SECTION 15212
LABORATORY AIR AND VACUUM PIPING

PART I - GENERAL

1.01 RELATED DOCUMENTS

A. Requirements of the following Division 15 Sections apply to this section:
   1. Division 15, Section 15010 – BASIC MECHANICAL REQUIREMENTS
   2. Division 15, Section 15050 – BASIC MECHANICAL MATERIALS AND METHODS

1.02 SUMMARY

A. This Section includes piping and related specialties aboveground and inside the building for the following systems:
   1. Compressed air, designated “laboratory air.”
   2. Vacuum, designated “laboratory vacuum.”
   3. Laboratory gas alarm system.

1.03 DEFINITIONS

A. PTFE: Polytetrafluoroethylene.
B. TFE: Tetrafluoroethylene.

1.04 SUBMITTALS

A. Product Data: For the following:
   1. Special-purpose valves.
   2. Laboratory air and vacuum specialties.
   3. Laboratory air manifolds.
   4. Laboratory gas alarm system components.
   5. Laboratory air cylinder racks.

B. Wiring diagrams for laboratory gas alarm system. Differentiate between manufacturer-installed and field-installed wiring.

C. Coordination Drawings: For laboratory air and vacuum piping and specialties, including relationship to other services that service same work areas. Show connections to laboratory fume hoods and casework.

D. Piping Certification: Certificates of compliance with ASTM B 819 for precleaned copper tubing.
E. Certificates of inspections and tests specified in “Field Quality Control” Article in Part 3 of this Section.

F. Maintenance Data: For special-duty valves and specialties to include in maintenance manuals specified in Division 1.

1.05 SYSTEM PERFORMANCE REQUIREMENTS

A. Installer Qualifications: Engage an experienced Installer of laboratory system.

1. The term “Experienced Installer” is specified in Division 1, Section 01420 – References.

B. Components and Installation: Capable of producing piping systems with following minimum working pressure ratings except where indicated otherwise:

1. Laboratory Compressed-Air Systems: 55 psig.

2. Laboratory High-Pressure Compressed-Air Systems: 125 psig.

3. Laboratory Vacuum Systems: 20 inches mercury system (and 55 psig working pressure rating).

1.06 QUALITY ASSURANCE

A. Testing Agency Services: Owner will provide independent testing agency services under separate contract to inspect, test, and certify laboratory air and vacuum piping and components, except for inspections and tests specified in “Field Quality Control” Article in Part 3 of this Section.

B. Testing Agency Qualifications: An independent testing agency with the experience and capability to conduct testing indicated without delaying the Work, as documented according to ASTM E 699.

C. Source Limitations: Obtain laboratory air and vacuum specialties through one source from a single manufacturer.

D. Source Limitations: Provide laboratory air and vacuum specialties compatible with existing systems.

E. Source Limitations: Provide laboratory air and vacuum specialties from manufacturer of existing specialties, compatible with existing systems.

F. Listing and Labeling: Provide electrically operated specialties specified in this Section that are listed and labeled.

1. Terms “Listed” and “Labeled”: As defined in NFPA 70, Article 100.


G. Comply with NFPA 70.
1.07 DELIVER, STORAGE, AND HANDLING

A. Deliver and store large laboratory air and vacuum piping specialties on shipping skids, small specialties in containers, and piping with end protection.

B. Store pre-cleaned and sealed pipe, fittings, valves, and specialties with sealing plugs and sealing packaging intact.

C. Label pipe, fittings, valves, and specialties that have not been pre-cleaned, and that have been pre-cleaned but have seal or packaging that is not intact, with temporary labels indicating that cleaning is required before installation.

PART II - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Piping Specialties:
   a. MEDAES, Incorporated.
   b. Puritan-Bennett Corporation.
   c. Or equal.

2. Alarm Systems:
   a. MEDAES, Incorporated.
   b. Puritan-Bennett Corporation.
   c. Or equal.

2.02 PIPES AND TUBES

A. General: Applications of the following pipe and tube materials are indicated in Part 3 “Piping Applications” Article.

B. Medical Gas, Copper Tube: ASTM B 819, seamless, drawn temper, factory cleaned for medical gas service, purged, and with ends sealed.

C. Copper Tube: ASTM B 88, Type K or L (ASTM B 88M, Type A or B), water tube, seamless, drawn temper.

2.03 PIPE AND TUBE FITTINGS

A. General: Applications of the following pipe and tube fitting materials are indicated in Part 3 “Piping Applications” Article.

B. Pre-cleaned, Wrought-Copper Fittings: ASME B16.22, solder-joint, pressure type. Fittings may be factory cleaned, purged, and sealed according to ASTM B 819 or field cleaned, purged, and sealed as specified below in “Preparation” Article.
C. Wrought-Copper Fittings: ASME B16.22, solder-joint, pressure type.


E. Flexible Pipe Connectors: Bronze hose, covered with bronze wire braid with copper-tube or bronze flanged ends brazed to hose.

2.04 JOINING MATERIALS

A. General: Applications of the following piping joining materials are indicated in Part 3 “Piping Applications” Article.

B. Brazing Filler Metals: AWS A5.8, BCuP Copper-phosphorus-series alloys. Flux is prohibited unless used with bronze fittings.

C. Threaded-Joint Tape: PTFE plastic.

D. Gasket Material: ASME B16.21, nonmetallic, flat, asbestos free, and suitable for oxygen service.

2.05 SPECIAL-DUTY VALVES

A. Laboratory Air Valves: Pre-cleaned for oxygen service and factory sealed.

B. Ball Valves, 4-inch NPS (DN 100) and Smaller: MSS SP-110, Class 150, 600 psig (4140 kPa) CWP, ASTM B 584 bronze body and bonnet, 3-piece, bolted-body construction; chrome-plated brass ball, full port; blowout proof; bronze or brass stem; PTFE or TFE seats and seals; threaded or solder-joint end connections; and vinyl-covered steel lever handle with locking device.

1. Include factory cleaning and sealing for oxygen use and factory-installed, ASTM B 88, Type K or L (ASTM B 88M, Type A or B), copper-tube extensions. Include pressure gage installed downstream from valve in air systems and upstream from valve in vacuum systems.

C. Check Valves, 4-inch NPS (DN 100) and Smaller: Bronze-body, straight-through pattern, spring-loaded ball check valve, designed for 300 psig (2070 kPa) minimum working pressure.

D. Safety Valves: Bronze body with settings to match system requirements.


2. Vacuum Relief Valves: Specialty manufacturer’s option.

E. Pressure Regulators: Brass or bronze body and trim; spring-loaded, diaphragm-operated, relieving type; manual pressure-setting adjustment; rated for 250 psig (1725 kPa) minimum inlet pressure; and capable of controlling delivered air pressure within 0.5 psig for each 10 psig (5.0 kPa for each 100 kPa) inlet pressure.

F. Vacuum Regulators: Bronze or aluminum body, corrosion-resistant trim, spring-loaded, diaphragm operation, with adjustable setting, and suitable for vacuum service.
G. Automatic Drain Valves: Corrosion-resistant metal body and internal parts, 200 psig (1380 kPa) minimum working-pressure rating, capable of automatic discharge of collected condensate.

H. Zone Valve Boxes: Steel valve boxes for recessed mountain, with holes for piping and anchors. Include space for single- or multiple-valve, with dual gauge upstream and downstream of valve, installation and in sizes to permit manual operation of valves. Include the following:

1. Interior Finish: Factory applied, white enamel.
2. Cover Plate: Satin-chrome finish steel with window.
3. Cover Plate: Aluminum with window.
4. Cover Plate: Stainless steel with NAAMM AMP 503, No. 4 finish and window.
5. Window: Frangible or removable, clear or tinted transparent plastic with labeling. Include space for rooms served.
6. Valve-Box Window: Clear or tinted transparent plastic with labeling, according to NFPA 99A and NFPA 99C.

I. Zone Valve Boxes: Aluminum valve boxes for recessed mounting, with holes for piping and anchors. Include space for single- or multiple-valve, with dual gauge upstream and downstream of valve, installation and in sizes to permit manual operation of valves. Include the following:

1. Cover Plate: Satin-chrome finish steel with window.
2. Cover Plate: Aluminum with window.
3. Cover Plate: Stainless steel with NAAMM AMP 503, No. 4 finish and window.
4. Window: Frangible or removable, clear or tinted transparent plastic with labeling.

### 2.06 PIPING SPECIALTIES

A. Laboratory Air Manifolds: Comply with NFPA 99A, Chapter 4, Paragraph "Cylinder Systems without Reserve Supply;" and NFPA 99C. Include the following features:

1. Central-Control Panel Unit: Weatherproof cabinet, supply and delivery pressure gages, electrical alarm system connections and transformer, indicator lights or devices, manifold connection, pressure changeover switch, line-pressure regulator, shutoff valves, and safety valve.

2. Manifold and Headers: Duplex, nonferrous-metal header for number of cylinders indicated, divided into 2 equal banks. Units include design for 200 psig (13.8 MPa) minimum inlet pressure. Include cylinder bank header inlet "pigtail" connections complying with CGA V-1, individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gage.
3. Operation: Automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators, and without supply interruption by shutoff of either cylinder bank header.

4. Mounting: Floor mounting, complete with mounting brackets for manifold control cabinet and headers.

5. Mounting: Floor mounting, complete with support legs for manifold control cabinet.

6. Label manifold control unit to indicate laboratory air and system operating pressure.

7. Laboratory Air Manifolds: 8 cylinders, 2500 cu. ft./h (19.7 L/s) at 55 psig (380 kPa) line pressure.

8. High-Pressure, Laboratory Air Manifolds: 12 cylinders, 3000 cu. ft./h (23.6 L/s) at 125 psig (860 kPa) line pressure.

B. Service Outlets: Gas specific for services listed, with roughing-in and finishing assemblies. Include the following:

1. Roughing-in Assembly: Include the following:
   a. Steel outlet box or mounting plate.
   b. Brass-body outlet block with secondary check valve that prevents gas flow when primary valve is removed.
   c. Double seals that prevent gas leakage.
   d. ASTM B 88, Type K, ⅜" NPS (ASTM B 88M, Type A, DN 10) copper inlet or outlet tube brazed to valve with gas-service marking and tube-end dust cap.

2. Finishing Assembly: Include the following:
   a. Brass housing with primary check valve.
   b. Double seals that prevent gas leakage.
   c. Cover plate with gas-service label.

3. Quick-Connect Coupling: Indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment, and with positive-locking ring that retains equipment stem in valve during use. Puritan Bennett style only.

4. Wall Outlet Cover Plates: One-piece stainless steel, with NAAMM AMP 503, No. 4 finish and permanent, color-coded, medical gas identifying label matching corresponding outlets.
5. Wall Outlet Cover Plates: One-piece metal, with chrome-plated finish and permanent, color-coded, medical gas identifying label matching corresponding outlets.

6. Wall Outlet Cover Plates: One-piece anodized aluminum, with permanent, color-coded, medical gas identifying label matching corresponding outlets.

7. Laboratory Vacuum Bottle-Slide Brackets: Bottle-slide and mounting assembly matching pattern of laboratory vacuum outlet. Include one slide bracket for each wall-mounted laboratory vacuum inlet, unless no slide bracket requirement is indicated.

C. Pressure-Control Panels: Steel box and steel support brackets for recessed installation. Include stainless-steel or anodized-aluminum cover plate with printed operating instructions. Arrange control panels with manifold assembly consisting of inlet-supply valve, inlet-supply pressure gage, line-pressure control regulator, outlet-supply pressure gage, CGA V-5, DISS service outlet, and tubing outlet for remote service outlet.

   2. Line-Pressure Control Regulator: Self-relieving, diaphragm type, with precision manual adjustment.
   3. Pressure Gages: 0- to 300-psig (0- to 2070 kPa) range.
   4. Furnish temporary dust shield and U-tube for testing before final assembly.
   5. Air-Control Panels: Label cover plate “Air Pressure Control.” Furnish with DISS No. 1160 air service outlet.

D. Service Hose Assemblies: Color-coded, conductive, neoprene, ¼” or 5/16” (6.4 or 7.9 mm) ID, of lengths indicated, and with indexed or DISS-type end-connection fittings suitable for medical gas service indicated.

   1. Hose Color: Black, when laboratory gas service is indicated.
   2. Laboratory Air-Hose Assemblies: 96” (2440 mm) long, with quick-connect laboratory air fitting; valve on one end and stem on the other.
   3. Laboratory Vacuum Hose Assemblies: 12’ (3.6 m) long, with laboratory vacuum CGA V-5, DISS No. 1220 fitting; nut on one end and male plug on the other.

2.07 ALARM SYSTEM

A. Description: Beacon Medical, Inc. MEGA alarm panels, remote sensing devices, and other related components where indicated and where required by NFPA 99 and NFPA 99C. Include the following laboratory gas systems:

   1. Laboratory air.
   2. High-pressure laboratory air.
   3. Laboratory Vacuum.
B. Components: Designed for continuous service and operation on power supplied from 120VAC power source to alarm panels. Include connections for 24- or 12-V, as low-voltage wiring to remote sensing devices. Include step-down transformers where required.

C. Dew-Point Monitors: Continuous line monitors having panel with gage or digital display. Include pipeline sensing element, electrical connections for alarm system, factory- or field-installed valved bypass, and a visual and cancelable audio signal for dryer site and master alarm panels. Activate alarm when pressure dew point rises above 39ºF (3.9ºC) at 55 psig (380 kPa).


2. Operation: Hygrometer moisture analyzer with sensor probe.

D. Pressure and Vacuum Switches or Pressure Transducer Sensors: Continuous line monitors with electrical connections for alarm system.

1. Low-Pressure Switches: 0 to 100 psig (0 to 690 kPa) operating range.

2. High-Pressure Switches: Up to 250 psig (1725 kPa) operating range.

3. Vacuum Switches: 0 to 30 inch Hg (0 to 101 kPa vacuum) range.

E. Carbon-Monoxide Monitors: Panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, and factory- or field-installed valved bypass. Operate alarm when carbon-monoxide level rises above 10 ppm.

F. Alarm Panels: Factory-wired, audible, and color-coded visual signals that indicate specified functions.

1. Mounting: Recess.


3. Enclosure: Fabricated from minimum 0.047” (1.2 mm) thick steel or minimum 0.05” (1.27 mm) thick aluminum, and with knockouts for electrical and piping connections.

G. Special Features: In addition to manufacturer’s standard features, include the following:

1. Master Alarm Panels: Separate trouble alarm signals, pressure and vacuum gages, and indicators for laboratory gases. Signal alarms at master alarm panels when the following conditions exist:

   a. Laboratory Air: When pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), back-up air compressor is in operation, pressure drop across filter assembly increases more than 2 psig (13.8 kPa), dew point rises above 39ºF (3.9ºC) at 55 psig (380 kPa), carbon-monoxide level rises above 10 ppm, and high-water level rises in receiver for liquid-ring laboratory air-compressor systems.

   b. High-Pressure Laboratory Air: When pressure drops below 160 psig (1100 kPa) or rises above 200 psig (1380 kPa).
c. Laboratory Vacuum: When laboratory vacuum drops below 16 inch Hg (54 kPa) and back up laboratory vacuum pump is in operation.

2. Area Alarm Panels: Separate trouble alarm signals, pressure and laboratory vacuum gages, and indicators for the following:
   a. Laboratory air. High alarm and low alarm.
   b. High-pressure laboratory air. High alarm and low alarm.
   c. Laboratory vacuum. Low alarm.

H. Johnson Controls Part #EN-EXP101-0 Controls System Equipment Enclosure should be used where interface of data is required by JCI.

2.08 LABORATORY AIR CYLINDER RACKS

A. Vertical, Cylinder Wall Racks: Fabricate as indicated or provide equivalent vendor's standard wall racks.

B. Horizontal, Cylinder Storage Racks: Fabricate as indicated or provide equivalent vendor's standard storage racks.

2.09 TEST GASES

A. Nitrogen for Pressure Testing: CGA G-10.1, oil free, dry and at least Grade D.

B. Nitrogen for Flow Testing: CGA P-9, oil free and dry.

PART III - EXECUTION

3.01 PREPARATION

A. Cleaning: If factory-pre-cleaned and -capped piping is unavailable or if pre-cleaned because of exposure, follow procedures for alkaline washing and meet cleanliness requirements in ASTM B 819.

B. Protect cleaned piping before and during installation.

3.02 PIPING APPLICATIONS

A. Laboratory Air Piping: Pre-cleaned, medical gas, copper tube with pre-cleaned, wrought-copper fittings and brazed joints.

B. Laboratory Air Piping: Copper water tube with wrought-copper fittings and brazed joints.

C. Laboratory Vacuum Piping: Pre-cleaned, medical gas, copper tube with pre-cleaned, wrought-copper fittings and brazed joints.

D. Laboratory Vacuum Piping: Copper water tube with wrought-copper fittings and brazed joints.
3.03 PIPING INSTALLATION

A. Refer to Division 15, Section 15050 – Basic Mechanical Materials and Methods, for basic piping installation and joint construction.

B. Install piping next to equipment, accessories, and specialties to allow service and maintenance.

C. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.

D. Flanges may be used on aboveground piping, unless otherwise indicated. Install supports and anchors according to Division 15 Section _______ - Hangers and Supports.

1. Spacing between Hangers: As described in NFPA 99A and NFPA 99C.

E. Valve Applications: Use ball valves specified in this Section for main shutoff and zone valve duties. Valve shall have dual purge ports.

F. Install zone valves in valve box anchored to structure. Install valves at an angle that prevents closure of cover when valve is in closed position. Single boxes may be used for multiple valves that serve same area or function. Zone valve to have dual purge ports.

G. Install pressure gages according to Division 15 Section _______ - Meters and Gages.

H. Purge laboratory air and vacuum piping using oil-free, dry nitrogen after installing piping but before connecting to service-outlet valves, alarms, and gages.

3.04 PIPING SPECIALTY INSTALLATION

A. Install piping specialties according to NFPA 99A and NFPA 99C.

B. Install laboratory air manifolds firmly anchored and with seismic restraints.

3.05 LABORATORY GAS ALARM SYSTEM INSTALLATION

A. General: Install alarm system components according to NFPA 99A, NFPA 99C, and manufacturer’s written instructions.

B. Install alarm panels in locations indicated.

3.06 CONNECTIONS

A. Connect laboratory air and vacuum piping to equipment, accessories, and specialties with unions. Install ball valve and strainer.

1. Install flexible piping connectors on air piping to laboratory air compressors and on vacuum piping to laboratory vacuum pumps.

2. Install thermometers on laboratory air-compressor discharge, air-receiver tanks, and vacuum receiver tanks.

3. Install pressure gages on laboratory air-compressor discharge piping and on vacuum-receiver tanks.
4. Install pressure regulators downstream from laboratory air compressors, dryers, purification units, and filter assemblies.

B. Ground electric-powered specialties.
1. Tighten electrical connectors and terminals according to manufacturer’s published torque tightening values. Where manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

C. Arrange for electric-power connections to specialties and devices that require power. Electric power, wiring, and disconnect switches are specified in Division 16 Sections.

3.07 LABELING AND IDENTIFICATION

A. Install labeling on piping, valves, valve-box covers, air manifolds, and alarm panels according to NFPA 99A and NFPA 99C. Use the following or similar captions and color-coding for specialties:
1. Laboratory Air: Black or white letters on yellow background.
2. Laboratory Vacuum: Black letters on white background.
3. Label laboratory air piping to indicate system operating pressure.

B. Refer to Division 15 Section _______ - Mechanical Identification, for labeling and identifying materials.

3.08 FIELD QUALITY CONTROL

A. Laboratory Air and Vacuum Piping Tests: Perform the following:
1. System Clearing: Purge laboratory air and vacuum piping using oil-free, dry nitrogen after installing piping but before installing service outlets, alarms, and gages.
2. Pressure Test: Subject each section of laboratory air and vacuum piping, except high-pressure laboratory air piping, to test pressure of 150 to 200 psig (1035 to 1380 kPa). Subject high-pressure laboratory air piping to test pressure of 250 psig (1725 kPa) with oil-free, dry nitrogen before attaching system components, after installing service outlets, and before concealing piping system. Maintain test until joints are examined for leaks by means of soapy water.
3. Standing-Pressure Test: Install assembled system components after testing individual piping systems as specified above. Subject systems to 24-hour standing-pressure test at 20% above normal line pressure, but not less than 66 psig (455 kPa).
   a. Option: Subject laboratory vacuum systems to a minimum of 12- to 18-in. Hg (40 to 61 kPa) vacuum instead of pressure test.
4. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.
5. Repair laboratory air and vacuum systems and replace components that fail tests specified.
A. Description: Provide services of an independent testing agency complying with requirements of Division 1, Section 01450 – Quality Control, to inspect, test, and certify laboratory air and vacuum systems as specified below. Inspect, test, and certify complete laboratory systems according to NFPA 99A and NFPA 99C. Inspect, test, and certify each laboratory air and vacuum system, including piping, outlets and inlets, specialties, alarm panels and devices, safety devices, gas sources, and equipment.

B. Prepare written reports of test results, including corrective action.

C. Certify that systems comply with specified requirements, that tests were properly performed, and that test results were satisfactory.

D. Inspect outlets and inlets, gages, alarms, and zone valves for proper labeling for service and function.

E. Inspect manifold supply systems for installation and operation according to NFPA 99A, Chapter 4 and NFPA 99C.

F. A0 Phase I Tests: Perform the following tests using dry nitrogen after installing laboratory air and vacuum systems but before connecting new systems to existing gas sources:

1. Outlet and Inlet Cross-Connection Test: Pressurize 1 gas system to 50 psig (345 kPa), with other system at atmospheric pressure, and access each outlet with an appropriated adapter and test gage. Repeat procedure for each system.

2. Outlet and Inlet Cross-Connection Test: Pressurize each system in 10 psig (69 kPa) increments and access each outlet with an appropriate adapter and test gage.

3. Alarm System Test: Test for operation of functions specified in “Alarm System” Article, within limits required.

4. Pressure Test: Test systems at operational pressure with system components installed. No leaks are allowed. Conduct tests by zone.

5. Particulate Sampling: Test positive-pressure terminal outlets, using a 0.45-micron filter, for evidence of solid particulate contamination. Allowable limit is 2 mg/cu. m.

6. Moisture: Test positive-pressure terminal outlets for dew point to verify absence of moisture in piping. Dew point of gas dispensed from terminal outlets shall not exceed dew point of source test gas by more than 4ºF (2.2ºC).

7. Systems Purity: Test terminal outlets and gas source for contaminant levels as defined below. Excessive contaminant levels will require additional purging of outlets within a specific zone until levels are within the following limits:

   a. Total Hydrocarbons as Methane: 1 ppm.

   b. Halogenated Hydrocarbons: 2 ppm.

   c. Carbon Monoxide: 2 ppm.
8. **Air-Compressor Purity:** Collect laboratory air-compressor air samples taken from downstream side of filters and air dryers. Test samples for contaminants and moisture within the following limits:

   a. Total Hydrocarbons as Methane: 25 ppm.
   b. Halogenated Hydrocarbons: 5 ppm.
   c. Carbon Monoxide: 10 ppm.
   d. Moisture, Dew Point: Plus 40°F (4.4°C) at dryer discharge.

**G. Phase II Tests:** After Phase I testing has been completed, test completed laboratory air and vacuum systems using applicable gas for each system. Completed systems have outlets and inlets, alarms, and gages installed; and gas supply systems installed and ready for operation.

1. **Final Purging:** Introduce applicable gas for each system into respective piping systems. Purge installed outlet valves to remove nitrogen test gas present from Phase I testing. Test laboratory vacuum inlets for ability to flow.

2. **Outflow Analysis:** Analyze gas at positive-pressure outlets to confirm delivery of proper gas at proper concentration level. Minimum allowable concentration levels are defined by USP-NF, "U.S. Pharmacopoeia 23 – National Formulary 18," and the following CGA Commodity Specifications:

   a. CGA G-6.2, "Commodity Specification for Carbon Dioxide."
   b. CGA G-7.1, "Commodity Specification for Air."
   c. CGA G-10.1, "Commodity Specification for Nitrogen."

3. **System Delivery Pressure:** Test pressure piping systems to confirm supply sources are set to deliver gas at the following nominal pressure levels:

   a. Laboratory Air Systems, except High-Pressure Air: 50 to 55 psig (345 to 380 kPa) at maximum flow.
   b. High-Pressure Laboratory Air: 180 psig (1240 kPa) minimum at maximum flow.

4. **System Suction Levels:** Test laboratory vacuum systems to confirm that laboratory vacuum producers are set to maintain suction of not less than 12 in. Hg (40 kPa) at most distant inlets.

**H. Certification:** Certify that specified inspections, tests, and procedures have been performed and report results. Include the following:

1. Inspections performed.
2. Procedures, materials, and gases used.
3. Test methods used.
4. Results of tests.
3.10 COMMISSIONING

A. Before startup, perform the following checks:

1. Tests of piping systems are complete.
2. Laboratory air-compressor inlet filters and piping and laboratory vacuum pump filters and discharge piping are clear.
3. System has equipment vibration-control supports and flexible pipe connectors, and equipment is properly attached to substrate.
4. Safety valves have setting that is greater than laboratory air-compressor discharge pressure, but not greater than pressure rating of system components.
5. Vacuum relief valves have been adjusted.
6. Water is supplied to water-cooled equipment.
7. Proper seismic restraints have been checked.

B. Startup Procedures: Follow manufacturer’s written procedures. If no procedures are prescribed by manufacturer, proceed as follows:

1. Energize circuits.
2. Check laboratory air and vacuum pressures.
3. Manually operate safety valves and vacuum relief valves.
4. Adjust operating controls, including pressure and vacuum settings.

C. Operate and adjust operating and safety controls. Replace damaged and malfunctioning controls and equipment discovered by service representative.

3.11 DEMONSTRATION

A. Startup Services: Engage a factory-authorized service representative to demonstrate procedures for alarm system startup and shutdown, preventative maintenance and servicing, and troubleshooting. Review maintenance information.

B. Provide written notice at least 7 days in advance of demonstration.

END OF SECTION 15212