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UNIFIED FACILITIES GUIDE SPECIFICATIONS

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DIVISION 22 - PLUMBING

SECTION 22 60 70

GAS AND VACUUM SYSTEMS FOR HEALTHCARE FACILITIES

05/09

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pipng system such as: above or below floors, above or below ceilings, above or below roofs, above or below ground.

3. Location of each sectionalizing valve.

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a reference ID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9 (2015) Load Ratings and Fatigue Life for Ball Bearings

ABMA 11 (2014) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.22 (2018) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

ASME B16.50 (2013) Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings

ASME B40.100 (2013) Pressure Gauges and Gauge Attachments

ASME BPVC SEC VIII D1 (2017) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 6000 SERIES (2012) Professional Qualification Standard

for Medical Gas Systems Installers,
Inspectors and Verifiers

ASTM INTERNATIONAL (ASTM)

ASTM B88	(2016) Standard Specification for Seamless Copper Water Tube
ASTM B819	(2000; R 2011) Standard Specification for Seamless Copper Tube for Medical Gas Systems
ASTM D2564	(2012) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2665	(2014) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM E2129	(2010) Standard Practice for Data Collection for Sustainability Assessment of Building Products

COMPRESSED GAS ASSOCIATION (CGA)

CGA G-4.1	(2009) Cleaning Equipment for Oxygen Service; 6th Edition
CGA M-1	(2018) Standard for Medical Gas Supply Systems at Health Care Facilities; 4th Edition
CGA V-5	(2008; R 2013) Diameter-Index Safety System (Non-Interchangeable Low Pressure Connections for Medical Gas Applications); 6th Edition

INTERNATIONAL CODE COUNCIL (ICC)

ICC IPC	(2018) International Plumbing Code
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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 9001	(2008; Corr 1 2009) Quality Management Systems- Requirements
ISO 11143	(2008) Dentistry - Amalgam Separators

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2018) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 55	(2016; TIA 16-1; TIA 16-2) Compressed
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Gases and Cryogenic Fluids Codes

NFPA 99

(2018; TIA 18-1) Health Care Facilities
Code

UNDERWRITERS LABORATORIES (UL)

UL 508A

(2018; Reprint Jul 2018) UL Standard for
Safety Industrial Control Panels

1.2 SYSTEM DESCRIPTION

NOTE: Choice of Level 1 versus Level 3 gas, support, and vacuum systems is determined by issues involving patient dependency on the system for life, effect of system failure on patient outcomes, and other criteria as defined in NFPA 99. In general, dental facilities (or dental areas within combined medical/dental facilities) utilize Level 3 systems. In general, medical facilities (or medical areas within combined medical/dental facilities) utilize Level 1 systems in patient care areas and Level 3 systems in non-patient care areas (Level 3 systems, if used, must be entirely separate from Level 1 systems). Confirm choice of Level 1 or Level 3 systems match intended function as outlined in NFPA 99.

- a. Provide the following gas, support, and vacuum systems conforming to NFPA 99 Level 3 criteria: [oxygen (O)] [nitrous oxide (NO)] [dental compressed air (DA)] [laboratory compressed air (LA)] [process compressed air (PA)] [NF-nitrogen (N)] [dental surgical vacuum (DSV)] [oral evacuation (OE)] [high-volume laboratory dust evacuation (LE)].
- b. Provide the following gas, support, and vacuum systems conforming to NFPA 99 Level 1 criteria: [oxygen (O)] [nitrous oxide (NO)] [medical compressed air (MA)] [NF-nitrogen (N)] [instrument compressed air (IA)] [laboratory compressed air (LA) supplied from IA source] [process compressed air (PA) supplied from IA source] [carbon dioxide (CO2)] [medical-surgical vacuum (MV)] [waste anesthetic gas disposal (WAGD)].

1.2.1 Design Requirements

1.2.1.1 Patient Care Systems

Oxygen (O), Medical Compressed Air (MA), Nitrous Oxide (NO), and Carbon Dioxide (CO2) systems intended for patient care shall not be supplied to or used for any purpose other than patient care applications.

1.2.1.2 Dental Surgical Vacuum (DSV), Medical-Surgical Vacuum (MV), and Waste Anesthesia Gas Disposal (WAGD)

Systems are dry vacuum systems and shall not be supplied to or used for any purpose other than patient care applications.

1.2.1.3 Oral Evacuation (OE)

System is a wet vacuum system and shall not be supplied to or used for any purpose other than patient care applications.

1.2.1.4 Support Utilities

Nitrogen (N), Dental Compressed Air (DA), Instrument Compressed Air (IA), Laboratory Compressed Air (LA), and Process Compressed Air (PA) systems are support utilities and shall not be supplied to or used for patient respiration applications.

1.2.1.5 High-volume Laboratory Dust Evacuation (LE)

System is a dry vacuum system, support utility and shall not be supplied to or used for patient care applications.

1.2.1.6 Laboratory Compressed Air (LA) and Process Compressed Air (PA)

May be configured as any of the following:

- a. Provided as separate systems with their own compressors, in which case the LA and/or PA system shall conform to NFPA 99 Level 3 criteria.
- b. Combined with and powered by the Dental Compressed Air (DA) system, in which case the LA and/or PA system shall conform to NFPA 99 Level 3 criteria.
- c. Combined with and powered by the Instrument Compressed Air (IA) system, in which case the LA and/or PA system shall conform to NFPA 99 Level 1 criteria. (IA is a Level 1 system).

1.2.2 Sustainable Design Requirements

1.2.2.1 Local/Regional Materials

NOTE: Using local materials can help minimize transportation impacts, including fossil fuel consumption, air pollution, and labor.

This is optional for Army projects.

Use materials or products extracted, harvested, or recovered, as well as manufactured, within a [800] [_____] km [500] [_____] mile radius from the project site, if available from a minimum of three sources.

1.2.2.2 Environmental Data

NOTE: ASTM E2129 provides for detailed documentation of the sustainability aspects of products used in the project. This level of detail may be useful to the Contractor, Government, building occupants, or the public in assessing the sustainability of these products.

This is optional for Army projects.

[Submit Table 1 of **ASTM E2129** for the following products: [____].]

1.2.3 Performance Requirements

- a. Provide all labor, equipment and services necessary for and incidental to the installation of piped [dental gas, support, and vacuum systems] [and] [medical gas, support, and vacuum systems]. [Oxygen systems shall be complete to the source valve, ready for connection to the bulk gas supply system.] All systems shall be complete, started, tested and ready for use.
- b. Government Furnished Materials provided to the Contractor for installation under this section include initial supply of gases in cylinders or containers as appropriate for cylinder sources [____] [,and initial supply of liquid oxygen].
- c. Provide system delivery pressure as follows:

NOTE: Process compressed air is generally supplied in the **825-860 kPa 120-125 psi range. However, a lower pressure may be required by the using facility. Modify range only if approved by the using facility.**

Oxygen, medical compressed air, nitrous oxide, carbon dioxide	379 kPa 55 psi
Dental compressed air	620 kPa 90 psi
Nitrogen, instrument compressed air	1275 kPa 185 psi
Laboratory compressed air	345-379 kPa 50-55 psi
Process compressed air	827-862 kPa 120-125 psi

- d. Provide system vacuum as follows:

Dental surgical vacuum, medical-surgical vacuum	37 kPa 19 inches Hg vacuum
Dental oral evacuation	73 kPa 8 inches Hg vacuum
Waste anesthesia gas disposal	60 kPa 12 inches Hg vacuum
High-volume laboratory dust evacuation	91 kPa 3 inches Hg vacuum at separator
kPa is absolute inches Hg vacuum is gauge	

1.2.4 Accessibility of Equipment

NOTE: The following requirement is intended to solicit the installer's help in the prudent location of equipment when there is some control over

locations. However, designers should not rely on it since enforcing this requirement in the field would be difficult. Therefore, the system designer needs to layout and indicate the locations of equipment, control devices, and access doors so that most of the accessibility questions are resolved inexpensively during design.

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, and equipment requiring access, in locations freely accessible through access doors.

1.3 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" following a submittal item indicates that the submittal is required for the Sustainability eNotebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING. Locate the "S" submittal under the SD number that best describes the submittal item.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality

Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Local/Regional Materials; G[, [____]]
Environmental Data; G[, [____]]
Manufacturer Qualifications
Installer Qualifications
Inspector Qualifications
Verifier Qualifications
Inspection, Testing, and Verification Agency

SD-02 Shop Drawings

Dental Gas, Support and Vacuum Systems; G[, [____]]
Medical Gas, Support and Vacuum Systems; G[, [____]]

SD-03 Product Data

Bulk Liquid Oxygen (LOX) Source; G[, [____]]
Emergency Oxygen Supply Connection; G[, [____]]
Cylinder Manifold Supply Source; G[, [____]]
Dental Compressed Air (DA) Source; G[, [____]]
Dental Surgical Vacuum (DSV) Source; G[, [____]]
Dental Oral Evacuation (OE) Source; G[, [____]]
High-Volume Laboratory Dust Evacuation (LE) Source; G[, [____]]
Medical Compressed Air (MA) Source; G[, [____]]
Lab Compressed Air (LA) [and Process Compressed Air (PA)] Source; G[, [____]]
Medical-Surgical Vacuum (MV) Source; G[, [____]]
Waste Anesthesia Gas Disposal Vacuum (WAGD) Source; G[, [____]]
Instrument Compressed Air (IA) Source; G[, [____]]
Pipe and Fittings; G[, [____]]
Valves and Assemblies; G[, [____]]
Nitrogen and Instrument Compressed Air Control Panels; G[, [____]]
Hangers and Supports; G[, [____]]
Dental Gas and Support Systems Outlets and Vacuum Systems Inlets; G[, [____]]
Medical Gas and Support Systems Outlets and Vacuum Systems Inlets; G[, [____]]
Warning Systems; G[, [____]]
Vibration-Absorbing Features; G[, [____]]

SD-06 Test Reports

Test Reports

SD-07 Certificates

Station Outlets/Inlets

SD-10 Operation and Maintenance Data

Dental Gas, Support, and Vacuum Systems; G[, [____]]

1.4 QUALITY ASSURANCE

1.4.1 Manufacturer Qualifications

Manufacturers shall be regularly engaging in the manufacturing, supplying, and servicing of specified products and equipment, as well as, providing engineering services, for gas and vacuum systems for healthcare facilities. Provide evidence demonstrating compliance for a minimum of 5 years, and on 5 projects of similar complexity.

1.4.2 Installer Qualifications

- a. [Dental gas, support, and vacuum systems] [and] [Medical gas, support, and vacuum systems] shall be installed only by Certified Medical Gas Installers. Installer **ASSE 6000 SERIES** (Standard #6010 Medical Gas System Installer) certification card shall have been issued within the previous 36 months and Installers certified through a recognized third party certification agency. Certification shall include the successful completion of a minimum 32-hour training course including a written and a practical examination covering all facets of **ASSE 6000 SERIES** Standard #6010, **NFPA 99**, and **NFPA 55**. Course instruction shall have been conducted by a Medical Gas Systems Instructor certified to **ASSE 6000 SERIES** (Standard #6050 Medical Gas Instructors). The installer shall have a minimum of four (4) years of documented practical experience in the installation of medical gas and vacuum piping systems. Detail drawings for the complete systems including piping layouts and location of connections; dimensions for roughing-in, foundation, and support points; schematic diagrams; and wiring diagrams or connection and interconnection diagrams. Detail drawings shall indicate clearances required for maintenance and operation. Where piping and equipment are to be supported other than as indicated, include loadings and proposed support method. All plans, elevations, views, and details, shall be drawn to scale.

- [b. Dental oral evacuation systems shall be installed only by contractors/tradespersons who have at least 5 years experience installing central oral evacuation systems for dental operatories.]

**NOTE: Include following if bulk liquid oxygen
source is included in project.**

- [c. Bulk liquid oxygen systems shall be installed only by Certified Bulk Medical Gas System Installer. Installer **ASSE 6000 SERIES** (Standard #6015 Bulk Medical gas Systems Installers) certification card shall have been issued within the previous 36 months and Installers certified through a recognized third party certification agency. Certification shall include the successful completion of a minimum 32-hour training course including a written and a practical examination covering their firm's standard operating procedures as they relate to bulk installations for medical gases, the FDA CGMP Regulation 21 CFR, Parts 210 and 211, **CGA M-1**, applicable sections of the **ASSE 6000 SERIES** Standard #6015), **NFPA 99**, and **NFPA 55**. Course instruction shall be conducted by a Bulk Medical Gas Systems Instructor certified to **ASSE 6000 SERIES** (Standard #6050 Medical Gas Systems Instructors). The bulk system installer shall have a minimum

of four (4) years of documented practical experience in the installation of bulk systems.]

1.4.3 Agency Qualifications

Retained by the general contractor, but independent of the facility, installing contractor, and product manufacturer(s).

1.4.3.1 Inspector qualifications

Systems shall be inspected only by Certified Medical Gas System Inspectors. Inspector **ASSE 6000 SERIES** (Standard #6020 Medical Gas Systems Inspectors) certification card shall have been issued within the previous 36 months and Inspectors certified through a recognized third party certification agency. Certification shall include the successful completion of a minimum 24-hour training course including a written and a practical examination covering all facets of **ASSE 6000 SERIES** (Standard #6020), **NFPA 99**, **NFPA 55**. Course instruction shall be conducted by a Medical Gas Systems Instructor certified to **ASSE 6000 SERIES** (Standard #6050 Medical Gas Systems Instructors). Certification to **ASSE 6000 SERIES** (Standard # 6030 Medical Gas Systems Verifier) meets the requirements of this section. The inspector shall have a minimum of four (4) years of documented practical experience in the inspection of medical gas and vacuum systems.

1.4.3.2 Verifier qualifications

Systems shall be verified only by Certified Medical Gas System Verifiers. Verifier **ASSE 6000 SERIES** (Standard #6030 Medical Gas System Verifiers) certification card shall have been issued within the previous 36 months and verifiers certified through a recognized third party certification agency. Certification shall include the successful completion of a minimum 32-hour training course including a written and a practical examination covering all facets of **ASSE 6000 SERIES** Standard #6030, **NFPA 99**, **NFPA 55** and **CGA M-1**. Course instruction shall be conducted by a Medical Gas Systems Instructor certified to **ASSE 6000 SERIES** (Standard #6050 Medical Gas Systems Instructors). The verifier shall have a minimum of four (4) years of documented practical experience in the verification of medical gas and vacuum systems. The verifier shall have a current certificate of insurance, in the individual's name or employing verification company for general liability, and professional liability insurance.

1.4.4 Certifying Agency Qualifications

Agency shall be an American National Standards Institute accredited certifier. Agency is responsible for testing and certifying individuals in compliance with **ASSE 6000 SERIES** Standards. Provide installer, inspector, and verifier certifications by one of the following agencies or by an agency with comparable qualifications:

- a. Medical Gas Professional Healthcare Organization (MGPHO).
- b. National Inspection, Testing and Certification Corporation (NITC), Los Angeles, California.

1.4.5 Regulatory Requirements

1.4.5.1 Standards

The Standards for design, materials, installation, and testing of gas and vacuum systems for healthcare facilities:

- a. National Fire Protection Association Standard for Health Care Facilities: NFPA 99.
- [b. National Fire Protection Association Standard for Storage, use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks: NFPA 55.]
- c. Interpret reference to the "Authority Having Jurisdiction" to mean the "Contracting Officer." For Government owned property, interpret references to the "owner" to mean the "Contracting Officer." For leased facilities, interpret references to the "owner" to mean the "lessor." Interpret references to the "permit holder" to mean the "Contractor."
- d. The provisions of Chapter 1, "Administration" in NFPA 99 [and NFPA 55] do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project.

1.4.5.2 Referenced Publications

In each of the publications referred to herein, interpret references to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.4.5.3 Alternative Qualifications

Products having less than a three-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.4.5.4 Service Support

Provide equipment items supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract. Submit manuals in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.5 DELIVERY, STORAGE, AND HANDLING

Deliver equipment and parts to site factory cleaned and processed in their original factory sealed package ready for installation. Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.6 COMMISSIONING

1.6.1 Inspection, Testing, and Verification Agency

NOTE: If project does not have a CxC, Commissioning Specialist, delete references to Project CxC, Commissioning Specialist.

Commissioning shall include retaining the Inspection, Testing, and Verification Agency prior to commencement of the installation of these systems. The Inspection, Testing, and Verification Agency shall coordinate their scope of work with that of the Project CxC, Commissioning Specialist and shall function in coordination with, not in lieu of, the Project CxC, Commissioning Specialist.

1.6.2 Responsibilities

The Inspection, Testing, and Verification Agencies responsibilities include:

- a. Review of the project drawings and specifications and providing comments and additional clarification(s), as needed, to the Contracting Officer and the Designer of Record.
- b. Witnessing by a certified inspector or certified verifier of the brazing of a minimum of two joints (one vertical and one horizontal) by each brazer assigned to the project. Evaluation of adequacy of the brazed joints shall be through observation of the brazing techniques, and by destructive methods (cutting the joints in half). This will be required of all brazers utilized throughout the duration of the project. Brazing of project materials shall not be permitted until the brazer qualifications, and the adequacy of their joints have been determined to be acceptable.
- c. Review and comment on the compliance of the project submittals required under "SUBMITTALS" and the specified items. Review shall be concurrent with the review being performed by the designated representative of the Government.
- d. Performing site observation visits prior to 1) backfilling exterior or interior below grade piping, 2) concealing above ceiling piping, and 3) concealing in wall piping. Conduct site observation visits by a certified inspector or certified verifier. Provide for each visit a written report stating progress of installation and any deficiencies needing corrective action.
- e. Review of revisions/substitutions relating to the Contract Documents and/or the Project Commissioning Plan.
- f. Coordination with the Project CxC, Commissioning Specialist in establishing a commissioning plan for components specific to the systems specified herein.
- g. Coordination with the Project CxC, Commissioning Specialist of the equipment start-up, and the system testing and verification procedures required by this specification.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products, essentially duplicate equipment that has performed satisfactorily at least two years prior to bid opening, and have been in satisfactory commercial or industrial use for 3 years prior to bid opening. The 3-year use shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 3 year period. Submit manufacturer's catalog data with highlighting to show model, size, options, etc., that are intended for consideration. Provide adequate data to demonstrate compliance with contract requirements.

2.2 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

[2.3 BULK LIQUID OXYGEN (LOX) SOURCE

NOTE: Bulk liquid oxygen systems are usually leased from a gas supplier by the user, and the tank, vaporizer(s), and associated appurtenances are not part of the project contract. Include the following and modify as required.

Provide complete factory-packaged, factory-tested, continuous-duty source(s). Each source shall contain LOX tank, source shutoff, valves, vaporizer(s), and other components required by the Regulatory Requirements, and necessary to provide complete performance. Each source shall require single-point connections to power wiring, warning system wiring, and piping system.

]2.4 EMERGENCY OXYGEN SUPPLY CONNECTION

NOTE: Emergency oxygen supply connection is required only on Level 1 systems where supply is remote from building. Coordinate location with building and site elements to assure accessibility.

Provide complete factory-packaged system including but not limited to enclosure, oxygen inlet, pressure gauge, 25 mm 1 inch shutoff valve, relief valve, and check valves. Provide lockable, weather tight enclosure for mounting on exterior of building. Enclosure shall be [recessed] [surface mounted]. Provide check valves for main and emergency oxygen lines.

[2.5 CYLINDER MANIFOLD SUPPLY SOURCE

NOTE: Coordinate manifold locations and power requirements with Division 26-Electrical.

Provide complete factory-packaged, factory-tested, continuous-duty source(s). Each source shall contain control panel, source shutoff, isolation valves and other components required by NFPA 99, and necessary to provide complete performance. Each source shall require single-point connections to power wiring, warning system wiring, and piping system. Each source shall have a minimum of two (2) cylinders on each side.

- a. Design the cylinder supply source so that when the switchover from the primary cylinders to the secondary cylinders occurs, there will be no drop or fluctuation in the line pressure. The control cabinet shall have a visual signal to indicate switchover from the primary to the secondary supply. Resetting of the control unit shall be accomplished automatically. Provide with a bronze-bodied poppet-type pressure-relief adjusted to relieve at 50 percent above maximum working pressure. Equip with an approved pressure switch for actuating a warning signal when, or before, the secondary bank goes into operation. The control valve shall be contained within a cabinet designed to prevent tampering by unauthorized personnel. One bank of cylinders shall be in service while the other bank is in reserve. Each bank shall be equipped with a master regulator and a gauge for 28 MPa 4,000 psi or greater cylinder-contents pressure. Switching from the empty bank of cylinders to the full bank of cylinders shall be fully automatic and shall not require resetting of the regulators.
- b. Provide cylinder supply source as follows:

- (1) Oxygen (O): Provide for [_____] primary and [_____] secondary cylinders, Item a).
- (2) Nitrogen (N): Provide for [_____] primary and [_____] secondary cylinders. Item a).

NOTE: Locate nitrous oxide supply where it will not be exposed to freezing temperatures. Consult manufacturer's literature for details.

- (3) Nitrous oxide (NO)
- (a) Provide for [_____] primary and [_____] secondary cylinders.

NOTE: Coordinate requirements of heated supply with electrical engineer. Connect to emergency electrical power.

- (b) Provide heated supply to prevent ice build-up during high demand.

- [(4) Carbon dioxide (CO2)

(a) Provide for [_____] primary and [_____] secondary cylinders.

NOTE: Coordinate requirements of heated supply with
electrical engineer. Connect to emergency
electrical power.

(b) Provide heated supply to prevent ice build-up during high demand.]

][2.6 DENTAL COMPRESSED AIR (DA) SOURCE

NOTE: Dental compressed air source can serve as
dental laboratory compressed air source.

- a. Provide complete factory-packaged, factory-tested, continuous-duty source(s). Each source shall contain air compressors, receiver, dryers, filters, control panel, source shutoff, compressor isolation valves and other components required by NFPA 99, and necessary to provide complete performance. Each source shall require single-point connections to power wiring, warning system wiring, and piping system.
- b. Tank-mounted air compressors shall be manufactured to comply with UL listing requirements. Air compressors shall have manufacturer's name and address, together with trade name and catalog number, on a nameplate securely attached to the equipment. Provide guards to shield exposed moving parts. Provide an intake air filter and silencer with each compressor. Provide aftercooler and moisture separator between compressors and air receivers, to remove moisture before the air enters the receiver. Aftercoolers shall be air cooled. The air shall pass through a sufficient number of tubes to affect cooling. Tubes shall be sized to give maximum heat transfer. Cooling capacity of the aftercooler shall be sized for the total capacity of the compressors.

2.6.1 Air Compressors

Provide [scroll type compressors] [reciprocating teflon-ring type compressors designed such that no oil is administered to the air cylinder, the portion of the piston rod that travels in the crankcase section does not travel in any portion of the air-cylinder section, and with provision to prevent the flow of lubrication oil along the piston rod into the air-cylinder section]. Provide a pressure gauge calibrated to 2068 kPa 300 psi, and equipped with a gauge cock and pulsation dampener for installation adjacent to the pressure switch. The motor and compressors shall be directly connected or operated by V-belt drive. Compressors shall be sequenced to start automatically when the pressure drops to a preset point. Compressors shall be air cooled. Provide each compressor chamber with a high-temperature sensor to activate a local alarm. Provide continuous duty NEMA rated, open dripproof motor with 1.15 service factor, and maximum of 3600 RPM.

2.6.2 Air Receiver

Provide air receiver delivering air to dental operatories designed for

1034 kPa 150 psi working pressure, factory air tested to 1.5 times the working pressure, meeting ASME BPVC SEC VIII D1. Provide receiver equipped with safety relief valves and accessories, including but not limited to pressure gauge, sight glass, and automatic and manual drains. The outside of receiver shall be galvanized or supplied with factory applied commercial enamel finish. The interior of the receiver shall be a factory applied vinyl lining. Provide a display of the ASME seal on the receiver, or a certified test report from an approved independent testing laboratory indicating conformance to the ASME Code. Provide receiver(s) with a three (3) valve bypass for servicing.

2.6.3 Control Panel

Provide UL 508A listed and labeled control panel in a NEMA 250 Type 12 enclosure. Provide Hand-Off-Auto switch for each compressor for selection of normal operation (automatic alternation) or manual selection of lead and lag compressors. Provide automatic alternation of compressors based on a first-on/first-off principle with provisions for simultaneous operation. The lag compressor shall be able to start automatically if the lead compressor fails to operate. Provide manual reset for thermal malfunction shutdown. All control and alarm functions shall remain energized while any compressor in the system remains electrically online. Provide magnetic motor starters with integral overload and short circuit protection, with lockable disconnecting means. Provide running light and elapsed run-time meter for each compressor. Provide circuit breakers with single point power feed connection. Provide 120 VAC control circuit transformers with fused primary and secondary. Provide pressure control switches or pressure transducer. Provide integral PLC controller for automatically switching operating sequence of compressors. Provide back-up circuit in case of PLC failure. Provide digital display interface. User interface shall display all alarm conditions, pump maintenance intervals, compressor performance warnings, average system air demand, average dewpoint and CO levels on system, compressors on/off status, system model number and serial number, and phone number to call for service. Provide audible and visual local alarms with silence button, remote alarm connections, and safety devices as required by NFPA 99. Local alarms shall have contacts to allow indication of a fault condition at the master alarm panel if one or more local alarms are activated. Provide the following alarms:

- a. Lag compressor In Use.
- b. High discharge temperature.
- c. High carbon monoxide levels.

2.6.4 Desiccant Air Dryers

Provide two identical twin-tower heatless desiccant air dryers. Provide dryers to achieve a pressure dewpoint -40 degrees C -40 degrees F at the maximum calculated NFPA system capacity. Provide lubricant free operation. Provide economizer cycle that reduces purge air requirements to match actual moisture loading. Provide solid-state cycle timer, OSHA purge exhaust mufflers, and a pressure gauge for each tower.

2.6.5 Filtration and Pressure Reducing Station

Provide two pre-filters rated 0.01 micron filtration with an efficiency of 99.9999 percent D.O.P. (Validated), two activated carbon filters, and two

1 micron final filters with an efficiency 99.9999 percent D.O.P. (Validated) installed downstream of the carbon filters. Provide all filters with a differential pressure gauge with color change indicator and automatic drain valve except the activated carbon filters. Provide downstream of the final filters a dual-line pressure regulating assembly consisting of two pressure regulators with pressure gauges, inlet and outlet isolation ball valves, and pressure relief valves. All filters/pressure regulators shall be arranged so that the isolation of one filter/ regulator will not affect the operation of the second filter/regulator.

2.6.6 Dew Point Monitor

Provide dew point monitor to continuously monitor the dew point of the dental compressed air. Provide ceramic type (aluminum oxide type is not acceptable) sensor with system accuracy of +/- 1 degree C 2 degrees F. The dew point alarm shall be factory set at 2 degrees C 36 degrees F and be field adjustable. Provide activation of local alarm and all master alarms when the dew point at system pressure exceeds + 4 degrees C 39 degrees F. Provide activation of monitor's signal at all master alarm panels if the monitor loses power. Monitor shall meet requirements of NFPA 99.

2.6.7 Carbon Monoxide Monitor

Provide carbon monoxide monitor to continuously monitor the dental compressed air for carbon monoxide and to actuate a local alarm if the carbon monoxide level is 10 ppm or higher. Provide activation of monitor's signal at all master alarm panels if the monitor loses power. Monitor shall meet requirements of NFPA 99.

] [2.7 DENTAL SURGICAL VACUUM (DSV) SOURCE

NOTE: Dental Surgical Vacuum was previously
designated as Dental High Vacuum (DHV).

Provide complete factory-packaged, factory-tested, continuous-duty source(s). Each source shall contain vacuum pumps, receiver, control panel, source shutoff, pump isolation valves and other components required by NFPA 99, and necessary to provide complete performance. Each source shall require single-point connections to power wiring, warning system wiring, and piping system.

2.7.1 Vacuum Pumps

NOTE: Water sealed liquid ring vacuum pumps should
generally not be used. If used then they must fully
meet the water conserving features outlined within.

Provide one of the following pumps and delete the others: [non-lubricated rotary] [non-contacting dry claw] [recirculating water sealed liquid ring] vacuum pumps. Mount each pump and its motor on modular skids in a horizontal or vertical configuration with coupling and guard. Pumps and motors for small systems may be tank mounted. Provide shutoff valve on each pump inlet. Provide vacuum gauge at each pump inlet.

- [a. Provide completely dry non-lubricated rotary vane pumps equipped with self-lubricating carbon/graphite vanes. Bearings shall be lubricated and sealed. No oil is permitted in any pump. Each pump shall be completely air-cooled and have absolutely no water requirement. Each pump shall be fitted with a 5 micron inlet filter and be equipped with a vacuum relief valve, check valve to prevent backflow through off-cycle units, flexible connector, isolation valve, and vibration isolators at each mounting location. Provide continuous duty NEMA rated, C-face, open dripproof motor with 1.15 service factor, and maximum of 1800 RPM.]
- [b. Provide non-contacting dry claw style rotary pumps. Internal construction shall be friction free and the rotors shall be non-contacting. The air end shall be oil free and require no sealants. Each pump shall be air cooled and continuous duty rated. Each pump shall be provided with a single lubricated gearbox requiring oil change not more often than 5,000 operating hours. Each pump shall be provided with an exhaust silencer. The pumps shall be equipped with high vacuum shutdown, high temperature shutdown and alarm. The lubricant supplied shall be inert with oxygen. Each pump shall be fitted with a 5 micron inlet filter and be equipped with a vacuum relief valve, check valve to prevent backflow through off-cycle units, flexible connector, isolation valve, and vibration isolators at each mounting location. Provide continuous duty NEMA rated, C-face, TEFC motor with 1.15 service factor, and maximum of 3500 RPM.]
- [c. Provide oil-free, single-stage positive displacement, and non-pulsating recirculating water sealed liquid ring type pumps. The pumps shall be fitted with mechanical seals. The pump shall be of all iron construction with a bronze or stainless rotor and carbon steel shaft. Under normal operation, system shall minimize fresh seal water required to 0.05 L/s 0.75 gpm. System shall include reservoir sufficient for up to 48 hours operation without fresh water supply. Each pump shall be equipped with a vacuum relief valve, check valve to prevent backflow through off-cycle units, flexible connector, isolation valve, and vibration isolators at each mounting location. System shall be totally self contained. Provide continuous duty NEMA rated, open dripproof motor with 1.15 service factor, and maximum of 1800 RPM.]

2.7.2 Vacuum Receiver

Provide receiver designed for 1034 kPa 150 psi minimum working pressure, factory air tested to 1.5 times the working pressure, meeting ASME BPVC SEC VIII D1. Provide receiver equipped with safety relief valves and accessories, including but not limited to vacuum gauge, sight glass, and automatic and manual drains. The outside of receiver shall be galvanized or supplied with factory applied commercial enamel finish. The interior of the receiver shall be a factory applied vinyl lining. Provide a display of the ASME seal on the receiver or a certified test report from an approved independent testing laboratory indicating conformance to the ASME Code. Provide receiver(s) with a three (3) valve bypass for servicing.

2.7.3 Control Panel

Provide UL 508A listed and labeled control panel in a NEMA 250 Type 12 enclosure. Provide Hand-Off-Auto switch for each vacuum pump for

selection of normal operation (automatic alternation) or manual selection of lead and lag vacuum pump. Provide automatic alternation of vacuum pumps based on a first-on/first-off principle with provisions for simultaneous operation. The lag vacuum pump shall be able to start automatically if the lead vacuum pump fails to operate. Provide manual reset for thermal malfunction shutdown. All control and alarm functions shall remain energized while any vacuum pump in the system remains electrically online. Provide magnetic motor starters with integral overload and short circuit protection, with lockable disconnecting means. Provide running light and elapsed run-time meter for each vacuum pump. Provide circuit breakers with single point power feed connection. Provide 120 VAC control circuit transformers with fused primary and secondary. Provide vacuum control switches. Provide integral PLC controller for automatically switching operating sequence of vacuum pumps. Provide back-up circuit in case of PLC failure. Provide digital display interface. User interface shall display all alarm conditions, vacuum pump maintenance intervals, vacuum pump performance warnings, average system vacuum demand, vacuum pumps on/off status, system model number and serial number, and phone number to call for service. Provide audible and visual local alarms with silence button, remote alarm connections, and safety devices as required by NFPA 99. Local alarms shall have contacts to allow indication of a fault condition at the master alarm panel if one or more local alarms are activated. Provide the following alarms: Lag vacuum pump In Use.

][2.8 DENTAL ORAL EVACUATION (OE) SOURCE

**NOTE: Oral Evacuation was previously designated as
Dental Low Vacuum (DLV).**

Provide complete factory-packaged, factory-tested, continuous-duty source(s). Each source shall contain vacuum pumps, separator(s), control panel, source shutoff, pump isolation valves and other components required by NFPA 99, and necessary to provide complete performance. Each source shall require single-point connections to power wiring, warning system wiring, and piping system.

2.8.1 Vacuum Pumps

Provide [turbine] [oil-lubricated rotary-vane] [regenerative blower] vacuum pumps. The pumps shall be connected in parallel to the central wet separator tanks.

[2.8.1.1 Turbines

Provide self-governing, multistage, centrifugal type turbines of overhung or outboard design. The vacuum pumps shall operate at a speed not to exceed 3,600 rpm and shall be connected to its driving motor by a flexible coupling. Bearings may be sealed or of the lubricatable type. A fan shall be connected directly to the vacuum pump shaft adjacent to vacuum pump shaft bearings to create a flow of ambient air over the bearing carrier while the unit is operating. A steel coupling guard encompassing the flexible coupling shall be installed between the motor and vacuum pump. Cases shall be cylindrical in design. Cases and end plates (inlet and exhaust heads included) shall be constructed of either heavy-gauge sheet steel rigidly welded at seams and sections, or of cast grey iron. Sheet steel end plates shall be either concave or convex. Inlet and

exhaust connections shall be tangential to the vacuum pump except the inlet connection can be axial to vacuum pump and sized to allow free air movement through the vacuum pump, without flow restriction and shall have class 150 flanges. The vacuum pump input shall have an adjustable volume control valve, a directional flow valve and antisurge valve. The vacuum pump output shall have an exhaust silencer. Plumbing shall be connected to the vacuum pump through flexible sleeve connectors. Internal moving parts shall be constructed with not less than 3.2 mm 0.125 inch clearance throughout to prevent damage by transient particulates. Impellers shall be constructed of fabricated sheet metal or high-tensile aluminum alloy, smooth on all surfaces to prevent imbalance by uneven dust deposits. Impellers shall be of the backward curved or radial design to provide optimal performance over a wide range of volume requirements. Impellers shall be securely attached to the vacuum pump shaft by set screws or clamps of high-tensile material. Each impeller shall be individually balanced. The complete assembly, with motor, shall not exceed 0.038 mm 1.5 mils of vibration when given a running test. Power to operate the vacuum pump shall be in direct proportion to the volume of air exhausted and shall not exceed the normal motor rating. The vacuum produced shall be substantially constant throughout the operating range of the vacuum pump. Provide continuous duty NEMA MG 1, 3500 RPM maximum, T-frame, dripproof design motor with either sealed or lubricatable bearings. Operating temperature rise of the motor shall not exceed 22 degrees C 72 degrees F. Each vacuum pump assembly shall be mounted on resilient isolator pads as recommended by the manufacturer. The pads shall not be fastened to the facility floor.

][2.8.1.2 Rotary-Vane Vacuum Pump

Provide low speed, positive displacement, oil lubricated rotary-vane vacuum pumps with separate, standard NEMA frame size, high efficiency motors. Provide automatic lubrication of moving pump parts by an oiling system not dependent on moving parts and operated only by gravity and vacuum. Provide vacuum pump constructed to provide protection against ingesting particulates larger than 15 µ into pump, operating with insufficient lubrication, and water contamination of oil. Provide electrical overload by thermal sensors built into single phase motors or thermal sensors built into three phase motor starters; three phase motor starters additionally protected against single phasing. Provide continuous duty, NEMA rated, C-face, TEFC motor with 1.15 service factor, and maximum of 1800 RPM.

][2.8.1.3 Regenerative Blower

Provide regenerative blower consisting of one impeller, mounted directly on the motor shaft. Provide precision cast aluminum impeller with multiple radial blades at its periphery. The impeller shall be the only moving part, and shall not require any lubrication. Dynamically balance the impeller to provide vibration-free operation without the need for vibration isolators. The impeller shall be installed between the blower housing and cover. Provide housing and cover of cast aluminum and provided with multiple heat-dissipating fins. There shall be no metal-to-metal contact within the blower housing. Oil lubrication shall not be required providing oil free discharge gas. The heat-dissipating fins shall efficiently minimize heating of the compressed gas. Blower shall have a guaranteed ultimate vacuum of 60 kPa 12 inches Hg vacuum. Provide motor supported by outboard mounted, grease lubricated, anti-friction bearings. The bearings shall be located outside of the compression chamber to maximize operating efficiency and bearing life.

Provide bearing housing conservatively loaded and rated for an L(10) life of not less than 200,000 hours. Shaft main bearings of the sleeve type with heavy duty bushings or rolling element type in accordance with ABMA 9 or ABMA 11. Provide a lip seal to minimize leakage where the motor shaft passes through the blower housing. Blower producing noise levels shall not exceed 75 dBA. Additional silencers may be installed to further reduce the noise level. Provide continuous duty NEMA rated, TEFC motor with 1.15 service factor, and maximum of 3600 RPM. Blower shall be direct driven. Provide blower manufactured in accordance with ISO 9001, and UL listed, CE compliant, DIN VDE 0530. Each blower module shall include a separator with check valve, flex connector, isolation valve and a relief valve. The vacuum pump control switches shall be control panel mounted and shall be set as follows:

Lead Pump	Continuous Operation
Lag Pump	Start 84 kPa 5 inches Hg vacuum
	Stop 73 kPa 8 inches Hg vacuum

12.8.2 Pipe Isolators

Provide flexible, resilient band-sealed (clamped) sleeves furnished to isolate the vacuum pump from associated piping. Size sleeve couplings in accordance with the exhaustor intake and output connections. Provide pipe isolators with steel coupling guards.

2.8.3 Valves

2.8.3.1 Volume Control Valve

Provide the input of each vacuum pump with an adjustable air volume control valve to prevent accidental vacuum pump overload and to provide a means of adjusting the upper design capacity limit. The volume control valve shall be built in or immediately adjacent to the first or input stage of the vacuum pump and shall be preset by the manufacturer during certification procedure. The valve shall be a butterfly type with cast iron body with corrosive resistant internals.

2.8.3.2 Antisurge Valve

Provide the input of each vacuum pump with an antisurge valve that will operate proportionally and automatically throughout the vacuum pump's designed range. This valve shall continually sense the motor current and maintain a predetermined operational level of volume by proportionally bleeding air into the system. The valve shall be equipped with a silencer to attenuate air noise to 85 dBA or below. The valve shall be installed in, on, or near the first stage of the vacuum pump and can be mounted in conjunction with the directional flow valve.

2.8.3.3 Directional Flow Valve

Provide the input of each vacuum pump with a directional flow valve to prevent back flow of air through the shutdown. The directional flow valve shall be cast iron with corrosive resistant internals.

2.8.4 Exhaust Silencer

Provide each vacuum pump exhaust with a separate air discharge silencer of the open-bore expansion type. No interior baffling or shrouding will be permitted. The silencer shall satisfactorily attenuate air noise to a level below 85 dBA.

2.8.5 Control Panel

Provide UL 508A listed and labeled control panel in a NEMA 250 Type 12 enclosure. Provide Hand-Off-Auto switch for each vacuum pump for selection of normal operation (automatic alternation) or manual selection of lead and lag vacuum pump. Provide automatic alternation of vacuum pumps based on a first-on/first-off principle with provisions for simultaneous operation. The lag vacuum pump shall be able to start automatically if the lead vacuum pump fails to operate. Provide manual reset for thermal malfunction shutdown. All control and alarm functions shall remain energized while any vacuum pump in the system remains electrically online. Provide magnetic motor starters with integral overload and short circuit protection, with lockable disconnecting means. Provide running light and elapsed run-time meter for each vacuum pump. Provide circuit breakers with single point power feed connection. Provide 120 VAC control circuit transformers with fused primary and secondary. Provide vacuum control switches. Provide integral PLC controller for automatically switching operating sequence of vacuum pumps. Provide back-up circuit in case of PLC failure. Provide digital display interface. User interface shall display all alarm conditions, vacuum pump maintenance intervals, vacuum pump performance warnings, average system vacuum demand, vacuum pumps on/off status, system model number and serial number, and phone number to call for service. Provide audible and visual local alarms with silence button, remote alarm connections, and safety devices as required by NFPA 99. Local alarms shall have contacts to allow indication of a fault condition at the master alarm panel if one or more local alarms are activated. Provide the following alarms: Lag vacuum pump In Use.

2.8.6 Central Wet Separators

The OE system shall utilize a central wet separator. Provide separator tanks constructed of a nonmetallic, noncorrosive, inert material or composite such as glass-reinforced plastic (GRP). Tanks shall be of one-piece construction, with smooth, interior walls. Tanks shall be freestanding. Tanks shall be high-pressure vessels able to withstand a constant negative pressure of 51 kPa 15 inches Hg vacuum. The bottom of the tanks shall be convex with drain at the apex of convexity. Provide separator tanks equipped with mechanical overflow protection. [Provide preplumbed with a 360 degree nozzle internal washdown system with timer. The washdown system shall include a 115 VAC automatic-flush clock-controlled mechanism which shall effect a complete washdown of the interior of the separator at any predetermined time of day or night. Washdown time shall be adjustable for up to at least 3 minutes. The timers shall be in the main electric control panel. The cold water supply to the automatic tank flush unit shall be equipped with an in-line filter with 40-mesh stainless steel screens. Filter shall be supplied as part of the OE system.] Each separator tank shall be equipped with an electronic high-low liquid level sensor which shall perform as the primary overflow protector. In multiple-tank installations, one tank shall be adjusted to sense 90 percent of its capacity and the other tank 100 percent of its capacity via the liquid-level sensing devices. Each sensor shall control

a 115 volt ac electrically operated output air solenoid valve located to control the outgoing air from the tank to the vacuum pump. Each tank shall be equipped with a gate and swing type check valve at the bottom drain. With negative pressure in the tank, the check valve shall remain closed to maintain vacuum. When negative pressure ceases, either by vacuum pump shutdown or by closure of the outgoing air solenoid control by the liquid level sensor, the check valve shall open and the tank shall undergo gravity drain.

2.8.7 Vacuum Relief Valve

Provide vacuum relief valve. The valve shall operate automatically. The valve shall be equipped with a silencer to attenuate air noise to 85 dBA.

2.8.8 Amalgam Separator

Provide amalgam separator consisting of a sedimentation collection chamber that is removable. Separation process shall be sedimentation which may be supplemented with filtration, and/or ion exchange. Unit shall be compatible for use on wet and dry vacuum systems. Assembly shall be wall or floor mounted. Provide minimum 40 mm 1-1/2 inch inlet and outlet connection. Unit shall be ISO 11143 Certified and have a minimum of 99 percent removal efficiency.

] [2.9 HIGH-VOLUME LABORATORY DUST EVACUATION (LE) SOURCE

NOTE: The high-volume laboratory dust evacuation system (LE) is an independent vacuum system specifically designed for scavenging, collecting, and filtering of grinding and polishing particulates generated in the dental/medical laboratory. This system was previously designated LDE.

- a. Provide complete factory-packaged, factory-tested, continuous-duty source(s). Each source shall contain vacuum pumps, receiver, control panel, source shutoff, pump isolation valves and other components as indicated, required by the Standards, and necessary to provide complete performance. Each source shall require single-point connections to power wiring, warning system wiring, and piping system.
- b. The LE system shall be composed of standard manufactured products, complete with devices normally furnished and devices required herein. The LE system shall be supplied by an established manufacturer of commercially available industrial quality vacuum system. The LE shall be a dry system for collection of dust and grinding particulates. The system shall consist of one vacuum pump, except for area laboratory (ADL) application, and a dry, cyclonic, filtered separator.

2.9.1 Vacuum Pumps

Provide self-governing, multistage, centrifugal type turbines of overhung or outboard design. The vacuum pump shall operate at a speed not to exceed 3600 RPM. The vacuum pump shall be connected to its drive motor by multiple V-belts. The vacuum pump shaft shall have a minimum of two radial bearings and at least one support bracket. Bearings may be permanently-lubricated sealed or lubricatable type. The vacuum pump/connector/drive motor assembly shall be fastened to a plate or frame

structure. Power to operate the exhauster at the calculated design load shall not exceed the normal motor rating. Power required shall be in direct proportion to the volume of air exhausted. The vacuum produced shall be substantially constant throughout the design operating range of the exhauster. Vacuum pump cases shall be cylindrical in design. Cases and end plates may be constructed of either heavy-gauge sheet steel rigidly welded at seams or sections, or of cast grey iron. Sheet steel end plates shall be either concave or convex for flex resistance. Inlet connections may be axially or tangentially placed. Exhaust connections may be tangential to the casing. Inlet and outlet connections shall be sized to allow free air movement through the vacuum pump, without flow restrictions. The vacuum pump shall have an adjustable volume control device in, on, or adjacent to the first stage of the input and an exhaust silencer on the output. The silencer and all plumbing shall be connected to the vacuum pump flexible sleeve connectors. Internal moving parts of the vacuum pump shall be constructed with not less than 3.2 mm 1/8 inch clearance throughout to prevent damage by transient particulates. Impellers shall be constructed of built-up sheet or high tensile composites. Impellers shall be of the backward curved design. Impellers shall be securely attached to the exhauster shaft by set screws or clamps of high-tensile material. Each impeller shall be individually balanced. The complete assembly with motor, shall not exceed 0.038 mm 1-1/2 mils of vibration when given a running test. The vacuum pump shall be sized to produce the designated performance standards at the above-sea-level elevation of the proposed installation site, and shall be so certified by the manufacturer by equipment tag or plate, or by letter of certification identifying the turbo-exhauster by serial number.

2.9.2 Motor

Provide continuous duty NEMA MG 1, 3500 RPM maximum, T-frame, dripproof design motor with either sealed or lubricatable bearings. Operating temperature rise of the motor shall not exceed 22 degrees C 72 degrees F.

2.9.3 Isolation Pads

The vacuum pump assembly shall be mounted on resilient isolator pads as recommended by the manufacturer. The pads shall not be fastened to the facility floor. Vibration transmission shall be limited to less than 5 percent of the lowest frequency of vibration.

2.9.4 Pipe Isolators

Provide flexible, resilient clamped sleeves furnished to isolate the vacuum pump from associated plumbing. Sleeve couplings shall be sized in accordance with the exhauster intake and output connections. Pipe isolators shall be provided with steel coupling guards.

2.9.5 Volume Control Device

Provide input of the vacuum pump with an adjustable air volume control device to prevent accidental overload and to provide a means of adjusting the upper design capacity limit. The volume control device may be built-in or immediately adjacent to the first or input stage of the exhauster and shall be preset by the manufacturer during certification procedure.

2.9.6 Exhaust Silencer

The vacuum pump shall output to an air discharge silencer of the open-bore expansion type. No interior baffling or shrouding will be permitted. The silencer shall satisfactorily attenuate air noise to a level below 85 dBA.

2.9.7 Control Panel

Provide **UL 508A** listed and labeled control panel in a **NEMA 250** Type 12 enclosure. Provide Hand-Off-Auto switch for each vacuum pump for selection of normal operation (automatic alternation) or manual selection of lead and lag vacuum pump. Provide automatic alternation of vacuum pumps based on a first-on/first-off principle with provisions for simultaneous operation. The lag vacuum pump shall be able to start automatically if the lead vacuum pump fails to operate. Provide manual reset for thermal malfunction shutdown. All control and alarm functions shall remain energized while any vacuum pump in the system remains electrically online. Provide magnetic motor starters with integral overload and short circuit protection, with lockable disconnecting means. Provide running light and elapsed run-time meter for each vacuum pump. Provide circuit breakers with single point power feed connection. Provide 120 VAC control circuit transformers with fused primary and secondary. Provide vacuum control switches. Provide integral PLC controller for automatically switching operating sequence of vacuum pumps. Provide back-up circuit in case of PLC failure. Provide digital display interface. User interface shall display all alarm conditions, vacuum pump maintenance intervals, vacuum pump performance warnings, average system vacuum demand, vacuum pumps on/off status, system model number and serial number, and phone number to call for service. Provide audible and visual local alarms with silence button, remote alarm connections, and safety devices as required by **NFPA 99**. Local alarms shall have contacts to allow indication of a fault condition at the master alarm panel if one or more local alarms are activated. Provide the following alarms: Lag vacuum pump In Use.

2.9.8 Central Separator

Provide freestanding central separator of heavy-gauge steel and all-welded construction. The separator chamber shall be of the cyclonic type and shall effectively separate and trap all particulate matter contained in the vacuum input. The internal configuration of the separator shall be such that air leaving the cyclonic chamber shall be directed upward through filter bags to effect final cleaning of the air before its entry into the vacuum pump. The lower part of the separator enclosure shall contain an easily accessible and serviceable debris container. The container shall lock into operating position to form a positive seal between the removable container and the separator enclosure. The debris container shall be removable and reinstallable without the use of tools. The container shall be equipped with casters to facilitate moving for emptying and reinstallation alignment and shall have a pivoting handle to facilitate handling. The separator shall be equipped with a filter-shaker mechanism actuated by an electric motor operating through mechanical linkage to the shaker mechanism. An electrical switch to control the shaker motor shall be on or adjacent to the separator. The separator shall be equipped with an easily removed screw- or bolt-fastened access panel to provide easy access for filter inspection and service.

2.9.9 Primary Separator

When necessary to satisfy specific design requirements, a primary separator shall be used in addition to, and ahead of, the central separator. The primary separator shall be of the cyclonic type and shall effect initial separation of abrasive particulates before vacuum air and debris enter the central separator. The primary separator shall be of heavy-gauge steel, all welded-seam construction, and may be freestanding or wall-mounted.

2.9.10 Air Volume Relief Valve

Provide mechanically operated air volume relief valve, requiring no electrical power. The valve shall operate automatically, sensing negative pressure in the system and opening and closing proportionately to maintain designed air capacity to the vacuum pump regardless of the number of inlets online. Valve shall be equipped with silencer to attenuate air noise to 85 dBA or less.

2.9.11 Vacuum Inlets

User inlets for technicians' benches shall be 32 mm 1-1/4 inches ID and for fixed-equipment locations, 40 mm 1-1/2 inches ID, with removable friction fit adapters sized to receive 80 mm 3 inch ID flexible hose. Adapters shall provide an airtight seal when inserted into the vacuum inlet. Inlets shall have attached pivot or hinge-mounted doors. When closed, the doors shall provide an airtight seal to close off the vacuum inlet; when open, they shall not interfere with insertion of the adapters with 80 mm 3 inch ID hose attached.

2.10 MEDICAL COMPRESSED AIR (MA) SOURCE

Provide complete factory-packaged, factory-tested, continuous-duty source(s). Each source shall contain air compressors, receiver, dryers, filters, control panel, source shutoff, compressor isolation valves and other components required by NFPA 99, and necessary to provide complete performance. Each source shall require single-point connections to power wiring, warning system wiring, and piping system. Tank-mounted air compressors shall be manufactured to comply with UL listing requirements. Air compressors shall have manufacturer's name and address, together with trade name and catalog number, on a nameplate securely attached to the equipment. Provide guards to shield exposed moving parts. Provide an intake air filter and silencer with each compressor. Provide aftercooler and moisture separator installed between compressors and air receivers, to remove moisture before the air enters the receiver. Aftercoolers shall be air cooled. The air shall pass through a sufficient number of tubes to affect cooling. Tubes shall be sized to give maximum heat transfer. Cooling capacity of the aftercooler shall be sized for the total capacity of the compressors.

2.10.1 Air Compressors

Provide [scroll type compressors] [reciprocating teflon-ring type compressors designed such that no oil is administered to the air cylinder, the portion of the piston rod that travels in the crankcase section does not travel in any portion of the air-cylinder section, and with provision to prevent the flow of lubrication oil along the piston rod into the air-cylinder section]. Provide a pressure gauge calibrated to 2068 kPa 300 psi, and equipped with a gauge cock and pulsation dampener for

installation adjacent to the pressure switch. The motor and compressors shall be directly connected or operated by V-belt drive. Compressors shall be sequenced to start automatically when the pressure drops to a preset point. Compressors shall be air cooled. Provide each compressor chamber with a high-temperature sensor to activate a local alarm. Provide continuous duty NEMA rated, open dripproof motor with 1.15 service factor, and maximum of 3600 RPM.

2.10.2 Air Receiver

Provide receiver designed for 1034 kPa 150 psi minimum working pressure, factory air tested to 1.5 times the working pressure, meeting ASME BPVC SEC VIII D1. Provide receiver equipped with safety relief valves and accessories, including but not limited to pressure gauge, sight glass, and automatic and manual drains. The outside of receiver shall be galvanized or supplied with factory applied commercial enamel finish. The interior of the receiver shall be a factory applied vinyl lining. Provide a display of the ASME seal on the receiver, or a certified test report from an approved independent testing laboratory indicating conformance to the ASME Code. Provide receiver(s) with a three (3) valve bypass for servicing.

2.10.3 Control Panel

Provide UL 508A listed and labeled control panel in a NEMA 250 Type 12 enclosure. Provide Hand-Off-Auto switch for each compressor for selection of normal operation (automatic alternation) or manual selection of lead and lag compressors. Provide automatic alternation of compressors based on a first-on/first-off principle with provisions for simultaneous operation. The lag compressor shall be able to start automatically if the lead compressor fails to operate. Provide manual reset for thermal malfunction shutdown. All control and alarm functions shall remain energized while any compressor in the system remains electrically online. Provide magnetic motor starters with integral overload and short circuit protection, with lockable disconnecting means. Provide running light and elapsed run-time meter for each compressor. Provide circuit breakers with single point power feed connection. Provide 120 VAC control circuit transformers with fused primary and secondary. Provide pressure control switches or pressure transducer. Provide integral PLC controller for automatically switching operating sequence of compressors. Provide back-up circuit in case of PLC failure. Provide digital display interface. User interface shall display all alarm conditions, pump maintenance intervals, compressor performance warnings, average system air demand, average dewpoint and CO levels on system, compressors on/off status, system model number and serial number, and phone number to call for service. Provide audible and visual local alarms with silence button, remote alarm connections, and safety devices as required by NFPA 99. Local alarms shall have contacts to allow indication of a fault condition at the master alarm panel if one or more local alarms are activated. Provide the following alarms:

- a. Lag compressor In Use.
- b. High discharge temperature.
- c. High carbon monoxide levels.
- d. High dewpoint level.

2.10.4 Desiccant Air Dryers

Provide two identical twin-tower heatless desiccant air dryers. Provide dryers sized to achieve a pressure dewpoint **-40 degrees C -40 degrees F** at the maximum calculated NFPA system capacity. Provide lubricant free operation. Provide economizer cycle that reduces purge air requirements to match actual moisture loading. Provide solid-state cycle timer, OSHA purge exhaust mufflers, and a pressure gauge for each tower.

2.10.5 Filtration and Pressure Reducing Station

Provide two pre-filters rated 0.01 micron filtration with an efficiency exceeding 99.9999 percent D.O.P. (Validated), two activated carbon filters, and two 1 micron filters with an efficiency exceeding 99.9999 percent D.O.P. (Validated) installed downstream of the carbon filters. Provide all filters with a differential pressure gauge with color change indicator and automatic drain valve except the activated carbon filters. Provide downstream of the final filters a dual-line pressure regulating assembly consisting of two pressure regulators with pressure gauges, inlet and outlet isolation ball valves, and pressure relief valves. All filters/pressure regulators shall be arranged so that the isolation of one filter/ regulator will not affect the operation of the second filter/regulator.

2.10.6 Dew Point Monitor

Provide dew point monitor to continuously monitor the dew point of the medical compressed air. Provide ceramic type (aluminum oxide type is not acceptable) sensor with system accuracy of **+/- 1 degree C 2 degrees F**. The dew point alarm shall be factory set at **2 degrees C 36 degrees F** and be field adjustable. Provide activation of local alarm and all master alarms when the dew point at system pressure exceeds **+ 4 degrees C 39 degrees F**. Provide activation of monitor's signal at all master alarm panels if the monitor loses power. Monitor shall meet requirements of **NFPA 99**.

2.10.7 Carbon Monoxide Monitor

Provide carbon monoxide monitor to continuously monitor the medical compressed air for carbon monoxide, and to actuate a local alarm if the carbon monoxide level is 10 ppm or higher. Provide activation of monitor's signal at all master alarm panels if the monitor loses power. Monitor shall meet requirements of **NFPA 99**.

2.11 MEDICAL-SURGICAL VACUUM (MV) SOURCE

Provide complete factory-packaged, factory-tested, continuous-duty source(s). Each source shall contain vacuum pumps, receiver, control panel, source shutoff, pump isolation valves and other components as indicated, required by **NFPA 99**, and necessary to provide complete performance. Each source shall require single-point connections to power wiring, warning system wiring, and piping system.

2.11.1 Vacuum Pumps

NOTE: Water sealed liquid ring vacuum pumps should generally not be used. If used then they must fully meet the water conserving features outlined within.

Provide [non-lubricated rotary] [non-contacting dry claw] [recirculating water sealed liquid ring] vacuum pumps. Mount each pump and its motor on modular skids in a horizontal or vertical configuration with coupling and guard. Pumps and motors for small systems may be tank mounted. Provide high efficiency motors. Provide shutoff valve on each pump inlet. Provide vacuum gauge at each pump inlet.

- [a. Provide completely dry non-lubricated rotary vane pumps equipped with self-lubricating carbon/graphite vanes. Bearings shall be lubricated and sealed. No oil is permitted in any pump. Each pump shall be completely air-cooled and have absolutely no water requirement. Each pump shall be fitted with a 5 micron inlet filter and be equipped with a vacuum relief valve, check valve to prevent backflow through off-cycle units, flexible connector, isolation valve, and vibration isolators at each mounting location. Provide continuous duty NEMA rated, C-face, open dripproof motor with 1.15 service factor, and maximum of 1800 RPM.]
- [b. Provide non-contacting dry claw style rotary pumps. Internal construction shall be friction free and the rotors shall be non-contacting. The air end shall be oil free and require no sealants. Each pump shall be air cooled and continuous duty rated. Each pump shall be provided with a single lubricated gearbox requiring oil change not more often than 5,000 operating hours. Each pump shall be provided with an exhaust silencer. The pumps shall be equipped with high vacuum shutdown, high temperature shutdown and alarm. The lubricant supplied shall be inert with oxygen. Each pump shall be fitted with a 5 micron inlet filter and be equipped with a vacuum relief valve, check valve to prevent backflow through off-cycle units, flexible connector, isolation valve, and vibration isolators at each mounting location. Provide continuous duty NEMA rated, C-face, TEFC motor with 1.15 service factor, and maximum of 3500 RPM.]
- [c. Provide oil-free, single-stage positive displacement, and non-pulsating recirculating water sealed liquid ring type pumps. The pumps shall be fitted with mechanical seals. The pump shall be of all iron construction with a bronze or stainless rotor and carbon steel shaft. Under normal operation, system shall minimize fresh seal water required to 0.05 L/s 0.75 gpm. System shall include reservoir sufficient for up to 48 hours operation without fresh water supply. Each pump shall be equipped with a vacuum relief valve, check valve to prevent backflow through off-cycle units, flexible connector, isolation valve, and vibration isolators at each mounting location. System shall be totally self contained. Provide continuous duty NEMA rated, open dripproof motor with 1.15 service factor, and maximum of 1800 RPM.]

2.11.2 Vacuum Receiver

Provide receiver designed for 1034 kPa 150 psi minimum working pressure, factory air tested to 1.5 times the working pressure, meeting ASME BPVC SEC VIII D1. Provide receiver equipped with safety relief valves and accessories, including but not limited to vacuum gauge, sight glass, and automatic and manual drains. The outside of receiver shall be galvanized or supplied with factory applied commercial enamel finish. The interior of the receiver shall be a factory applied vinyl lining. Provide a display of the ASME seal on the receiver or a certified test report from

an approved independent testing laboratory indicating conformance to the ASME Code. Provide receiver(s) with a three (3) valve bypass for servicing.

2.11.3 Control Panel

Provide UL 508A listed and labeled control panel in a NEMA 250 Type 12 enclosure. Provide Hand-Off-Auto switch for each vacuum pump for selection of normal operation (automatic alternation) or manual selection of lead and lag vacuum pump. Provide automatic alternation of vacuum pumps based on a first-on/first-off principle with provisions for simultaneous operation. The lag vacuum pump shall be able to start automatically if the lead vacuum pump fails to operate. Provide manual reset for thermal malfunction shutdown. All control and alarm functions shall remain energized while any vacuum pump in the system remains electrically online. Provide magnetic motor starters with integral overload and short circuit protection, with lockable disconnecting means. Provide running light and elapsed run-time meter for each vacuum pump. Provide circuit breakers with single point power feed connection. Provide 120 VAC control circuit transformers with fused primary and secondary. Provide vacuum control switches. Provide integral PLC controller for automatically switching operating sequence of vacuum pumps. Provide back-up circuit in case of PLC failure. Provide digital display interface. User interface shall display all alarm conditions, vacuum pump maintenance intervals, vacuum pump performance warnings, average system vacuum demand, vacuum pumps on/off status, system model number and serial number, and phone number to call for service. Provide audible and visual local alarms with silence button, remote alarm connections, and safety devices as required by NFPA 99. Local alarms shall have contacts to allow indication of a fault condition at the master alarm panel if one or more local alarms are activated. Provide the following alarms: Lag vacuum pump In Use.

[2.12 WASTE ANESTHESIA GAS DISPOSAL VACUUM (WAGD) SOURCE

Provide complete factory-packaged, factory-tested, continuous-duty source(s). Each source shall contain vacuum pumps, receiver, control panel, source shutoff, pump isolation valves and other components as indicated, required by NFPA 99, and necessary to provide complete performance. Each source shall require single-point connections to power wiring, warning system wiring, and piping system.

2.12.1 Vacuum Pumps

Provide [non-lubricated rotary] [non-contacting dry claw] [regenerative blower] [recirculating water sealed liquid ring] vacuum pumps. Mount each pump and its motor on modular skids in a horizontal or vertical configuration with coupling and guard. Pumps and motors for small systems may be tank mounted. Provide high efficiency motors. Provide shutoff valve on each pump inlet. Provide vacuum gauge at each pump inlet.

- [a. Provide completely dry non-lubricated rotary vane pumps equipped with self-lubricating carbon/graphite vanes. Bearings shall be lubricated and sealed. No oil is permitted in any pump. Each pump shall be completely air-cooled and have absolutely no water requirement. Each pump shall be fitted with a 5 micron inlet filter and be equipped with a vacuum relief valve, check valve to prevent backflow through off-cycle units, flexible connector, isolation valve, and vibration isolators at each mounting location. Provide continuous duty NEMA

rated, C-face, open dripproof motor with 1.15 service factor, and maximum of 1800 RPM.]

- [b. Provide non-contacting dry claw style rotary pumps. Internal construction shall be friction free and the rotors shall be non-contacting. The air end shall be oil free and require no sealants. Each pump shall be air cooled and continuous duty rated. Each pump shall be provided with a single lubricated gearbox requiring oil change not more often than 5,000 operating hours. Each pump shall be provided with an exhaust silencer. The pumps shall be equipped with high vacuum shutdown, high temperature shutdown and alarm. The lubricant supplied shall be inert with oxygen. Each pump shall be fitted with a 5 micron inlet filter and be equipped with a vacuum relief valve, check valve to prevent backflow through off-cycle units, flexible connector, isolation valve, and vibration isolators at each mounting location. Provide continuous duty NEMA rated, C-face, TEFC motor with 1.15 service factor, and maximum of 3500 RPM.]

- [c. Provide regenerative blower vacuum pumps consisting of one impeller, mounted directly on the motor shaft. Provide precision cast aluminum impeller with multiple radial blades at its periphery. The impeller shall be the only moving part, and shall not require any lubrication. Dynamically balance the impeller to provide vibration-free operation without the need for vibration isolators. The impeller shall be installed between the blower housing and cover. Provide housing and cover of cast aluminum and provided with multiple heat-dissipating fins. There shall be no metal-to-metal contact within the blower housing. Oil lubrication shall not be required providing oil free discharge gas. The heat-dissipating fins shall efficiently minimize heating of the compressed gas. Blower shall have a guaranteed ultimate vacuum of 11 inches Hg vacuum. Provide motor supported by outboard mounted, grease lubricated, anti-friction bearings. The bearings shall be located outside of the compression chamber to maximize operating efficiency and bearing life. Provide bearing housing conservatively loaded and rated for an L(10) life of not less than 200,000 hours. Shaft main bearings of the sleeve type with heavy duty bushings or rolling element type in accordance with ABMA 9 or ABMA 11. Provide a lip seal to minimize leakage where the motor shaft passes through the blower housing. Blower producing noise levels shall not exceed 75 dBA. Additional silencers may be installed to further reduce the noise level. Provide continuous duty NEMA rated, TEFC motor with 1.15 service factor, and maximum of 3600 RPM. Blower shall be direct driven. Provide blower manufactured in accordance with ISO 9001, and UL listed, CE compliant, DIN VDE 0530. Each pump shall include a check valve, inlet filter, flex connector, isolation valve and a relief valve mounted at the pump inlet. The vacuum pump control switches shall be control panel mounted and shall be set as follows:

Lead Pump	Continuous Operation
Lag Pump	Start 88 kPa 4 inches Hg vacuum
	Stop 81 kPa 6 inches Hg vacuum

-]
- [d. Provide oil-free, single-stage positive displacement, and non-pulsating recirculating water sealed liquid ring type pumps. The pumps shall be fitted with mechanical seals. The pump shall be of all iron

construction with a bronze or stainless rotor and carbon steel shaft. Under normal operation, system shall minimize fresh seal water required to 0.05 L/s 0.75 gpm. System shall include reservoir sufficient for up to 48 hours operation without fresh water supply. Each pump shall be equipped with a vacuum relief valve, check valve to prevent backflow through off-cycle units, flexible connector, isolation valve, and vibration isolators at each mounting location. System shall be totally self contained. Provide continuous duty NEMA rated, open dripproof motor with 1.15 service factor, and maximum of 1800 RPM.]

2.12.2 Vacuum Receiver

Provide receiver designed for 1034 kPa 150 psi minimum working pressure, factory air tested to 1.5 times the working pressure, meeting ASME BPVC SEC VIII D1. Provide receiver equipped with safety relief valves and accessories, including but not limited to vacuum gauge, sight glass, and automatic and manual drains. The outside of receiver shall be galvanized or supplied with factory applied commercial enamel finish. The interior of the receiver shall be a factory applied vinyl lining. Provide a display of the ASME seal on the receiver or a certified test report from an approved independent testing laboratory indicating conformance to the ASME Code. Provide receiver(s) with a three (3) valve bypass for servicing.

2.12.3 Control Panel

Provide UL 508A listed and labeled control panel in a NEMA 250 Type 12 enclosure. Provide Hand-Off-Auto switch for each vacuum pump for selection of normal operation (automatic alternation) or manual selection of lead and lag vacuum pump. Provide automatic alternation of vacuum pumps based on a first-on/first-off principle with provisions for simultaneous operation. The lag vacuum pump shall be able to start automatically if the lead vacuum pump fails to operate. Provide manual reset for thermal malfunction shutdown. All control and alarm functions shall remain energized while any vacuum pump in the system remains electrically online. Provide magnetic motor starters with integral overload and short circuit protection, with lockable disconnecting means. Provide running light and elapsed run-time meter for each vacuum pump. Provide circuit breakers with single point power feed connection. Provide 120 VAC control circuit transformers with fused primary and secondary. Provide vacuum control switches. Provide integral PLC controller for automatically switching operating sequence of vacuum pumps. Provide back-up circuit in case of PLC failure. Provide digital display interface. User interface shall display all alarm conditions, vacuum pump maintenance intervals, vacuum pump performance warnings, average system vacuum demand, vacuum pumps on/off status, system model number and serial number, and phone number to call for service. Provide audible and visual local alarms with silence button, remote alarm connections, and safety devices as required by NFPA 99. Local alarms shall have contacts to allow indication of a fault condition at the master alarm panel if one or more local alarms are activated. Provide the following alarms: Lag vacuum pump In Use.

] [2.13 INSTRUMENT COMPRESSED AIR (IA) SOURCE

NOTE: Instrument compressed air may be used in lieu of nitrogen as a support gas in medical and dental

facilities with prior approval by the using facility. If instrument compressed air is present in the facility, the source equipment can also supply the laboratory compressed air (LA) and/or the process compressed air (PA) systems. Pressure regulators are required.

- a. Provide complete factory-packaged, factory-tested, continuous-duty source(s). Each source shall contain air compressors, receiver, dryers, filters, control panel, source shutoff, compressor isolation valves and other components as indicated, required by NFPA 99, and necessary to provide complete performance. Each source shall require single-point connections to power wiring, warning system wiring, and piping system.
- b. Tank-mounted air compressors shall be manufactured to comply with UL listing requirements. Air compressors shall have manufacturer's name and address, together with trade name and catalog number, on a nameplate securely attached to the equipment. Provide guards to shield exposed moving parts. Provide an intake air filter and silencer with each compressor. Provide aftercooler and moisture separator installed between compressors and air receivers, to remove moisture before the air enters the receiver. Aftercoolers shall be air cooled. The air shall pass through a sufficient number of tubes to affect cooling. Tubes shall be sized to give maximum heat transfer. Cooling capacity of the aftercooler shall be sized for the total capacity of the compressors.

2.13.1 Air Compressors

Provide compressors with the scheduled capacity at a minimum of 1378 kPa 200 psi. Provide two stage, high pressure oil-lubricated continuous duty reciprocating type air compressors. A pressure gauge calibrated to 2068 kPa 300 psi, and equipped with a gauge cock and pulsation dampener shall be furnished for installation adjacent to the pressure switch. The motor and compressors shall be connected by V-belt drive. Compressors shall be sequenced to start automatically when the pressure drops to a preset point. Compressors shall be air cooled. Each compressor chamber shall have a high-temperature sensor to activate a local alarm. Provide continuous duty NEMA rated, C-face, open dripproof motor with 1.15 service factor, and maximum of 1800 RPM.

2.13.2 Control Panel

Provide UL 508A listed and labeled control panel in a NEMA 250 Type 12 enclosure. Provide Hand-Off-Auto switch for each compressor for selection of normal operation (automatic alternation) or manual selection of lead and lag compressors. Provide automatic alternation of compressors based on a first-on/first-off principle with provisions for simultaneous operation. The lag compressor shall be able to start automatically if the lead compressor fails to operate. Provide manual reset for thermal malfunction shutdown. All control and alarm functions shall remain energized while any compressor in the system remains electrically online. Provide magnetic motor starters with integral overload and short circuit protection, with lockable disconnecting means. Provide running light and elapsed run-time meter for each compressor. Provide circuit breakers with single point power feed connection. Provide 120 VAC control circuit transformers with fused primary and secondary. Provide pressure control

switches or pressure transducer. Provide integral PLC controller for automatically switching operating sequence of compressors. Provide back-up circuit in case of PLC failure. Provide digital display interface. User interface shall display all alarm conditions, pump maintenance intervals, compressor performance warnings, average system air demand, average dewpoint and CO levels on system, compressors on/off status, system model number and serial number, and phone number to call for service. Provide audible and visual local alarms with silence button, remote alarm connections, and safety devices as required by NFPA 99. Local alarms shall have contacts to allow indication of a fault condition at the master alarm panel if one or more local alarms are activated. Provide the following alarms:

- a. Lag compressor In Use.
- b. High discharge temperature.
- c. High carbon monoxide levels.
- d. High dewpoint level.

2.13.3 Air Receiver

Provide receiver designed for 1724 kPa 250 psi minimum working pressure, factory air tested to 1.5 times the working pressure, meeting ASME BPVC SEC VIII D1. Provide receiver equipped with safety relief valves and accessories, including but not limited to pressure gauge, sight glass, and automatic and manual drains. The outside of receiver shall be galvanized or supplied with factory applied commercial enamel finish. The interior of the receiver shall be a factory applied vinyl lining. A display of the ASME seal on the receiver or a certified test report from an approved independent testing laboratory indicating conformance to the ASME Code. Provide receiver(s) with a three (3) valve bypass for servicing.

2.13.4 Desiccant Air Dryers

Provide two identical twin-tower heatless desiccant air dryers. Provide dryers sized to achieve a pressure dewpoint -40 degrees C -40 degrees F at the maximum calculated NFPA system capacity. Provide lubricant free operation. Provide economizer cycle that reduces purge air requirements to match actual moisture loading. Provide solid-state cycle timer, OSHA purge exhaust mufflers, and a pressure gauge for each tower.

2.13.5 Filtration and Pressure Reducing Station

Provide two separators with zero loss drain valve, two pre-filters rated 0.01 micron filtration with an efficiency exceeding 99.9999 percent D.O.P. (Validated), two activated carbon filters, and two final filters rated 0.01 micron filtration with an efficiency exceeding 99.9999 percent D.O.P. (Validated) installed downstream of the carbon filters. Provide all filters with a differential pressure gauge with color change indicator and automatic drain valve except the activated carbon filters. Provide downstream of the final filters with a dual-line pressure regulating assembly consisting of two pressure regulators with pressure gauges, inlet and outlet isolation ball valves, and pressure relief valves. All filters/pressure regulators shall be arranged so that the isolation of one filter/ regulator will not affect the operation of the second filter/regulator.

2.13.6 Dew Point Monitor

Provide dew point monitor to continuously monitor the dew point of the instrument compressed air. Provide ceramic type (aluminum oxide type is not acceptable) sensor with system accuracy of +/- 1 degree C 2 degrees F. The dew point alarm shall be factory set at -30 degrees C -22 degrees F and be field adjustable. Provide activation of local alarm and all master alarms when the dew point at system pressure exceeds + -30 degrees C -22 degrees F. Provide activation of monitor's signal at all master alarm panels if the monitor loses power. Monitor shall meet requirements of NFPA 99.

][2.14 LAB COMPRESSED AIR (LA) [AND PROCESS COMPRESSED AIR (PA)] SOURCE

- a. Provide complete factory-packaged, factory-tested, continuous-duty source(s). Each source shall contain air compressors, receiver, dryers, filters, control panel, source shutoff, compressor isolation valves and other components required by NFPA 99, and necessary to provide complete performance. Each source shall require single-point connections to power wiring, warning system wiring, and piping system.
- b. Tank-mounted air compressors shall be manufactured to comply with UL listing requirements. Air compressors shall have manufacturer's name and address, together with trade name and catalog number, on a nameplate securely attached to the equipment. Provide guards to shield exposed moving parts. Provide an intake air filter and silencer with each compressor. Provide aftercooler and moisture separator between compressors and air receivers, to remove moisture before the air enters the receiver. Aftercoolers shall be air cooled. The air shall pass through a sufficient number of tubes to affect cooling. Tubes shall be sized to give maximum heat transfer. Cooling capacity of the aftercooler shall be sized for the total capacity of the compressors.

2.14.1 Air Compressors

Provide [scroll type compressors] [reciprocating teflon-ring type compressors designed such that no oil is administered to the air cylinder, the portion of the piston rod that travels in the crankcase section does not travel in any portion of the air-cylinder section, and with provision to prevent the flow of lubrication oil along the piston rod into the air-cylinder section]. Provide a pressure gauge calibrated to 2068 kPa 300 psi, and equipped with a gauge cock and pulsation dampener for installation adjacent to the pressure switch. The motor and compressors shall be directly connected or operated by V-belt drive. Compressors shall be sequenced to start automatically when the pressure drops to a preset point. Compressors shall be air cooled. Provide each compressor chamber with a high-temperature sensor to activate a local alarm. Provide continuous duty NEMA rated, open dripproof motor with 1.15 service factor, and maximum of 3600 RPM.

2.14.2 Air Receiver

Provide air receiver delivering air to dental operatories designed for 1034 kPa 150 psi working pressure, factory air tested to 1.5 times the working pressure, meeting ASME BPVC SEC VIII D1. Provide receiver equipped with safety relief valves and accessories, including but not limited to pressure gauge, sight glass, and automatic and manual drains.

The outside of receiver shall be galvanized or supplied with factory applied commercial enamel finish. The interior of the receiver shall be a factory applied vinyl lining. Provide a display of the ASME seal on the receiver, or a certified test report from an approved independent testing laboratory indicating conformance to the ASME Code. Provide receiver(s) with a three (3) valve bypass for servicing.

2.14.3 Control Panel

Provide **UL 508A** listed and labeled control panel in a **NEMA 250** Type 12 enclosure. Provide Hand-Off-Auto switch for each compressor for selection of normal operation (automatic alternation) or manual selection of lead and lag compressors. Provide automatic alternation of compressors based on a first-on/first-off principle with provisions for simultaneous operation. The lag compressor shall be able to start automatically if the lead compressor fails to operate. Provide manual reset for thermal malfunction shutdown. All control and alarm functions shall remain energized while any compressor in the system remains electrically online. Provide magnetic motor starters with integral overload and short circuit protection, with lockable disconnecting means. Provide running light and elapsed run-time meter for each compressor. Provide circuit breakers with single point power feed connection. Provide 120 VAC control circuit transformers with fused primary and secondary. Provide pressure control switches or pressure transducer. Provide integral PLC controller for automatically switching operating sequence of compressors. Provide back-up circuit in case of PLC failure. Provide digital display interface. User interface shall display all alarm conditions, pump maintenance intervals, compressor performance warnings, average system air demand, average dewpoint and CO levels on system, compressors on/off status, system model number and serial number, and phone number to call for service. Provide audible and visual local alarms with silence button, remote alarm connections, and safety devices as required by **NFPA 99**. Local alarms shall have contacts to allow indication of a fault condition at the master alarm panel if one or more local alarms are activated. Provide the following alarms:

- a. Lag compressor In Use.
- b. High discharge temperature.

2.14.4 Desiccant Air Dryers

Provide two identical twin-tower heatless desiccant air dryers. Provide dryers to achieve a pressure dewpoint **-40 degrees C -40 degrees F** at the maximum calculated NFPA system capacity. Provide lubricant free operation. Provide economizer cycle that reduces purge air requirements to match actual moisture loading. Provide solid-state cycle timer, OSHA purge exhaust mufflers, and a pressure gauge for each tower.

2.14.5 Filtration and Pressure Reducing Station

Provide two pre-filters rated 0.01 micron filtration with an efficiency of 99.9999 percent D.O.P. (Validated), two activated carbon filters, and two 1 micron final filters with an efficiency 99.9999 percent D.O.P. (Validated) installed downstream of the carbon filters. Filters without validation shall not be used except the activated carbon filters. Provide all filters with a differential pressure gauge with color change indicator and automatic drain valve except the activated carbon filters. Provide downstream of the final filters a dual-line pressure regulating assembly

consisting of two pressure regulators with pressure gauges, inlet and outlet isolation ball valves, and pressure relief valves. All filters/pressure regulators shall be arranged so that the isolation of one filter/ regulator will not affect the operation of the second filter/regulator.

2.14.6 Dew Point Monitor

Provide dew point monitor to continuously monitor the dew point of the laboratory compressed air. Provide ceramic type (aluminum oxide type is not acceptable) sensor with system accuracy of +/- 1 degree C 2 degrees F. The dew point alarm shall be factory set at 2 degrees C 36 degrees F and be field adjustable. Provide activation of local alarm and all master alarms when the dew point at system pressure exceeds + 4 degrees C 39 degrees F. Provide activation of monitor's signal at all master alarm panels if the monitor loses power. Monitor shall meet requirements of NFPA 99.

]2.15 PIPE AND FITTINGS

2.15.1 Service Entrance

Piping at service entrance (from 300 mm 12 inches inside building to 1500 mm 5 feet outside): Same as Indicated for outside utilities.

2.15.2 Positive pressure piping systems up to 1379 kPa 200 psi

NOTE: The following applies to dental/medical
compressed air, instrument compressed air,
laboratory compressed air, process compressed air,
oxygen, nitrogen, nitrous oxide, carbon dioxide.

Hard-drawn seamless copper tubing (ASTM B819), Type K or L, bearing one of the following markings, OXY, MED, OXY/MED, and brazed solder-type wrought copper fittings (ASME B16.22), or brazed fittings (ASME B16.50) cleaned for oxygen service by the manufacturer in accordance with Pamphlet CGA G-4.1. Cast fittings shall not be used. Minimum size shall be 15 mm 1/2 inch. Install branch piping full size to each terminal device, including vertical drops, and provide reducer fitting at the device pigtail. Type L tubing is not acceptable for installation below grade. Provide with NF nitrogen purge and capped/plugged ends until prepared for installation. Tubing joining material shall be ANSI/AWS-BCuP series filler material.

2.15.3 [Dental surgical] [Medical-Surgical] [WAGD] vacuum piping systems up to 34 kPa 20 inches Hg vacuum

NOTE: The following applies to dental/medical
vacuum, WAGD.

Hard-drawn seamless copper tubing (ASTM B819), Type K or L, and solder-type wrought copper fittings (ASME B16.22) or brazed fittings (ASME B16.50). Cast fittings shall not be used. Minimum size shall be 20 mm 3/4 inch. Install branch piping full size to each terminal device, including vertical drops, and provide reducer fitting at the device

pigtail. Tubing joining material shall be ANSI/AWS-BCuP series filler material. Nitrogen purge not required. Labeled or otherwise identified prior to installation in order to preclude inadvertent inclusion into the pressurized systems. Labeling is not required if installation meets all requirements for pressurized piping including prohibition of flux on copper-to-copper joints and the use of a NF nitrogen purge during brazing.

2.15.4 Dental Oral Evacuation System

Provide polyvinyl chloride (PVC) drainage, waste and vent (DWV) pipe and fittings conforming to ASTM D2665. Solvent cement for PVC pipe fittings shall conform to ASTM D2564. Fittings, supports, and joint assembly shall comply with ICC IPC. Fittings shall be the long-radius type for turns and the wye type for branches. The most distant end of each trunk line from the separators may terminate with a vacuum relief valve.

2.15.5 High-Volume Laboratory Dust Evacuation System

Provide polyvinyl chloride (PVC) drainage, waste and vent (DWV) pipe and fittings conforming to ASTM D2665. Solvent cement for PVC pipe fittings shall conform to ASTM D2564. Fittings, supports and joint assembly shall comply with ICC IPC. The assembled piping system shall be suitable for 84 kPa 5 inches Hg vacuum. Fittings shall be the long-radius type for turns and the wye type for branches. The most distant end of the main trunk line from the central filter-separator may terminate with an air volume relief valve.

2.15.6 Compressed Air Intake and Vacuum Pump Exhaust Line(s)

Hard-drawn seamless copper tubing (ASTM B88 or ASTM B819), Type K or L, and solder-type wrought copper fittings (ASME B16.22). Cast fittings shall not be used. Tubing joining material shall be ANSI/AWS-BCuP series filler material.

2.16 VALVES AND ASSEMBLIES

2.16.1 Valves

- a. Positive pressure piping systems up to 1379 kPa 200 psi: Bronze, full port, quarter-turn ball type, three piece construction, 4137 kPa 600 psi WOG, blow-out proof stem, in-line repairable. Cleaned for oxygen service by manufacturer in accordance with Pamphlet CGA G-4.1. All sizes: 316 stainless steel ball and stem, glass reinforced polytetrafluoroethylene (RPTFE) seat seals and packings. Clean, cap and deliver to site in sealed package bearing manufacturer's identifying tag or stamp. Keep sealed until prepared for installation. Provide with valve manufacturer installed brazed Type K copper tube extensions a minimum of 150 mm 6 inch long on the inlet and outlet side of the valve for making connection to the pipeline(s). A purge port shall be provided on both the inlet and outlet tube extensions. Valves in locations other than zone valve boxes shall be lockable.
- b. Vacuum piping systems up to 34 kPa 20 inches Hg vacuum: Bronze full port, quarter-turn ball type, three piece construction, 3 kPa 29 inches Hg vacuum, blow out proof stem, in-line repairable. All sizes: 316 stainless steel ball and stem, glass reinforced polytetrafluoroethylene (RPTFE) seat seals and packings. Provide with valve manufacturer installed brazed Type K copper tube extensions a

minimum of 150 mm 6 inch long on the inlet and outlet side of the valve for making connection to the pipeline(s). A purge port shall be provided on both the inlet and outlet tube extensions. Valves in locations other than zone valve boxes shall be lockable.

2.16.2 Zone Valve Assemblies

NOTE: Coordinate stud depth with architects.
Provide minimum 6 inch 150 mm stud to allow for
varying box depths.

- a. Recessed wall box, minimum 1.2 mm 18 GA sheet steel, baked enamel finish. Stainless steel or chrome front trim. Transparent plastic door with pull handle or ring for emergency access to valves. Service access to valves shall be by removal and replacement of door, which shall neither cause damage nor require special tools. Opaque plastic is not acceptable. Openings to box interior shall be dust-tight. Provide each shutoff valve with pressure gauge and integral extension tubes for joining to piping system outside of box. Provide gauge port on each tubing extension. Valves shall not be lockable.
- b. Up to 5 shutoff valves of 25 mm 1 inch size or smaller may be installed in one box. Use single-valve boxes for 32 mm 1-1/4 inch valves and larger. Front trim with interlocking edges where single-valve boxes are jointed together for multiple valve installations. Provide custom-made boxes as specified above for those valves that are too large for pre-manufactured boxes.
- c. Surface mounted wall box, same as recess mounted except provide with exposed surface finish primed for field painting and provide only where surface mounting is specifically indicated on drawings.
- d. Arrange shutoff valves in following order from top to bottom: Oxygen, nitrous oxide, carbon dioxide, dental compressed air, medical compressed air, nitrogen, WAGD, dental surgical vacuum, and medical-surgical vacuum. If 2 or more valves for same service are located in common box, larger of valves shall be lower.

2.17 NITROGEN AND INSTRUMENT COMPRESSED AIR CONTROL PANELS

Nitrogen and instrument compressed air control panels shall be designed to deliver variable pressures to power pneumatic surgical tools. The control panel shall be provided with a 0-2070 kPa 0-300 psi pressure gauge, shutoff valve, pressure regulator, delivery pressure gauge and DISS outlet. A quarter turn of the valve handle shall be required to obtain a fully "open" or "closed" position. Provide an adjustable self relieving type pressure regulator, with a operating range of 70 to 1725 kPa 10 to 250 psi. Control panels shall be pre-piped internally requiring only external supply line connections. Additional outlets in the same room may be connected to the remote outlet pigtail furnished in the control panel. Remote outlets shall be regulated by the adjustable pressure regulator within the panel and shall match the nitrogen control panel outlet type. Control panels shall be available in horizontal or vertical orientation.

2.18 HANGERS AND SUPPORTS

Pipe hangers and supports shall be copper plated when in direct contact

with copper tubing. Tubing installed on trapeze hanger shall be secured in place with appropriately sized clamp and be fully isolated from dissimilar metals.

2.19 GAUGES

- a. Provide for line pressure use adjacent to source equipment, ASME B40.100 pressure gauges, 115 mm 4 1/2 inches in diameter with metal case for oxygen, nitrous oxide, carbon dioxide, dental compressed air, medical compressed air, laboratory compressed air, process compressed air, and nitrogen, accurate to within two percent. Range shall be two times operating pressure. Dial graduations and figures shall be black on a white background, or white on a black background. Gauges shall be expressly made for and cleaned for oxygen use, labeled for appropriate service, and marked "USE NO OIL". Provide bourdon tube and brass movement. Install with gauge cock. Gauges for all services downstream of main shutoff valve shall be same as those adjacent to source equipment except diameter may be reduced to 40 mm 1-1/2 inches. Dial ranges shall be 0 to 690 kPa 0 to 100 psi for pressurized gases and compressed air services except nitrogen and instrument compressed air; 0 to 2070 kPa 0 to 300 psi for nitrogen and instrument compressed air.
- b. Provide for vacuum line use adjacent to source equipment, ASME B40.100 vacuum compound gauges, 115 mm 4 1/2 inches in diameter with metal case for dental surgical vacuum, medical-surgical vacuum, dental oral evacuation, WAGD, and laboratory dust evacuation, accurate to within two percent. Dial graduations and figures shall be black on a white background, or white on a black background. Label for vacuum service. Provide with bourdon tube and brass movement. Install with gauge cock. Gauges for all services upstream of main shutoff valve shall be same as those adjacent to source except diameter may be reduced to 40 mm 1 1/2 inches. Dial range shall be 100 to 0 kPa 0 to 30 inches Hg vacuum.

2.20 DENTAL GAS AND SUPPORT SYSTEMS OUTLETS AND VACUUM SYSTEMS INLETS

2.20.1 Station Outlets/Inlets

NOTE: The type of connectors at station outlets will be as specified by the using service. This is required to ensure that the connectors provided are compatible with those on Government-furnished mobile apparatus. Unless otherwise required by the using facility, outlets/inlets shall be DISS type.

Submit proof that outlets/inlets, as an assembly, are listed by Underwriters Laboratories, Inc., and are manufactured in accordance with applicable NFPA 99 and CGA standards. Provide station outlets/inlets (Oxygen, Nitrogen, Nitrous Oxide, Dental Surgical Vacuum, WAGD, Instrument Compressed Air) conforming to NFPA 99. Provide station outlets/inlets for concealed piping made of brass and having an adjustable valve mechanism to compensate for variation in wall thickness. Each unit shall be securely mounted and self-sealing. Each unit as an assembly shall conform to the requirements of the Underwriters Laboratories Inc.; submit proof of such conformance. The label or listing of the specified agency will be acceptable evidence. In lieu of the label or listing, the Contractor may

submit a written certificate from any approved nationally recognized testing organization adequately equipped and competent to perform such services, including the follow-up service, stating that the item has been tested and conforms to the requirements, including method of testing, of the specified agency. Station outlets/inlets shall be equipped with threaded DISS connector per CGA standards [noninterchangeable quick disconnect coupler, except for nitrogen which shall be equipped with DISS connections as assigned for gas and vacuum systems in CGA V-5, except that inlets for the WAGD system shall be 22 mm 7/8 inch nonthreaded connections]. DISS outlets shall be used for all dental vacuum and ceiling mount applications. Provide recessed wall type outlets/inlets unless specified otherwise. Station outlets shall be cleaned for oxygen service in accordance with Pamphlet CGA G-4.1 and the assembly shall be capped and the finished assembly poly bagged for shipment.

[2.20.1.1 Couplers

Where quick-disconnect couplers are furnished they shall be of the noninterchangeable type. Connector shall lock firmly into position and shall have a finger-type quick release.

]2.20.1.2 Faceplates

Faceplates shall be polished chromium-plated metal or satin-finish stainless steel secured with chromium-plated countersunk screws. Provide service identification either cast into, or permanently etched by the manufacturer into each faceplate.

2.20.1.3 Rough-In Assembly

The rough in assembly shall be of modular design and include a gas specific 16 gauge steel mounting plate designed to permit on-site ganging of multiple outlets, on 125 mm 5 inch center line spacing. A machined brass outlet block shall be permanently attached to the mounting bracket to permit the 13 mm 1/2 inch OD, type-K copper inlet to swivel 360 degrees for attachment to the piping system. The rough in assembly shall contain a double seal to prevent gas leakage between the rough in and latch-valve assemblies after the wall is finished. A single o-ring seal shall not be acceptable. The latch-valve assembly shall telescope up to 19 mm 3/4 inches to allow for variation in finished wall thickness from 13 to 32 mm 1/2 to 1-1/4 inches.

2.20.1.4 Ceiling Applications/Hose Assemblies

Provide hose assemblies for all ceiling outlets for the finished ceiling height as indicated on drawings. Provide each hose with a heavy-duty chain type dual retractor for pressure gases and for vacuum. Retractions made of stainless cable are not acceptable. Allow an extra 450 mm 18 inches of hose length for retractors.

2.20.1.5 Vacuum Slides

Provide one vacuum slide of the same manufacturer of the vacuum inlet for each vacuum inlet. Coordinate location with room elevations.

2.20.2 Dental Compressed Air Outlets

Provide dental compressed air outlets as follows:

- a. Provide dental treatment rooms (DTR) with a 13 mm 1/2 inch service pipe terminated with a 13 x 10 mm 1/2 x 3/8 inch compression angle stop valve.
- b. Dental laboratory. Provide each of the following, and coordinate locations with the laboratory casework supplier.
 - (1) 13 mm 1/2 inch service pipe terminated with a ball valve.
 - (2) 13 mm 1/2 inch service pipe terminated with a needle valve.
 - (3) 13 mm 1/2 inch service pipe terminated with a quick disconnect brass body coupler and sleeve, 10 mm 3/8 inch NPT, 2070 kPa 300 psi maximum pressure rating, Buna-N seals, and complying with the dimensional requirements of military specification MIL-C-4109.
- c. Provide dental instrument processing center with a 16 mm 5/8 inch OD service pipe terminated with a quick disconnect brass body coupler and sleeve, 10 mm 3/8 inch NPT, 2070 kPa 300 psi maximum pressure rating, Buna-N seals, and complying with the dimensional requirements of military specification MIL-C-4109.

2.20.3 Dental Oral Evacuation Inlets (Dental Treatment Room)

Provide dental treatment rooms (DTR) with a 13 mm 1/2 inch service pipe terminated 50 mm 2 inches above bottom of floor box or above finished floor. Cover pipe end to prevent entrance of debris. Prepare end for continuation of service by another Division.

2.21 MEDICAL GAS AND SUPPORT SYSTEMS OUTLETS AND VACUUM SYSTEMS INLETS

2.21.1 Station Outlets/Inlets

 NOTE: The type of connectors at station outlets will be as specified by the using service. This is required to ensure that the connectors provided are compatible with those on Government-furnished mobile apparatus. Unless otherwise required by the using facility, outlets/inlets shall be DISS type.

Provide station outlets/inlets (Oxygen, Nitrogen, Nitrous Oxide, Carbon Dioxide, Medical Compressed Air, Medical-Surgical Vacuum, WAGD, Instrument Compressed Air) conforming to NFPA 99. Provide station outlets/inlets for concealed piping made of brass and having an adjustable valve mechanism to compensate for variation in wall thickness. Each unit shall be securely mounted and self-sealing. Each unit as an assembly shall conform to the requirements of the Underwriters Laboratories Inc.; submit proof of such conformance. The label or listing of the specified agency will be acceptable evidence. In lieu of the label or listing, the Contractor may submit a written certificate from any approved nationally recognized testing organization adequately equipped and competent to perform such services, including the follow-up service, stating that the item has been tested and conforms to the requirements, including method of testing, of the specified agency. Station outlets/inlets shall be equipped with threaded DISS connector per CGA standards [noninterchangeable quick disconnect coupler, except for nitrogen which shall be equipped with DISS connections as assigned for gas and vacuum systems in CGA V-5, except that

inlets for the WAGD system shall be 22 mm 7/8 inch nonthreaded connections]. DISS outlets shall be used for all ceiling mount applications. Provide recessed wall type outlets/inlets unless specified otherwise. Station outlets shall be cleaned for oxygen service in accordance with Pamphlet CGA G-4.1 and the assembly shall be capped and the finished assembly poly bagged for shipment.

[2.21.1.1 Couplers

Where quick-disconnect couplers are furnished they shall be of the noninterchangeable type. Connector shall lock firmly into position and shall have a finger-type quick release.

]2.21.1.2 Faceplates

Faceplates shall be polished chromium-plated metal or satin-finish stainless steel secured with chromium-plated countersunk screws. Provide service identification either cast into, or permanently etched by the manufacturer in to each faceplate.

2.21.1.3 Rough-In Assembly

The rough in assembly shall be of modular design and include a gas specific 16 gauge steel mounting plate designed to permit on-site ganging of multiple outlets, on 125 mm 5 inch center line spacing. A machined brass outlet block shall be permanently attached to the mounting bracket to permit the 13 mm 1/2 inch OD, type-K copper inlet to swivel 360 degrees for attachment to the piping system. The rough in assembly shall contain a double seal to prevent gas leakage between the rough in and latch-valve assemblies after the wall is finished. A single o-ring seal shall not be acceptable. The latch-valve assembly shall telescope up to 19 mm 3/4 inches to allow for variation in finished wall thickness from 13 to 32 mm 1/2 to 1-1/4 inches.

2.21.1.4 Ceiling Applications/Hose Assemblies

Provide hose assemblies for all ceiling outlets for the finished ceiling height as indicated on drawings. Provide each hose with a heavy-duty chain type dual retractor for pressure gases and for vacuum. Retractions made of stainless cable are not acceptable. Allow an extra 450 mm 18 inches of hose length for retractors.

2.21.1.5 Vacuum Slides

Provide one vacuum slide of the same manufacturer of the vacuum inlet for each vacuum inlet. Coordinate location with room elevations.

2.22 LABORATORY COMPRESSED AIR [AND PROCESS COMPRESSED AIR] TERMINATION

Provide 13 mm 1/2 inch tube at each location and terminate 100 mm 4 inches from finished face of wall/partition with 13 mm 1/2 inch ball valve and 150 mm 6 inch long capped extension.

2.23 WARNING SYSTEMS

NOTE: Coordinate alarm panel locations and power
requirements with Division 26.

Alarm panels for gas and vacuum systems shall be located as specified and indicated. Each signal and gauge shall be appropriately labeled "OPERATING" and "EMERGENCY." Each gauge and device shall be clearly identified by means of engraved plastic nameplates. Alarms and pressure gauges shall be provided for each pressurized system. Alarms and vacuum gauges shall be provided for each vacuum, WAGD, and oral evacuation system. Signal systems shall be energized by the normal and emergency power systems.

2.23.1 Master Alarm Panels

NOTE: Coordinate locations with using facility.
Recommended locations include emergency room,
central information desk, and a connection to the
UMCS (UFGS 23 09 00) as determined by the project.

a. Master alarm panel features:

- (1) Provide recessed panel, complete with all necessary displays, factory wiring, transformers, and circuitry requiring only [115] [230] VAC 60 Hz primary power connected to the Life Safety branch. Provide with metallic back (rough-in) box. Provide panel that is compliant with NFPA 99 and UL Listed as an assembly.
- (2) Provide one green Light Emitting Diode (LED) indicating that the panel is powered and operating normally, and one red LED indicating a fault in the panel power and/or microprocessor has been detected. The red LED shall not be able to be reset until the fault has been repaired, and then the red LED shall automatically reset to green. Muting of the audible alarm in "Abnormal" status shall not cancel illumination of the red LED. Only correction of the abnormal condition shall allow resetting of the LED to green.
- (3) Provide each individual signal with one green and one red LED. Provide illuminated green LED for "Normal" status. Provide illuminated red LED for "Abnormal" status. Muting of the audible alarm in "Abnormal" status shall not cancel illumination of the red LED. Only correction of the abnormal condition shall allow resetting of the LED to green.
- (4) Provide audible alarm upon actuation of any abnormal condition. Provide audible signal producing a minimum sound pressure level of 80 dBA measured at a distance of 1 meter 3 feet. The audible alarm shall be provided with a reset relay to shut off only the audible alarm and not affect the illuminated "Abnormal" LED, until the condition is corrected. The audible alarm shall sound again upon actuation of any additional abnormal condition.
- (5) Provide back (rough-in) box factory configured for internal sensor mounting. Provide gas specific sensors for periodic testing without interrupting pipeline pressures or vacuum. External sensors, when applicable, shall be designed to function up to 1524 m 5,000 feet from the alarm panel.
- (6) Provide front panel TEST button to initiate a self-test function

to test the LED indicators, visual displays, audible alarm, and to view alarm set points.

- (7) Provide contacts for connecting to UMCS (UFGS 23 09 00). Alarms requiring installation of additional circuit boards for PC-based monitoring are not acceptable.

b. Provide alarm points based on installed systems:

- (1) Oxygen Liquid (Main Supply) Less Than One Day [Notify [____]]
- (2) Oxygen Changeover to Secondary Supply [Notify [____]]
- (3) Oxygen Reserve in Use [Notify [____]]
- (4) Oxygen Reserve Supply Less Than One Day [Notify [____]]
- (5) Oxygen Reserve Pressure Low [Notify [____]]
- (6) Oxygen Main Line Pressure High/Low
- (7) Nitrous Oxide Main Supply Less Than One Day [Notify [____]]
- (8) Nitrous Oxide Changeover to Secondary Supply [Notify [____]]
- (9) Nitrous Oxide Reserve in Use [Notify [____]]
- (10) Nitrous Oxide Reserve Supply Less Than One Day [Notify [____]]
- (11) Nitrous Oxide Reserve Pressure Low [Notify [____]]
- (12) Nitrous Oxide Main Line Pressure High/Low
- (13) Nitrogen Changeover to Secondary Supply [Notify [____]]
- (14) Nitrogen Main Line Pressure High/Low
- [(15) Carbon Dioxide Changeover to Secondary Supply [Notify [____]]]
- [(16) Carbon Dioxide Main Line Pressure High/Low]
- (17) Medical Compressed Air Main Line Pressure High/Low
- (18) Medical Compressed Air Dew Point High

NOTE: Use following only if medical compressed air
is provided by cylinder manifold.

- [(19) Medical Compressed Air Changeover to Secondary Supply [Notify [____]]]
- (20) Medical-Surgical Vacuum Main Line Vacuum Low
- (21) WAGD Main Line Vacuum Low
- (22) Instrument Compressed Air Main Line Pressure High/Low

(23) Instrument Compressed Air Dew Point High

**NOTE: Use following only if instrument compressed
air is provided by cylinder manifold.**

[(24) Instrument Compressed Air Cylinder Reserve in Use [Notify [____]]
]

[(25) Instrument Compressed Air Cylinder Reserve Less Than One Hour
Supply [Notify [____]]]

(26) Dental Compressed Air Main Line Pressure High/Low

(27) Dental Surgical Vacuum Main Line Vacuum Low

(28) Dental Oral Evacuation Vacuum Low

(29) Medical Compressed Air Compressor(s) Local Alarm

(30) Instrument Compressed Air Compressor(s) Local Alarm

(31) Medical-Surgical Vacuum Pump(s) Local Alarm

(32) WAGD Vacuum Pump(s) Local Alarm

2.23.2 Area Alarm Panels

**NOTE: Alarm panels are only required in areas
designated in NFPA 99 unless otherwise required by
using facility.**

a. Area alarm panel features:

- (1) Provide recessed panel, complete with all necessary displays, factory wiring, transformers, and circuitry requiring only [115] [230] VAC 60 Hz primary power connected to the Life Safety branch. Provide with metallic back (rough-in) box. Provide panel that is compliant with NFPA 99 and UL Listed as an assembly.
- (2) Provide one green Light Emitting Diode (LED) indicating that the panel is powered and operating normally.
- (3) Provide each individual signal with one green and one red LED. Provide illuminated green LED for "Normal" status. Provide illuminated red LED for "Abnormal" status. Muting of the audible alarm in "Abnormal" status shall not cancel illumination of the red LED. Only correction of the abnormal condition shall allow resetting of the LED to green.
- (4) Provide audible alarm upon actuation of any abnormal condition. Provide audible signal producing a minimum sound pressure level of 80 dBA measured at a distance of 1 meter 3 feet. The audible alarm shall be provided with a reset relay to shut off only the audible alarm and not affect the illuminated "Abnormal" LED, until the condition is corrected. The audible alarm shall sound again

upon actuation of any additional abnormal condition.

- (5) Provide back (rough-in) box factory configured for internal sensor mounting. Provide gas specific sensors for periodic testing without interrupting pipeline pressures or vacuum. External sensors are not permitted.
- (6) Provide front panel TEST button to initiate a self-test function to test the LED indicators, visual displays, audible alarm, and to view alarm set points.
- [(7) Alarm panels shall be provided in each nursing unit on a wing/ward basis as indicated, but these panels shall not include nitrous oxide, nitrogen, nor WAGD and oral evacuation vacuum alarms, unless specifically indicated.]

b. Provide alarm points based on installed systems:

- (1) High/Low Line Pressure (for each positive pressure system piped to the area). Actuation when the pressure in the line being monitored reaches approximately 20 percent above or below normal operating pressure.
- (2) Low Line Vacuum (for each vacuum system piped to the area). Medical-surgical alarm shall be actuated when the vacuum in the line being monitored reaches 60 kPa 12 inches Hg vacuum. [WAGD and oral evacuation alarm[s] shall be actuated when the vacuum in the line being monitored reaches 80 kPa 6 inches Hg vacuum].

2.23.3 Local Alarm Panels

a. Provide alarm points based on installed systems:

**NOTE: Use following for oil-less and oil-free
medical compressed air sources.**

- (1) Medical Compressed Air Source Backup (Lag) Compressor Operating
- (2) Medical Compressed Air Source Carbon Monoxide High
- (3) Medical Compressed Air Source High Discharge Air Temperature
- (4) Medical Compressed Air Source High Water in Receiver
- (5) Medical Compressed Air Source Dew Point High

**NOTE: Use following for instrument compressed air
sources.**

- (6) Instrument Compressed Air Source Backup (Lag) Compressor Operating
- (7) Instrument Compressed Air Source Dew Point High

NOTE: Use following for medical-surgical vacuum

sources.

(8) Medical-Surgical Vacuum Source Backup (Lag) Vacuum Pump Operating

NOTE: Use following for WAGD vacuum sources.

(9) WAGD Vacuum Source Backup (Lag) Vacuum Pump Operating

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

[3.2 BULK LIQUID OXYGEN SOURCE

NOTE: Include only if bulk liquid oxygen source exists.

Bulk liquid oxygen source: Connect oxygen gas supply line to bulk storage facility in accordance with the Regulatory Requirements.

]3.3 EMERGENCY OXYGEN SUPPLY CONNECTION

NOTE: Delete if no emergency oxygen supply connection exists.

Pipe relief valve discharge to exterior of building.

]3.4 CYLINDER MANIFOLD SUPPLY SOURCE

- a. Provide complete set of full primary and secondary cylinders after successful completion of final tests. Coordinate source of cylinders with Owner.
- b. Pipe system relief discharges to exterior of building.
- c. Provide check valve between each cylinder head and the manifold header. Each header shall be connected to the manifold controls with shutoff valves. The relief valve shall be vented to the outside atmosphere if the total capacity of the system is more than 57 cubic meters 2,000 cubic feet of gas. Venting shall be accomplished by piping the relief valve to the outside atmosphere or by approved ductwork having a minimum opening of 0.047 square meters 72 square inches. The manifold shall be installed according to the manufacturer's recommendation and as required by NFPA 99.

3.5 COMPRESSED AIR AND VACUUM SOURCES

Installation shall be in accordance with manufacturer's instructions and

recommendations. Align compressor and vacuum pump couplings in accordance with manufacturers' specifications. Provide factory service representative to supervise installation and to set pressure and vacuum switches. System start-up shall be performed by factory trained personnel and documented.

3.5.1 Central Dry Separator for High-Volume Laboratory Dust Evacuation

Locate the separator so that the lower canister can be removed easily and cleaned. The separator shall be equipped with a cut-off valve to permit shutdown when the system is not in use.

3.5.2 Amalgam Separator for Dental Oral Evacuation

Amalgam separator shall be installed between the treatment rooms and the central wet separator in a location that is accessible from a standing position adjacent to the separator.

3.6 PIPING SYSTEMS

- a. Piping shall be cleaned, tested, and installed as specified in NFPA 99.
- b. Provide Nitrogen NF gas purge to prevent oxide formation inside the copper tubing when brazing joints. Joints shall be made with BCuP series brazing alloy, except as permitted otherwise by NFPA 99. Brazing alloy shall fully penetrate joints.
- c. Make up threaded joints, as permitted by NFPA 99, with polytetrafluoroethylene tape, or other thread sealant approved for oxygen service. Thread sealant shall be applied to male threads only.
- d. Install pipe lines where they will not be subject to physical damage.
- e. Install branch piping full size to each outlet/inlet, including vertical drops. Provide reducer at the outlet/inlet pigtail connection.
- f. Provide protection of underground piping against frost, corrosion, and physical damage by installing piping in nonmetallic ducts or casings. Encase underground piping passing beneath load bearing surfaces and traffic areas in split PVC pipe sized to accommodate piping. Secure split PVC piping with galvanized steel draw bands. Support at regular intervals by insulating spacers providing complete circumferential clearance.
- g. Install piping intended to contain cryogenic liquids such that the liquid does not come in contact with concrete in the event of a leak.
- h. Piping shall be connected near the top of receivers.
- i. Compressed air intake pipe, and vacuum pump exhaust pipe shall be extended to the outside of the building and their end turned down and screened against insects.
- j. Provide vibration-absorbing couplings between the compressed air and vacuum source(s) and the system pipeline, and the compressed air and vacuum sources and the intake air/vacuum pump exhaust piping.
- k. Provide laboratory and process air piping system(s) separate from the

dental and medical compressed air system(s).

- l. Dental oral evacuation system piping shall be installed with a minimum slope of 7 mm per 3.05 m 1/4 inch per 10 feet from the DTR utility box to the separator tanks.
- m. Provide pipelines with appropriate system labeling conforming to NFPA 99.

3.7 STATION OUTLETS/INLETS

3.7.1 Wall Outlets/Inlets

Wall outlets/inlets shall be located 1.5 m 60 inches from finished floor or as indicated. Back boxes shall be permanently stamped with the gas or vacuum service identification and shall be safety-keyed to accept only the appropriate gas or vacuum faceplate.

3.7.2 DISS Connections

Where threaded connections are furnished, DISS connections as described in CGA V-5 shall be used to provide noninterchangeable connections. In order to facilitate connection making, the threads of the connection shall engage before the check valve is depressed and pressure is allowed to enter the attached fitting. No leakage shall occur when threads are fingertight.

3.7.3 Height of Hose-reel Type Outlets/Inlets

Termination shall be a minimum of 2 m 80 inches above the finished floor.

3.8 VALVES AND ASSEMBLIES

Valve cabinets shall be recess mounted on the corridor side of the partition. Cabinets shall house alarm system sensors and zone control valves. The valves shall be installed in the cabinet 1.5 m 5 feet above the floor at the center line of the box and shall provide complete shutoff of each of the piped services. Provide valves and exposed piping connecting the valves with appropriate system labeling conforming to NFPA 99. Valves and exposed piping connecting the valves shall be labeled or identified in an approved manner with colors as follows:

System	Color
Compressed Air	Yellow
Oxygen	Green
Nitrogen	Black
Nitrous Oxide	Blue
Vacuum	White

Each valve shall be securely mounted in a fixed position by means of brackets. Position of each valve shall allow for a firm grip to facilitate easy closing and opening. Each valve or valve box shall be labeled in substance as follows:

"Caution - (Name of applicable system) Valves. Do not close except in emergency. This valve controls (Name of applicable system) to [insert room name/number]."

3.9 GAUGES

- a. Calibrate and zero gauges at job site.
- b. Permanently label gauges with system name.

3.10 VIBRATION-ABSORBING FEATURES

NOTE: Designer will indicate on the drawings where equipment should be mounted resiliently. Details for proper mounting of equipment will be indicated on the drawings. Designer will insert required isolation efficiency in the blank space for installations where specific values for reduction of noise and vibration transmission are necessary; otherwise the sentence will be deleted. For areas where the maximum tolerable transmissibility in percent is considered necessary, the isolation efficiency will be given. Recommended transmissibility in percentages is as follows: 10 percent for equipment mounted in very critical areas, 10 to 20 percent for critical areas, and 20 to 40 percent for noncritical areas. The drawings should be checked to ensure that all structural and equipment connection factors or conditions surrounding the equipment, which are to be provided with vibration isolation units, favorably influence the effectiveness of the isolators. Where many items of equipment require different transmission values because of different equipment locations, the specification may be revised to indicate the appropriate values on the drawings.

Delete submittal of vibration-absorption features when not required.

Mechanical equipment, including compressors and pumps, shall be isolated from the building structure by approved vibration-absorbing features unless otherwise shown. Each foundation shall include standard isolation units as indicated. Each unit shall consist of machine and floor or foundation fastening, together with intermediate isolation material, and shall be a standard product with printed loading rating. Piping connected to mechanical equipment shall be provided with flexible connectors. Isolation unit installation shall limit vibration to [_____] percent of the lowest equipment rpm. Submit details of vibration-absorbing features, including arrangement, foundation plan, dimensions and specifications.

3.10.1 Tank or Skid Mounted Compressors

Floor attachment shall be as recommended by compressor manufacturer. Compressors shall be mounted to resist seismic loads as specified in [Section 23 05 48.19 [SEISMIC] BRACING FOR HVAC] [Section 22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL].

3.10.2 Foundation Mounted Compressors

Foundation attachment shall be as recommended by the compressor manufacturer. Compressors shall be mounted to resist seismic loads as specified in [Section 23 05 48.19 [SEISMIC] BRACING FOR HVAC] [Section 22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL].

3.11 TRAINING

- a. Provide the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work.
- b. Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with the equipment or system.
- c. When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

3.12 GAS, SUPPORT, AND VACUUM SYSTEMS TESTING

3.12.1 Test Reports

- a. Certified installers, inspectors, and verifiers shall conduct, document tests in accordance with NFPA 99, furnish their own test equipment and supplies (including gases) for their respective tests. Reports shall be certified with the signature of an officer of the company responsible for conducting the test.
- b. Submit reports in booklet form, within two weeks of test date with separate copies of each report for Contractor Quality Control, and Contracting Officer. Submit reports of both failed and passed tests. Except as indicated under specific test description, reports may be subdivided by tested area to allow timely submission. Submit test reports showing all field tests performed to adjust each component and field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed systems. Each test report shall indicate the final position of controls.
- c. Document each report separately in an easy-to-follow manner, organized by areas and systems tested. (An area is typically a group of outlets downstream of a zone valve assembly.)
- d. At the beginning of each report, document the following information:
 - (1) Name of project.

- (2) Date of report.
- (3) Name of company responsible for performing test.
- (4) Name of person conducting test.
- (5) Date of test.
- (6) Area(s) tested.
- (7) Name and address of facility.

- e. Pressure readings shall be made with calibrated gauges that have accuracies of +/- 7 kPa 1 psi.
- f. Temperature readings shall be made with calibrated thermometers that have accuracies of +/- 0.5 degrees C 1 degrees F.

3.12.2 Report Status

Project is acceptable only after systems have passed tests performed by the Inspection, Testing, and Verification Agency. Failure of test requires corrective action and retesting. Corrective actions taken to pass test and subsequent retesting shall be provided at no extra cost.

3.12.3 Tests and Reports Prior to Start of Installation

**NOTE: Delete this test and report when
interconnections will not be made between new and
existing systems.**

Conduct test of existing medical gas/vacuum warning system to verify existing conditions and document.

3.12.4 Level 3 Systems Testing

3.12.4.1 General

- a. Inspection and testing shall be performed on all new piped systems, additions, renovations, temporary installations, or repaired systems, to ensure by a documented procedure, that all applicable provisions of NFPA 99 and the Contract Documents have been adhered to and system integrity has been achieved or maintained.
- b. Inspection and testing shall include all components of the system or portions thereof, including, but not limited to, medical gas source(s), compressed air sources (e.g., compressors, dryers, filters, regulators), alarms and monitoring safeguards, pipelines, isolation valves, and station inlets (vacuum) and outlets (positive pressure gases).
- c. All systems that are breached and components that are subject to additions, renovations, or replacement (e.g., new medical gas sources, compressors, dryers, alarms) shall be inspected and tested. Systems shall be deemed breached at the point of pipeline intrusion by physical separation or by system component removal, replacement, or addition. Breached portions of the systems subject to inspection and

testing shall be confined to only the specific altered zone and components in the immediate zone or area that is located upstream (inlet side) for vacuum systems and downstream (outlet side) for positive pressure gases at the point or area of intrusion.

- d. Provide inspection, testing and verifier reports containing detailed findings and results directly to the Contracting Officer. All inspection, testing, and verification records shall be maintained on-site within the facility. The Contracting Officer shall review the records prior to the use of all systems.
- e. The Contracting Officer will accept the Verifier's Report as determining that the gas/vacuum delivered to the outlet/inlet is that shown on the outlet/inlet label and the proper connecting fittings are installed for the specific gas/vacuum service.

3.12.4.2 Initial Tests and Reports - All Level 3 Systems

The installing Contractor, a representative of the system supplier, or a representative of the system manufacturer is responsible for conducting and documenting these tests. Test gas shall be oil-free, dry Nitrogen NF. Provide all necessary materials and test apparatus to satisfactorily perform tests.

- a. Initial Blow Down Test.
- b. Initial Pressure Test for Positive Pressure Gas Systems and Copper Vacuum Piping.
- c. Initial Leak Test for PVC Vacuum Piping. Subject piping to a vacuum of not less than 12 inches Hg vacuum.
- d. Initial Cross-Connection Test. Conduct this test only after completion of every system within test area.
- e. Initial Piping Purge Test.
- f. Initial Standing Pressure Test for Positive-Pressure Gas Piping.
- g. Initial Standing Vacuum Test for Copper and PVC Vacuum Systems. Subject PVC piping to a vacuum of not less than 60 kPa 12 inches Hg which shall not reduce to less than 73 kPa 8 inches Hg vacuum at the end of the 24 hour test period.

3.12.4.3 I,T&V Agency Tests and Reports

**NOTE: Delete Final Tie-In Test Report when
interconnections will not be made between new and
existing systems.**

The Inspection, Testing and Verification Agency is responsible for conducting and documenting gas and Nitrogen tests. Test gas shall be oil-free, dry Nitrogen NF. Provide all necessary materials and test apparatus to satisfactorily perform tests.

- [a. Verifier Final Tie-In Test.]

- b. Verifier Standing Pressure Test.
- c. Verifier Cross-Connection Test.
- d. Verifier Warning System Test.
- e. Verifier Piping Purge Test.
- f. Verifier Piping Particulate Test.
- g. Verifier Piping Purity Test.
- h. Verifier Operational Pressure Test.
- i. Verifier Gas Concentration Test.
- j. Labeling.
- k. Oxygen and Nitrous Oxide Source Equipment Operational Test.

3.12.4.4 Final Tests and Reports - All Level 3

**NOTE: Delete Final Tie-In Test Report when
interconnections will not be made between new and
existing systems.**

The installing Contractor, a representative of the system supplier, a representative of the system manufacturer, or a certified system verifier is responsible for conducting and documenting Gas, Support, and Vacuum Systems (except Oxygen and Nitrous Oxide) tests. Test gas shall be oil-free, dry Nitrogen NF. Provide all necessary materials and test apparatus to satisfactorily perform tests.

- [a. Final Tie-In Test.]
- b. Final Standing Pressure Test.
- c. Final Standing Vacuum Test.
- d. Final Cross-Connection Test.
- e. Final Piping Purge Test.
- f. Labeling.
- g. Gas, Support Systems Source Equipment Operational Test.
- h. Vacuum Systems Source Equipment Operational Test.
- i. Dental Oral Evacuation (OE) System Test

Materials needed: Two vacuum gauges, accuracy of at least ± 0.15 kPa at 79-73 kPa ± 0.5 " Hg at 6-8" Hg. Flow restrictors (quantity = 70 percent x number of dental treatment rooms). Flow restrictor components:

(1)

Part A	Hose, smooth bore OE tubing, 16 mm ID x 100 mm 5/8 inch ID x 4 inch long.
Part B	Hose adaptor, brass, 15 mm male pipe thread x 10 mm 1/2 inch male pipe thread x 3/8 inch hose barb.
Part C	Tubing, vinyl, 15 mm ID x 35 mm 1/2 inch ID x 1-3/8 inch long.
Part D	Tubing, vinyl, 15 mm OD, 5 mm ID x 25 mm 1/2 inch OD, 3/16 inch ID x 1 inch long.
Part E	Tubing, soft copper, 8 mm x 50 mm 5/16 inch x 2 inch long.

(2) Clear burrs on cut ends with 24 mm 15/16 inch drill bit.

Flow restrictor assembly:

- a. Insert threaded end of the hose barb (Part B) completely into the 16 mm 5/8 inch OE hose (Part A).
- b. Slip the 13 mm 1/2 inch ID tubing (Part C) completely over the hose barb (Part B).
- c. Slip 13 mm 1/2 inch OD tubing (Part D) into the 13 mm 1/2 inch ID tubing (Part C) to butt against the hose barb (Part B).
- d. Slip the copper tubing (Part E) into the 13 mm 1/2 inch OD tubing (Part D) approximately 19 mm 3/4 inch.
- e. Flow restrictors as designed allow a flow of 3.5 L/s 7.4 SCFM when attached to plumbing under 79 kPa 6 inches Hg vacuum pressure.

NOTE: Vacuum gauge No. 1 shall be shown on the contract documents.

- (1) Install vacuum gauge No. 1 on a pipe common to the power units close to the separating tanks. Install this gauge in a manner that will have minimal effect on airflow through the pipe.
- (2) Install vacuum gauge No. 2 on the OE inlet in the floor box of the dental treatment room (DTR) farthest from the vacuum power units. Note that this inlet will be closed, with no flow passing through it.
- (3) Place a flow restrictor over one OE inlet in 70 percent of the facility DTRs. DTRs fitted with flow restrictors should include a mix of DTRs most distant and DTRs nearest the vacuum source.
- (4) Block off all other OE inlets and any other openings in the fixed pipe system.

NOTE: OE systems utilize two or more vacuum pumps and are sized so that when one pump is inoperable the remaining pump(s) are capable of meeting the demand of 70 percent of the facility DTRs. For this reason, testing will be conducted with one pump inoperable. Utilization of flow restrictors simulates flow obtained through a functioning dental

unit. Attaching flow restrictors to inlets in 70 percent of the DTRs (with other inlets blocked) verifies that an appropriate vacuum level can be obtained, with one pump inoperable, under flow conditions at a 70 percent system demand.

(5) Operate the vacuum system with one pump inoperable and note the readings on the two vacuum pressure gauges. Next, operate the vacuum system with a different pump inoperable and note the reading on both vacuum pressure gauges. Continue this process until a vacuum reading has been obtained with each of the system pumps taking a turn as the inoperable pump.

(6) An acceptable OE system shall be able to maintain a minimum of 79 kPa 6 inches Hg vacuum as measured on the vacuum gauge on the furthest DTR inlet (gauge No. 2) under the conditions outlined above. The system piping pressure drop between the vacuum gauge near the power units (gauge No. 1) and the vacuum gauge at the farthest DTR (gauge No. 2) should be no more than 0.3 kPa 1 inch Hg vacuum.

3.12.5 Level 1 Systems Testing

3.12.5.1 General

- a. Inspection and testing shall be performed on all new piped systems, additions, renovations, temporary installations, or repaired systems, to assure by a documented procedure, that all applicable provisions of NFPA 99 and the Contract Documents have been adhered to and system integrity has been achieved or maintained.
- b. Inspection and testing shall include all components of the system or portions thereof, including, but not limited to, bulk source(s), cylinder manifolds, compressed air sources (e.g., compressors, dryers, filters, regulators), source alarms and monitoring safeguards, master alarms, pipelines, isolation valves, area alarms, zone valves, and station inlets (vacuum) and outlets (pressure gases).
- c. All systems that are breached and components that are subject to additions, renovations, or replacement (e.g., new gas sources: bulk, manifolds, compressors, dryers, alarms) shall be inspected and tested. Systems shall be deemed breached at the point of pipeline intrusion by physical separation or by system component removal, replacement, or addition. Breached portions of the systems subject to inspection and testing shall be confined to only the specific altered zone and components in the immediate zone or area that is located upstream for vacuum systems and downstream for pressure gases at the point or area of intrusion.
- d. Provide inspection, testing, and verifier reports containing detailed findings and results directly to the Contracting Officer. All inspection, testing, and verification records shall be maintained on-site within the facility. The Contracting Officer or their appointed representative shall review the records prior to the use of all systems.
- e. Before piping systems are initially put into use the Contracting Officer shall accept the Verifier's Report as determining that the

gas/vacuum delivered to the outlet/inlet is that shown on the outlet/inlet label and the proper connecting fittings are installed for the specific gas/vacuum service.

3.12.5.2 Installer Performed Tests and Reports

**NOTE: Delete Connection Report when
interconnections will not be made between new and
existing systems.**

The installing Contractor is responsible for conducting and documenting these tests. Test gas shall be oil-free, dry Nitrogen NF. Provide all necessary materials and test apparatus to satisfactorily perform tests. Tests apply to all Gas, Support, and Vacuum Systems.

[a. Connection Report.]

- b. Initial Blow Down Test.
- c. Initial Pressure Test.
- d. Cross Connection Test.
- e. Piping Purge Test.
- f. Standing Pressure Test for Positive Pressure Piping.
- g. Standing Vacuum Test for Vacuum Piping.

3.12.5.3 I,T&V Agency Tests and Reports

**NOTE: Delete Final Tie-In Test Report when
interconnections will not be made between new and
existing systems.**

**Delete Initial Alarm Test Report when
interconnections will not be made between new and
existing systems.**

The Inspection, Testing, and Verification Agency is responsible for conducting and documenting these tests. Test gas shall be oil-free, dry Nitrogen NF. Provide all necessary materials and test apparatus to satisfactorily perform tests. Tests apply to all Gas, Support, and Vacuum Systems.

[a. Final Tie-In Test.]

- [b. Initial Alarm Test. For each system, document operation of existing alarm systems prior to interconnecting new and existing systems.]
- c. Standing Pressure Test.
- d. Cross Connection Test.
- e. Individual Pressurization Test.

- f. Pressure Differential Test.
- g. Valve Test.
- h. Alarm Test. Master Alarms. Area Alarms.
- i. Piping Purge Test.
- j. Piping Particulate Test.
- k. Piping Purity Test.
- l. Operational Pressure Test.
- m. Medical Gas Concentration Test.
- n. Medical Compressed Air Purity Test.
- o. Labeling.
- p. Source Equipment Verification:
 - (1) Gas Cylinder Supply Sources.
 - (2) Medical Compressed Air Compressor Sources.
 - (3) Medical-Surgical Vacuum Sources.

3.13 WARNING SYSTEM

Provide wiring required for warning system except for power source at each alarm panel, which is provided by Electrical Specification Division contractor. Install wiring in conduit [including underground portion to the bulk oxygen site].

- a. Label each alarm position on each alarm panel. Coordinate designations with using facility. Coordinate area designations with associated zone valve assembly designations.
- b. Master alarm panels shall not be daisy-chained. Provide panel dedicated sensors and wiring from the alarm points to each installed master alarm panel.
- c. Provide master alarm panels at the following locations:

Emergency Receiving Desk	Room [_____]
Central Information Desk	Room [_____]
Building Engineers Office	Room [_____]
Building Security Office	Room [_____]

- d. Provide master alarm connection to UMCS (UFGS 23 09 00).
- e. Area alarm panels shall not be daisy-chained.

[3.14 EXISTING PIPED DISTRIBUTION SYSTEMS

NOTE: Include existing piped distribution systems
when remodels affect them. Edit to match project.

When bulk oxygen systems are leased to the Hospital,
their upgrade is not part of these construction
documents: Include the bracketed sentence.

Upgrade existing systems as indicated and as required to comply with the
Regulatory Requirements.[Do not upgrade the bulk oxygen system, but do
provide upgraded alarms at system site.]

] -- End of Section --