacuum gauge, size 4-1/2" gauge for air, accurate to within two percent, with metal case. Range shall be 0-30 inches Hg. Dial graduations and figures shall be black on a white background, or white on a black background. Label for vacuum service. Install with gaugecock.

2) For vacuum service upstream of main shutoff valve: Provide 1-1/2 inch diameter gauge with steel case, Bourdon tube and brass movement, dial range 0-30 inches Hg.

c. All gauges shall be manufactured by Ohmeda, Puritan Bennett or equivalent.

(3) Alarms

a. Master Alarm Functions:

Provide all low voltage control wiring, including wiring from existing master alarm panel location to new location. Maintain existing monitoring functionality of master alarm panel, ensuring a complete, proper functioning system.

b. Area Alarm Functions:

1) Oxygen and Compressed Air Alarms:

(a) Pressure Alarms: Function when pressure in branch drops below 40 psig (Plus/Minus two psig) or increased above 65 psig (Plus/Minus two psig) set points; operated by pressure switches.

2) Vacuum Alarm:

(a) Low vacuum alarm function when pressure in branch drops below 12 inches Hg: operated by vacuum switch.

c. Alarm Panels:

1) Existing area alarm panel in Emergency Department shall be relocated as indicated on the plans. Extend existing wiring to new panel location. Work shall be performed such that downtime is minimal. Coordinate any monitoring outages with Hospital staff.
(4) Pressure and Vacuum Switches and Relief Valves

a. General purpose, contact or mercury type, allowing both high and low pressure set points, with contact type provided with a protective dust cover; adjustable range set by inside or outside adjustment; switches activate when indicated by alarm requirements.

b. Each central supply system shall have a pressure relief valve set at 50% above normal line pressure, installed downstream of the pressure regulator and upstream of any shutoff valve. This pressure relief valve may be set at a higher pressure provided another pressure relief valve set at 50% above normal line pressure is installed in the main supply line. All pressure relief valves shall close automatically when excess pressure has been released. Pressure relief valves set at 50% above normal line pressure shall be vented to the outside if the total capacity of the supply system is in excess of 2000 cu ft (57 m3) of gas. Pressure relief valves shall be of brass or bronze and especially designed for the gas service involved.

c. The pressure relief valve downstream of the line pressure regulator in nitrogen systems, used to provide power for gas-drive medical tools, instruments, or other systems, that vary from the normal 50-55 psig (345-380 kPa gauge) line pressure (i.e., systems supplying medical gases to hyperbaric chambers), shall be set at 50 percent above line pressure or 200 psig (1.4 MPa gauge), whichever is lower.

d. All pressure and vacuum switches shall be manufactured by Ohmeda, Puritan Bennett or equivalent.

(5) Valves

a. General

1) All valves shall comply with the latest NFPA 99 Gas and Vacuum Systems.

b. Ball

In line, other than zone valves in cabinets.

1) Three Inches and Smaller: Fed. Spec. WW-V-35, Type II, Class A, Style 1, with brazed connections. Three-piece, Buna-N or teflon seat seals, full flow, 300 psig minimum working pressure, with locking type handle.

c. Check

1) Three Inches and Smaller: Brass body, self-aligning, spring loaded ball type check mating with teflon cone seat.

d. Zone Valve in Cabinet

Brass or bronze body, double seal union ball valve with replaceable BUNA-N or teflon seat seals; 300 psig, cold, non-shock gas working pressure, designed specifically for oxygen service, requiring a 90 degree turn of handle from full open to full closed position. Operating parts of valves shall be products of one manufacturer, and uniform throughout
in pattern, overall size and appearance. Trim with color coded plastic inserts or color coded stick-on labels. Install valves in cabinets such that cover window cannot be in place when any valve is in the closed position. Color coding for identification plates and labels is as follows:

<table>
<thead>
<tr>
<th>SERVICE LABEL</th>
<th>IDENTIFICATION COLOR</th>
<th>MFG. STD. CLR.</th>
</tr>
</thead>
<tbody>
<tr>
<td>OXYGEN</td>
<td>White Letters On Green Background</td>
<td>Green</td>
</tr>
<tr>
<td>MED AIR</td>
<td>Black Or White Letters On Yellow</td>
<td>Yellow</td>
</tr>
<tr>
<td>MED VACUUM</td>
<td>Black Letters On White Background</td>
<td>White</td>
</tr>
</tbody>
</table>

e. Valve Cabinets

1) Flush mounted commercially available item for use with medical gas services, not lighter than 18 gauge steel or 14 gauge extruded aluminum, rigidly assembled, of adequate size to accommodate valve(s) and fittings. Punch or drill sides to receive tubing. Provide anchors to secure cabinets to wall construction. Seal openings in cabinet to be substantially dust tight. Locate bottom of cabinet approximately four-feet six-inches above floor unless otherwise indicated.

2) Mount metal or plastic identification plate on cabinets. Identification plate must be clearly visible at all times. Plate colors shall correspond to the service label colors previously listed. Provide inscriptions on plate to read in substance:

   CAUTION – (insert gas type) VALVE
   DO NOT CLOSE EXCEPT IN AN EMERGENCY
   THIS VALVE CONTROLS SUPPLY TO:
   (insert equipment type)
   ROOMS (insert room numbers)

3) Cover Plates: Fabricated from 18 gauge sheet metal with satin chromed finish, extruded anodized aluminum, or 22 gauge stainless steel. Provide cover window of replaceable plastic, with a corrosion resistant device or lever secured to window for emergency window removal. Permanently paint or stencil on window: "FOR EMERGENCY ONLY, SHUT-OFF VALVES FOR PIPED GASES," or equivalent wording. Configure such that it is not possible to install window with any valve in the closed position.

6. PURGING

A. After all medical gas piping systems have been tested, the source of the test gas shall be disconnected and the proper gas source of supply connected to each respective system. Following this connection and pressurization, all outlets shall be opened in a progressive order, starting nearest the source and completing the process of purge flushing at the outlet farthest from the source.

B. Purge gas shall be allowed to impinge upon a white cloth material at a minimum flow rate of 100 liters per minute until no evidence of discoloration is evident and the test gas used during the previous tests has been removed from the piping systems.

7. ANALYSIS
A. After completing the purge flushing of the piping in accordance with the latest NFPA 99, the flow of gas from each station outlet for oxygen, mixed gases containing oxygen and medical compressed air shall be tested with an oxygen analyzer to confirm the presence of the desired percentage of oxygen.

NOTE: Testing of outlets for other gases to confirm the presence of the designated gas is also required.

(1) Where mixtures are piped that involve a low concentration of one component, such as 95% oxygen and 5% carbon dioxide, an analyzer must be used having sufficient accuracy to properly indicate the mixture. This, in some cases, may require an analyzer specific to each component.

(2) The test specified in the latest NFPA 99, shall be conducted on the downstream portions of the medical gas piping system whenever a system is breached and whenever modifications are made or maintenance performed in anesthetizing locations or vital life support or critical area.

The only test required when the oxygen (pure or mixed) or medical compressed air portion of an existing piped medical gas system is repaired is an analysis test to assure that no cross-connection of gases has been created. This may seem unnecessary when replacing a broken outlet or zone valve, but it is very important to document that the correct gas is flowing out of a labeled outlet. There can be no compromises in patient safety with respect to gases that will be inhaled by patients.

Once verification and analysis have been conducted on a new or modified of a system, it does not have to be repeated until the system is again breached or modified.

B. Prior to the connection of any work to the systems, all tests shall be successfully performed. After connection to the systems and before use for patient care, the tests in the above sections shall be successfully completed.

C. The final connection shall be leak tested with the source gas at the normal operating pressures. This pressure shall be maintained until each joint has been examined for leakage by means of soapy water or other equally effective means of leak detection safe for use with oxygen.

8. INSTALLATION AND TESTING OF MEDICAL GAS SYSTEM

A. In accordance with the latest NFPA 99

Before installation, all piping, valves, fittings and other components for all nonflammable medical gas systems shall be thoroughly cleaned of oil, grease and other readily oxidizable materials as is for oxygen service. After cleaning, particular care shall be exercised in the storage and handling of such material. Such material shall be temporarily capped or plugged to prevent recontamination before final assembly. Just prior to final assembly, such material shall be examined internally for contamination and shall be recleaned if necessary.

(1) Piping, valves, fittings and other components may be especially prepared in a facility equipped to clean, rinse and purge the material in accordance with the requirements of the latest NFPA 99 or may be prepared on the job site in accordance with NFPA 99. Trichloroethylene shall not be used in any cleaning operation at the job site. Carbon tetrachloride shall not be employed in any cleaning operation.
a. Piping, valves, fittings and other components that have been especially prepared shall have been cleaned in accordance with the provisions of CGA Pamphlet G-4.1, Cleaning Equipment for Oxygen Service. Such material shall be delivered capped or plugged and shall be inspected prior to final assembly as required in the latest NFPA 99. If necessary, recleaning shall be done in accordance with NFPA 99.

b. Piping, valves, fittings and other components prepared at the job site shall be cleaned by washing in a hot alkaline cleaner-water solution, such as sodium carbonate or trisodium phosphate (proportion of one pound to three gallons of water). Scrubbing shall be employed where necessary to ensure complete cleaning. After washing, the materials shall be thoroughly rinsed in clean, hot water.

B. Comply with other specification section for exposed piping and sleeves.

C. Keep open ends of tube capped or plugged at all times. Wash and rinse unplugged, partially completed piping system in accordance with Article, Cleaning of Piping, Valves and Fittings.

D. Cut piping square and accurately with a tube cutter (sawing not permitted) to measurements determined at place of installation. Ream tube to remove burrs, being careful not to expand tube and so no chips of copper remain in the tube. Work into place without springing or forcing. Bottom tube in socket so there are no gaps between tube and fitting. Exercise care in handling equipment and tools used in cutting or retaining of tube to prevent oil or grease being introduced into tubing. Where contamination has occurred, rewash affected items in accordance with Article, Cleaning of Piping, Valves and Fittings.

E. Spacing of Hangers: Shall comply with the latest NFPA 99, but shall in no case be greater than 10 feet.

F. Rigidly support valves and other equipment to prevent strain on tube or joints.

G. Take care not to anneal copper tube while brazing. Braze only while purging the interior tube with nitrogen, minimum U.S.P. or Grade B as specified in CGA G-10.1.

All brazed joints in the piping shall be made up using brazing filler allows that bond with the base metals being brazed and that comply with Specification for Brazing Filler Metal, ANSI/AWS A5.8 and the latest NFPA 99.

H. Do not bend tubing. Use fittings.

I. Install pressure and vacuum switches to be easily accessed and provide access panel where installed above plaster ceiling.

J. Apply pipe labeling during installation process and not after.

K. Pipe compressor intake to a source of clean ambient air as indicated in the latest NFPA 99.

L. After initial leakage testing is completed, allow piping to remain pressurized with testing gas until testing agency perform final tests complying with the latest NFPA 99.
M. Provide lockable shut-off valves on each piping system where installed for future connection to subsequent phases. Valves shall be locked open after connections in subsequent phases. Refer to drawings for phasing work.

N. Penetrations

(1) Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floor, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases as specified in other sections. Completely fill and seal clearances between raceways and openings with the fire stopping materials.

(2) Waterproofing: At floor penetrations, completely seal clearances around the pipe and make watertight with sealant as specified in other sections.

9. CERTIFICATION AND TESTS

A. Cross connection certification shall be the responsibility of the Contractor and shall be as follows:

(1) Cross-connection testing and certification of the medical-gas system shall be performed by medical gas testing agency.

(2) Medical-gas system shall be tested in accordance with the latest NFPA 99.

(3) In addition to cross-connection testing, this specification shall require the medical gas testing agency to test each individual pipeline system component for performance to design specifications and the Contractor make any necessary adjustments to ensure a complete and working system.

(4) In the event the cross-connection test indicates contaminated or cross connected medical gas systems, it shall be the responsibility of the Contractor to correct the problems at no additional cost to the Owner. This procedure shall be repeated until the cross-connection test proves positive and is hence certified.

B. Tests

(1) Initial Tests: Blowdown, and high and low pressure leakage tests as required by the latest NFPA 99, with documentation.

(2) Medical Gas Testing Agency Shall Perform the Following:

a. Perform and document all cross connection tests, labeling verification, supply system operation and valve and alarm operation tests as required by and in accordance with NFPA 99 and the procedures set for in prequalification documentation.

b. Verify that the systems, as installed, meet or exceed the requirements of NFPA 99 and this specification and that the systems operate as required.

c. Piping Purge Test: For each positive pressure gas system, verify cleanliness of piping system. Filter a minimum of 3.5 cubic feet (100 liters) of gas through a clean white 0.45 micron filter at a minimum velocity of 3.5 scfm (100 1pm). Filter shall show no discoloration and shall accrue no more than 0.1 mg of matter. Test each zone at the
outlet most remote from the source. Perform test with the use of an inert gas a described in CGA P-9.

d. Piping Purity Test: For each positive pressure system, verify purity of piping system. Test each zone at the most remote outlet for dew point, carbon monoxide, total hydrocarbons (as methane) and halogenated hydrocarbons and compare source gas. The two tests must in no case exceed variation as specified in Paragraph, Maximum Allowable Variation. Perform test with the use of an inert gas.

e. Outlet and Inlet Flow Test:
   1) Test all outlets for flow. Perform test with the use of an inert gas.
   2) Oxygen, nitrous oxide and air outlets must deliver 3.5 scfm with a pressure drop of no more than 5 psig and static pressure of 50 psig.
   3) Nitrogen outlets must deliver 5.0 scfm with a pressure drop of no more than 5 psig and static pressure of 160 psig. High pressure nitrogen outlet must deliver same at 250 psig static pressure.
   4) Vacuum inlets must draw no less than 3.0 scfm with adjacent inlet flowing, at a dynamic inlet pressure of 12-inches Hg and a static vacuum of 15-inches Hg.
   5) Anesthesia evacuation inlets must draw no less than 1.0 scfm at a dynamic inlet pressure of 12-inches Hg and a static vacuum of 15-inches Hg.

f. Source Contamination Test: Analyze each pressure gas source for concentration of contaminants, by volume. Take samples for air system test at the intake and at a point immediately downstream of the final filter outlet. The compared tests must in no case exceed variation as specified in Paragraph, Maximum Allowable Variation. Allowable concentrations are below:

   1) Dew Point: Air - Minus 18°C atmospheric  
      All Others - Minus 45°C atmospheric
   2) Carbon Monoxide: - 10 ppm
   3) Carbon Dioxide: Air - 1000 ppm  
      All Others - 300 ppm
   4) Gaseous Hydrocarbons: Air - 5 ppm (as methane)
   5) Halogenated Hydrocarbons: Air - 2 ppm

g. Analysis Test:
   1) Analyze each pressure gas source and outlet for concentration of gas, by volume.
   2) Make analysis with instruments designed to measure the specific gas dispensed.
   3) Allowable concentrations are within the following:

      (a) Oxygen - 99(+)% Oxygen
(b) Nitrous Oxide  - 99(+)% Nitrous Oxide
(c) Nitrogen       - Less than 1% Oxygen or 99(+)% Nitrogen
(d) Medical Air   - 19.5% to 23.5% Oxygen

h. Maximum Allowable Variation: Between comparative test results required as follows:

1) Dew Point     - 2°C
2) Carbon Monoxide - 2 ppm
3) Total Hydrocarbons as methane - 1 ppm
4) Halogenated Hydrocarbons - 2 ppm

10. MEDICAL GAS ALARM SYSTEMS

A. General

(1) Description of Work

Medical gas alarm system work is indicated by drawings and schedules, and is hereby defined to include, but not limited to medical gas alarm system panel relocation, conduit, wiring, backboxes, and electrical connections.

(2) Quality Assurance

Installer: Qualified with at least 5 years of successful installation experience on projects with nurse call system installation work similar to that required for project.

NEC Compliance: Comply with NEC as applicable to communication system materials and installations.

NEMA Compliance: Comply with applicable portions of NEMA standards pertaining to types of electrical equipment enclosures.

B. Execution

(1) Installation of Medical Gas Alarm System

Install medical gas alarm system conduit, wiring and backboards of types indicated, where shown, in accordance with the drawings and schedules and with recognized industry practices. Ensure systems comply with installation requirements of NEC.

Make final connections to alarms and pressure switches.

Coordinate with other electrical work, including raceways, electrical boxes and fittings, as necessary to interface installation of medical gas alarm system work with data processing and other work.
Coordinate installation of medical gas alarm system with installation of medical gas system.

END OF SECTION 220600
I. EQUIPMENT

A. QUALIFICATIONS

(1) Manufacturer shall be a company specializing in the design and manufacture of commercial / industrial custom HVAC equipment. Manufacturer shall have been in production of custom HVAC equipment for a minimum of 5 years.

(2) Each unit shall bear an ETL or UL label under UL Standard 1995 indicating the complete unit is listed as an assembly. ETL or UL listing of individual components, or control panels only, is not acceptable.

(3) Manufacturer shall have at least 10 unique installations of fan array (minimum 4 fans in fan array) air handling units.

B. WARRANTY

(1) The complete unit shall be covered by a parts and labor warranty issued by the manufacturer covering the first year of operation. This warranty period shall start upon substantial completion.

C. ACCEPTABLE MANUFACTURERS

(1) Provide custom air handling units as manufactured by:

   a. CES Group (Governair, HuntAir, etc.)
   b. York Custom
   c. Climatecraft
   d. Haakon
   e. Air Enterprises
   f. Trane Custom
   g. TMI
   h. Ventrol
   i. Daikin Applied
   j. Scott Springfield Manufacturing, Inc.

D. GENERAL

(1) Furnish and install where shown on the plans, air handling units construction features as specified below. The units shall be provided and installed in strict accordance with the specifications. All units shall be complete with all components and accessories as specified. Any exceptions must be clearly defined. The contractor shall be responsible for any additional expenses that may occur due to any exception made.

(2) AHU-30 shall be completely factory assembled and tested with the exception of unit splits as required for shipping or installation requirements as indicated on the schedule and drawings. The equipment's cooling, heating, humidifying, ventilating, exhausting capacity and performance shall meet or exceed that shown on the schedule. Tags and decals to aid in service or to indicate caution areas shall be provided. Electrical wiring diagrams shall be attached to the control panel access doors. Operation and Maintenance manuals shall be furnished with each unit.
a. The unit shall be tested by a certified testing agency on site after completion by the contractor. All testing shall be the responsibility of the unit manufacturer. Provide all testing equipment and instrumentation needed for the testing.

b. The manufacturer shall provide a full time on site construction supervisor during the entire unit assembly process. The supervisor shall manage the unit assembly and provide a lead contact for project meetings, owner/engineer/general contractor relations and answer questions from associated trades.

E. TESTING AND QUALITY CONTROL

(1) Factory Tests: The fans shall be factory run tested to ensure structural integrity and proper RPM. Units shall pass quality control and be thoroughly cleaned prior to shipment.

(2) On Site Leak Testing: The unit manufacturer shall provide an on site leak test after the unit has been constructed. This shall be performed by a certified company in accordance with AMCA Standard 210. The cabinet shall be tested at 1.5 times the static pressure of differential static pressure across the cabinet exterior walls) for both the high and low pressure sides. Cabinet leakage shall not exceed 0.5% of design airflow. All supply and return air openings shall be sealed. The air shall then be pumped into the unit until the appropriate operating pressures are achieved. Air flow measurements shall be performed in compliance with AMCA Standard 210. The unit shall also be tested to show that the specified airflow is produced at the specified static pressure for both supply and return fans. The contractor shall notify owner/engineer 10 days prior to test for witnessing. A written test report shall be prepared by the manufacturer and issued to the Owner’s representative. Any corrective actions taken on the tested unit to achieve a satisfactory test shall be applied to all of the other AHU’s at no additional cost to the owner.

(3) Field Panel Deflection Testing: The unit manufacturer shall provide a deflection test on one unit at 8” of differential static pressure across the cabinet exterior walls. A deflection limit of L/200 will be demonstrated at this time. “L” is defined as the height panel on the side of the unit. Measurements shall be at midpoint of “L” along the vertical seam of the largest panel on one side.

   Height of panel = H x (.005) = inches deflection allowed

   a. The contractor shall notify the engineer and owner 10 days prior to test for witnessing. A written test report shall be prepared by the manufacturer and issued to the Owner’s representative. This test shall be performed in the field when the factory leak test is performed.

(4) Acoustic Requirements: The equipment manufacturer shall furnish calculations showing the estimated sound power levels at the supply and, return connections, as well as unit casing radiation for each air conditioning unit. Calculations shall be based on fan sound power levels which were determined in accordance with AMCA Standard 300 and 301. Sound data from a single fan or group of fans shall not be acceptable. Sound calculation shall calculate resultant sound levels entering or leaving the unit.

(5) Field Basin Leakage Testing: The basin shall be tested for leakage. The base sections shall be filled with 2” of water and must hold for for 24” hours. Any leaks shall be repaired and the basin re-tested.

(6) Block-off Testing: Manufacturer shall provide block off on-site testing of unit. The supply fan shall be run at full speed, the outside air dampers shall be closed. The dampers and
internal walls shall not permanently deflect beyond the L/200 standard described above. If dampers or internal walls deflect, the manufacturer shall repair and strengthen components and retest.

F. UNIT CONSTRUCTION

(1) Unit manufacturer shall provide certified ratings conforming to the latest edition of AMCA 210, 310, 500 and ARI 410. All electrical components and assemblies shall comply with NEMA standards. Unit internal insulation must have a flame spread rating not over 25 and smoke developed rating no higher than 50 complying with NFPA 90A, “Standard for the Installation of Air Conditioning and Ventilating Systems.” Units shall comply with NFPA 70, “National Electrical Code,” as applicable for installation and electrical connections of ancillary electrical components of air handling units. Tags and decals to aid in service or indicate caution areas shall be provided. Electrical wiring diagrams shall be attached to the control panel access doors. Operation and maintenance manuals shall be furnished with each unit. Units shall be UL or ETL listed.

(2) Unit Base - Floor: Unit perimeter base shall be completely welded and fabricated using heavy gauge structural steel tubing. (C-Channel cross supports shall be welded to perimeter base steel tubing and located on maximum 24 IN centers to provide support for internal components. Base rails shall include lifting lugs welded to perimeter base at the corner of the unit or each section if de-mounted. Entire base frame is to be painted with a phenolic coating for long term corrosion resistance. Internal walk-on floor shall be 10 gauge aluminum tread plate and shall be turned up the wall 4" and welded. Caulk joints are not acceptable. The outer sub-floor of the unit shall be made from 20 gauge galvanized steel. The 4 IN double wall floor shall be insulated. Floor seams shall be gasketed for thermal break and sealed for airtight / watertight construction. Single wall floors with glued and pined insulation and no sub floor are not acceptable.

(3) The base and unit frame shall be painted with a lacquer resisting gray phenolic corrosion inhibitive primer. All drain pans shall be stainless steel IAQ type and have a rigid 12 IN wide safety tread plate walk bridge stretched across the unit width. Walk bridge shall be of the same material type and thickness as the unit floor. The walk bridge and support system shall be suspended above the drain pan (not in contact with the drain pan bottom) and shall be easily removable for drain pan cleaning. A galvanized steel liner shall be attached to the underside of the unit base and cross members, ensuring that the floor insulation is completely encapsulated.

(4) All gasket and necessary assembly hardware shall ship loose with unit. Junction boxes with a factory supplied numbered terminal strip shall be supplied for field wiring.

(5) Unit Casing – The construction of the air handling unit shall consist of a (1 x 2) steel frame with formed 16 gauge G-90 galvanized steel exterior casing panels. The exterior casing panels shall be attached to the gasketed (1 x 2) steel frame with corrosion resistant fasteners.

(6) All casing panels shall be completely removable from the unit exterior without affecting the unit's structural integrity. (Units without framed type of construction shall be considered, provided the exterior casing panels are made from 14 gauge galvanized steel, maximum panel center lines are less than 20 inches and deflection is less than L/200 @ 8 IN positive pressure).
The air handling unit casing shall be of the “no-through-metal” design. The casing shall incorporate insulating thermal breaks as required so that, when fully assembled, there’s no path of continuous unbroken metal to metal conduction from inner to outer surfaces. Provide necessary support to limit casing deflection to L/200 of the narrowest panel dimension. If panels cannot meet this deflection, additional internal reinforcing is required.

All panel seams shall be caulked and sealed for an airtight unit. Leakage rates shall be less than 0.5% at 8 IN W.C. Note: If manufacturer cannot provide thermal break (no through metal) and or removable exterior panel construction it must be noted as an exception on the bid.

a. As an option to steel panels, all panels may be double wall all-aluminum construction with minimum 0.040 IN exterior and interior skin thicknesses. Interior finish to be smooth, mill finish; exterior finish to be a low-reflective textured mill finish. Each panel shall contain an integral frame or be properly supported by a structural framing system. Panel shall have continuous tight seal at the interior and exterior skins completely encapsulating the insulation.

Insulation - Entire unit (walls, roof, doors, and floor) to be insulated with a min 4” thick insulation. The insulation shall have a minimum effective thermal resistant R of 20 and a noise reduction coefficient (NRC) of 0.70 / per inch thick (based on a type "A" mounting). Insulation shall meet the erosion requirements of UL 181 facing the air stream and fire hazard classification of 25/50 (per ASTM-84 and UL 723 and CAN/ULC S102-M88). All insulation edges shall be encapsulated within the panel. All perforated sections shall have Tuf-Skin or equal insulation with black acrylic coating as manufactured by Johns Manville or approved equal. Panels shall be insulated with minimum 3-PCF high density polyisocyanurate foam insulation. Fiberglass insulation in panels shall not be acceptable.

a. Provide alternate price to utilize 3” insulated panels in lieu of specified 4” thick panel construction.

Access Doors - The unit shall be equipped with a solid double wall insulated, hinged access doors as shown on the plans. The doorframe shall be extruded aluminum with a built in thermal break barrier and full perimeter gasket. The door hinge assembly shall be die cast zinc with stainless steel pivot mechanism, completely adjustable. There shall be a minimum of two heavy duty handles per door. Provide ETL, UL 1995, and CAL-OSHA approved tool operated safety latch on all fan section access doors. Note: If manufacturer cannot provide thermal break door design it must be noted as an exception on the bid.

a. Access doors in the fan section shall be provided with a 10 x 10 dual thermal pane safety glass window. Provide sufficient test ports to be able to measure DP across each section.

1) Provide IAQ drain pans in segments as indicated on the schedule. IAQ drain pans shall comply with ASHRAE Standard 62-2007, Section 5.

(a) The IAQ pans shall be triple sloped, positive draining stainless steel pan. Pan design shall ensure that water drains freely from the pan whether the fan is in operation or stagnant. P-Trap guidelines shall be affixed to the unit. P-Trap components shall be provided and installed by the jobsite contractor.

(b) Coat IAQ drain pans with a anti-microbial coating to reduce microbial growth contaminating the air stream.

(c) Drain connection shall be located at the lowest point(s) of the pan, per ASHRAE 62-2007 Section 5. Drain connection shall be of like material as liner, draining to one side of the unit.
(d) IAQ drain pan shall allow visual inspection and physical cleaning, including underneath coils, without removal of the coil.

G. UNIT COMPONENT DESCRIPTION

(1) Fan Array:
   a. The fan array shall consist of multiple, direct driven, arrangement 6 supply and 4 return plenum fans spaced in the air way tunnel cross section to provide a uniform air flow and velocity profile across the entire air way tunnel cross section and components contained therein. The Fan array shall be constructed per AMCA requirements for the duty specified, (Class I, II, or III). All fans shall be selected to deliver design air flow at the specified operating TSP at the specified motor speed and as scheduled. The Fan array shall be selected to operate at a system Total Static Pressure that does not exceed 90% of the specified fan’s peak static pressure producing capability at the specified fan speed.
   b. All motors shall be IEEE inverter duty, premium efficiency TEAO T-frame motors selected at the specified operating voltage, RPM, and efficiency as specified or scheduled elsewhere. Each motor shall be provided with an AEGIS bearing protection ring to prevent Electrical Discharge Machining (EDM) damage to the motor bearings.
   c. Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, category BV-2.5, Grade 1.0 with peak to peak deflection equal to or less than 0.8 mil at the design operating speed for the fan/motor cartridge.
      1) The Discharge and Inlet bare fan sound power levels for each individual octave band shall NOT exceed the values specified or scheduled for the Fan array.
      2) Each fan motor shall be individually wired to a unit mounted control panel. Wire sizing shall be determined, and installed, in accordance with applicable NEC standards. All VFD’s to be provided by the Controls sub-contractor and are not part of this bid.
      3) Motor Current Sensors for each individual motor, factory wired to terminal strip(s) for field connection By Others to BAS/BMS interfaces.
      4) Fan array shall be sized such that the unit is capable of producing 100% of scheduled airflow at design static pressure after losing one fan. Selection showing this shall be included in the submittal.
      5) Fan motors shall not exceed 15 hp.
      6) Provide hoisting system internal to unit to be able to remove one complete fan/motor assembly.
      7) Provide one blank off plate per unit that allows service personal to prevent re-entrainment of air through a non-functional fan.
      8) Each fan shall be test run at their operating speed or at the maximum RPM for the particular fan’s construction class prior to shipment. The fans are to be balanced and records maintained of the readings in the axial, vertical, and horizontal direction on each of the fan’s bearings. Final peak velocity measurements shall not exceed 0.1 in/sec.
      9) Coordinate minimum quantities of supply fans with the schedule indicated on the drawings.
   d. Fan Array Electrical:
      1) Provide a complete electrical system required to run the Fan array system including all equipment, material, electrical enclosure and electrical components. All electrical conduit and wiring shall be installed to allow the complete remove of the wall panel. Horizontal conduit along side walls is not permitted.
2) Fan array Electrical designs shall be in accordance with the NEC, UL 508A, and Local Codes.

e. Motor Circuit Protection:
1) All motors in the Fan array shall be provided with individual Motor Protection for thermal overload protection. All motor circuit protectors shall be located in main enclosure.
2) If required by design, all motor circuit protectors shall be mounted and located in a remote motor circuit protector panel as needed that is separate from the main enclosure. Motor circuit protector enclosure must be located and mounted at a minimal distance from motors in the Fan array.

f. Fan Array Control:
1) As required by system design, one Variable Frequency Drive for normal operation and a second Variable Frequency Drive for Redundant Backup operation shall be provided by the controls sub-contractor.

H. HEAT TRANSFER COILS – WATER COIL

(1) All coil assemblies shall be leak tested under water at 315 PSIG and PERFORMANCE is to be CERTIFIED under ARI Standard 410. Coils exceeding the range of ARI standard rating conditions shall be noted.

(2) Cooling coils shall be mounted on stainless steel support rack to permit coils to slide out individually from the unit. Provide intermediate drain pans on all stacked cooling coils. The intermediate pan shall drain to the main drain pan through a copper downspout. Water coils shall be constructed of seamless copper tubing mechanically expanded into fin collars. All fins shall be continuous within the coil casing to eliminate carryover inherent with a split fin design. Fins are die formed Plate type.

(3) Headers are to be seamless copper with die formed tube holes.

(4) Connections shall be male pipe thread (MPT) Schedule 40 Red Brass with 1/8” vent and drain provided for complete coil drainage. All coil connections shall be extended to the exterior of the unit casing by the manufacturer. Coils shall be suitable for 250 PSIG working pressure. Intermediate tube supports shall be supplied on coils over 44 IN fin length with an additional support every 42” multiple thereafter. Grooved pipe connections are acceptable.

(5) Water coils shall have the following construction:
Standard 5/8 IN:

(6) 5/8 IN o.d. x 0.035” wall copper tube with .028 return bends.

(7) .0095 IN aluminum fins

(8) 16 gauge galvanized steel casing

I. Filters - Provide filters of the type indicated on the schedule. All filter to be either 24” x 24” or 12” x 24”. Factory fabricated filter sections shall be of the same construction and finish as the unit. Face loaded pre and final filters shall have Type 8 frames as manufactured by AAF, FARR or equal. Side service filter sections shall include hinged access doors on both sides of the unit. Internal blank-offs shall be provided by the air unit manufacturer as required to prevent air bypass around the filters. The filters shall be as manufactured by Farr, Purolator, AAF or equal. Filters shall be in compliance with ANSI/UL 900 – Test Performance of Air Filters.

(1) Filter Gauge: Each Filter bank shall be furnished with: (Magnehelic / Photohelic) filter gauge with a 4 3/4 IN OD white static pressure dial with black figures and zero pointer adjustment. / Dwyer Series 2000 Air filter gauge Dwyer Mark 25 Inclined manometer (DWYER 250 AF).
(2) Flat Racks - Filter racks shall be completely factory assembled and designed for industrial applications. Filter racks shall be fabricated from no less than 16 gauge galvanized steel. Filter racks shall be applied in low efficiency filter applications and will be upstream accessible. Upstream access filter racks shall have one central access cover per row of filters centered in the unit for easy access. Filter racks over 72 IN in length shall require an angle center reinforcement support. Filter racks shall be designed for a maximum of 500 fpm, or meet or exceed the area specified in the mechanical schedule.

(3) Medium Efficiency Pleated Filters - Filters shall be 2 IN thick, 30% efficient. Filter media shall be 100% synthetic. The filter shall have an average efficiency of 25-30% and an average arrestance of 90-92%. The filters shall be listed as Class II under UL Standard 900. Filters shall be tested per ASHRAE Standard 52-76. The effective media shall not be less than 4.6 square feet of media per 1.0 square foot of filter face area, and shall contain not less than 15 pleats per linear foot. Initial resistance at 500 fpm approach shall not exceed 0.28 IN wg.

(4) High Efficiency Rigid Filters - Filters shall be 4 IN deep high performance, pleated, totally rigid and totally disposable type. Each filter shall consist of high density glass fiber media; media support grid, contour stabilizers and enclosing frame. Filter media shall be laminated to a non-woven synthetic backing to form a lofted filter blanket. The filter media shall have an average efficiency of 95%. The media support shall be a metal grid with an effective open area of not less than 95%. The metal grid shall be bonded to the filter media to eliminate the possibility of media oscillation and media pull-away. The metal grid shall be formed in such a manner that it affects a tapered radial pleat design. The grid shall be designed to support the media both vertically and horizontally. Filters shall be listed Class II under UL Standard 900. Filters shall be tested per ASHRAE Standard 52.1-76. Contour stabilizers shall be permanently installed on both entering air and exit air sides of the filter media pack to ensure that the tapered radial pleat configuration is maintained throughout the life of the filter. The filter shall be capable of withstanding a 10 IN wg pressure drop without noticeable distortion of the media pack. The enclosing frame shall be constructed of galvanized steel. It shall be constructed and assembled in such a manner that a rigid and durable enclosure for the filter pack is affected. The periphery of the filter pack shall be continuously bonded to the inside of the enclosing frame, thus eliminating the possibility of air bypass. The enclosing frame shall be equipped with protective diagonal support members on both the entering air and air exit sides of the filters.

(5) Provide filter clips for pre-filters equal to Camfil Farr model C-78-6. Provide filter clips for final filters equal to AAF model SL-12.

(6) Dampers – Provide Class 1 rated ultra low leak dampers as indicated on the unit drawings. Low leakage dampers shall have extruded aluminum airfoil blades. Flat or formed metal blades are not acceptable. The damper blade shall incorporate santoprene rubber edge seals and zinc plated tubular steel shaft for a non-slip operation. Shaft bearings holes shall be N.C. machine punched and fitted with one inch O.D. heavy duty nylon bearings to eliminate friction and any metal to metal contact. Damper jamb seals shall be UV rated, nylon glass reinforced or stainless steel spring arcs designed for a minimum air leakage and smooth operation. Damper linkage shall be concealed within a 16 gauge galvanized steel frame.

J. ELECTRICAL POWER AND CONTROLS

(1) All electrical and automatic control devices not previously called out or listed below are to be furnished and installed in the field by OTHERS. All electrical conduit and wiring shall be installed to allow the complete remove of the wall panel. Horizontal conduit along side walls is not permitted.
(2) All wiring and electrical connections shall be of copper wires, copper bus bars, and copper fittings throughout, except internal wire of the control transformer may be aluminum, if copper termination is provided. Identify power supply terminals with permanent markers. The maximum temperature of terminals shall not exceed 167°F (75°C) when the equipment is tested in accordance with its rating.

(3) The unit shall feature a mounted permanent nameplate displaying at a minimum the manufacturer, serial number, model number, date of manufacture, and current and voltage readings. The unit must have an ETL or UL Listing and bear the appropriate mark.

(4) Provide permanent schematic and connection wiring diagrams indicating how the unit motors, starters, controls, etcetera are wired. The controls diagram shall follow recognized industry standards and shall feature line and terminal numbers.

(5) The unit shall bear warning alerting personnel of arc flash hazard and the need for PPE.

(6) Conduit shall consist of a combination of EMT or flexible metal conduit as required. Liquidtight flexible metal conduit may be used outside the air tunnel for wet locations. Electrical connection boxes shall be galvanized steel with knockouts. In wet locations the connection boxes shall be Nema 4 epoxy coated.

(7) Unit Convenience Features
   a. Each access section shall be equipped with a vapor-proof 64 watt vapor proof fluorescent light fixtures with low temperature ballast for service.
   b. Each light shall have its own light switch mounted adjacent to the access door.
   c. Furnish a 120 volt GFI duplex convenience outlet on the exterior of each unit.
   d. Lights, switches and outlets shall be wired through a transformer and external light disconnect. Lights shall be wired to remain functional whether the main power disconnect is in the on or off position.

END OF SECTION 230200