PART 1 - GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 220500 - Basic Plumbing Materials and Methods, and other Sections in Division 22 specified herein.

1.2 SCOPE

A. Provide all labor and materials to install the following types of valves:
   1. Manual Valves
   2. Control Valves (Modulating and On/Off)
   3. Regulating

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 220500: Basic Plumbing Materials and Methods

1.4 QUALITY ASSURANCE

A. Manufacturer of all components shall be pre-approved by the Owner's Representative.
   1. Document the following in submittals:
      a. Material
      b. Measured wall thickness tolerance.
      c. Verification of surface electropolishing for stainless steel valves.
      d. Measured Ra or Rmax surface roughness values as noted for each component for high purity valves.
      e. Cleaning procedure for high purity valves.
      f. Year and month of manufacturing.
      g. Certificate of conformance with all requirements of this specification.

1.5 SUBMITTALS

A. Prior to construction submit for approval in accordance with Division 01 the following:
   1. List of any exceptions to specifications.
   2. Literature on components with enough data to confirm product quality.
   3. Cv
   4. Leak rates for Helium testing.
   5. Surface finish guarantee.
   6. Dimensions

PART 2 - PRODUCTS

2.1 GENERAL

A. Valves specified in this section are divided by type and subdivided into general and high purity service.

B. All valves to have brass or plastic tags indicating service and number.

C. Valves are identified by their designation letters as follows:

VALVES

DESIGNATION	VALVE TYPE
BA	Ball Valve
BF	Butterfly Valve
CK	Check Valve
GA	Gate Valve
GL	Globe Valve
PL	Plug Valve
ND	Needle Valve
PRG	Pressure Regulating Valve
GV	Gas Venturi
DV	Diaphragm Valve
ACTUATORS	
PN	Pneumatic
ES	Electric Solenoid

Example: BA-PN-## = Ball Valve with pneumatic actuator

D. All valves shall be sized to match inlet piping unless specifically noted on drawing.

E. All high purity valves shall be cleaned and sealed in nitrogen filled plastic bags at the manufacturer. Valves arriving at site with seals broken shall not be used. Field cleaning of high purity valves is not permitted. Valves can be cleaned in A.O. Reed's office if required.

2.2 BALL VALVES

A. Vacuum:
1. Shutoff Valves provide two-piece, full port, bronze ball valve with bronze trim and soldered ends, MSS SP-110, 600 psi CWP rating, 150 psi SWP rating, PTFE or TFE seats, bronze stem, brass ball with hard chrome plate, and blowout-proof stem. Manufacturers: Nibco S-585, Apollo series 77, or approved equal.
2. Check Valves: Size 2-inch and smaller: Provide Nibco S-433, Jenkins or equal, 150 psi SWP bronze check valve, 300 psi non-shock WOG with renewable bronze disc.

B. Compressed Air:
1. Shutoff Valves provide two-piece, full port, bronze ball valve with bronze trim and soldered ends, MSS SP-110, 600 psi CWP rating, 150 psi SWP rating, PTFE or TFE seats, bronze stem, brass ball with hard chrome plate, and blowout-proof stem. Valve shall be cleaned, capped/bagged, and delivered certified for "Oxygen Service" from the manufacturer. Manufacturers: Nibco S-585, Apollo series 77, or approved equal.
2. Pressure Regulators: Provide pressure regulator with pressure gauge, adjustable from 10 to 120 psi, at compressed air point of connection to laboratory. Manufacturers: Norgren Excelon 73, Watts R10, or approved equal.

C. Laboratory (Natural) Gas:
1. Shutoff Valves provide two-piece, full port, brass or bronze ball valve with brass trim and threaded ends, 400 psi CWP rating, 150 psi SWP rating, PTFE or TFE seats, brass stem, brass ball with hard chrome plate. Quarter-turn (closed to fully open) design, vinyl-coated steel lever handle requiring less than 5 lbs. pressure to operate. Ball valves shall be in compliance with NFPA 54, UL listed and AGA/CGA certified for natural gas service. Manufacturers: Nibco, Apollo, or approved equal.
2. Zone Shutoff Valve Box:

a. Provide recessed zone valve box assembly consisting of the following components: minimum 16-gauge steel recessed valve box with white baked enamel finish, flush box door, continuous concealed door hinge, and 7.5" x 5.5" vision panel. Provide recessed zone valve box assembly with flush paddle handle latch, lock and key is not acceptable. Approximate recessed dimensions: 12-inch wide x 12-inch high x 4-inch deep.
   1) Identification:
      a) Zone valve box to be provided with engraved plastic label "LABORATORY GAS CONTROL VALVE", "CLOSE ONLY IN EMERGENCY". Engraved label to have white lettering on black label.
b. Manufacturers: Acudor model ARVB or approved equal.

D. General Purity Specialty Gases:
   1. Application:
      a. Nitrogen (N2): Labs 211, 311
   2. Valves: Provide three-piece, full-port, bronze ball valve with stainless-steel trim and soldered ends, MSS SP-110, 600 psi CWP rating, 150 psi SWP rating, PTFE or TFE seats, stainless steel stem and ball (vented), blowout-proof stem. Valve shall be cleaned, capped and delivered certified for "Oxygen Service" from the manufacturer. Manufacturers: Nibco S-590, Apollo series 82, or approved equal.

E. High Purity Specialty Gases (Ball Valve):
   1. Application:
      a. NanoFab SG1: Nitrogen (N2)
      b. NanoFab SG2: Argon (Ar)
      c. NanoFab SG3: Oxygen (O2)
      d. NanoFab SG4: Forming Gas (<5% Hydrogen in Nitrogen)
      e. Argon (Ar): Lab 222
      f. Hydrogen (H2): Lab 222
      g. Nitrogen (N2): Lab 222
   2. Valves: Provide Type 316L stainless steel ball valve with nylon directional rotary handle suitable for high purity applications. Cleaning and Packaging shall be per Swagelok Specification SC-11 (Rev A) titled "Special Cleaning and Packaging" or equal specification to comply with ASTM G 93 Level C cleanliness requirements. Manufacturers: Swagelok 40G series with VCR fittings or equal.

F. High Purity Specialty Gases (Diaphragm Valve):
   1. Application:
      a. Oxygen (O2): Lab 222
   2. Valves: Provide Type 316L stainless steel springless diaphragm valve with black nylon directional rotary handle suitable for high purity applications. Cleaning and Packaging shall be per Swagelok Specification SC-11 (Rev A) titled "Special Cleaning and Packaging" or equal specification to comply with ASTM G 93 Level C cleanliness requirements. Manufacturers: Swagelok DP series with VCR fitting or equal.

G. Reverse Osmosis (RO) Water:
   1. Shutoff Valves provide one-piece, full port, PVC ball valve with soldered ends, MSS SP-122, 150 psi CWP rating, PTFE seats, EPDM seals, and PVC ball. Manufacturers: Nibco 4660-S, Hayward.

2.3 REGULATOR ASSEMBLIES FOR SPECIALITY GASES

A. Manufacturers: Products, which comply with this specification section as judged and approved by the Owner's representative, may be provided by the following manufacturers. All products specified in this section shall be the provided by a single manufacturer.
   a. Spectra Gases, Inc. (Linde), http://www.spectragases.com
   b. Advanced Specialty Gas Equipment, http://www.asge-online.com
   c. Applied Energy Systems, Inc., http://www.appliedenergysystems.com
   d. Or approved equal

B. Regulator Assembly for Single Cylinder or Single Bank of Cylinders Arrangement (Flammable or High Purity Gases):
   1. Application:
      a. Argon (Ar): Lab 222
      b. Hydrogen (H2): Lab 222
      c. Nitrogen (N2): Lab 222
   2. General: Dual-stage regulator assembly consisting of inlet regulator, line regulator, accessories, and mounting plate. Assembly shall be complete and ready for use upon cylinder hookup. Inlet pressure rating of 3,000 psig; assembly line delivery pressure range 0 – 125 psig (unless otherwise noted).
   3. Regulator: High purity diffusion resistant type regulator, Type 316 stainless steel body, bonnet, and diaphragm, Teflon or Kel-F seats, metal-to-metal seals on the diaphragm.
      a. Regulators for halogenated corrosive gases shall have Hastelloy internal components.
      b. Provide sub-atmospheric regulator for gases with low operating vapor pressure.
      c. Provide gas heater for gases subject to excessive cooling.
   4. Flash Arrestor (Flammable gases only): A flash arrestor shall be installed on the outlet of the system. Body shall be Type 316 stainless steel with Viton seats and Teflon coated O-rings. Maximum outlet pressure to match system operating pressure.
   5. Check Valves: Check valves shall be integral to the CGA connection, Type 316 stainless steel, and furnished with Viton O-rings.
   6. Gauges: Bourdon tube type, Type 316 stainless steel, 2-inch face for inlet and outlet pressures. Accuracy ±2% of full scale. Inlet pressure: 0 – 4,000 psig range. Outlet pressure: 0 – 200 psig or 1.25 times system operating pressure.
   7. Relief Valve: Seat-type, Type 316 stainless steel relief valve with Teflon-coated Viton O-ring and adjustable setting.
   8. Isolation Valve: Type 316 stainless steel, high purity packless diffusion resistant diaphragm valve with multi-turn handle.
   9. Cylinder Pigtails:
      a. Stainless Steel Tubing: Type 316L ¼-inch O.D. electropolished stainless steel tubing type with check valve and orbitally welded / VCR connections, Type 316 stainless steel CGA connection with integral check valve, 3,000 psig inlet working pressure.
   10. Mounting Plate: Regulator assembly shall be attached to an anodized aluminum or stainless steel mounting plate (No. 4 finish or better), functionally labeled, pre-drilled and ready for wall mounting.
   11. Pressure Switch: Switch or explosive proof switch (flammable gases) senses decreasing cylinder pressure to activate alarm; non-powered, single-pole, double-throw, 125 vac, 5 amp, 60 Hz. Contractor shall provide required conduit and wiring for system operation.
   12. Entire assembly helium leak checked to 1 x l0-9 scc/sec out board with a mass spectrometer. Dead end pressure tested for 12 hours creep test.
   13. Alarm Annunciator Panel: Provide alarm annunciator panel equipped with red (alarm) and green (normal) system status lights, minimum 80 dB audible alarm,

audible alarm silence button, and test button. Panel shall include power cord to plug into a 120vac 60 Hz electrical supply receptacle and be equipped with integral 120vac/24vac step-down power transformer as required. Provide permanent engraved labeling to identify alarm channel gas nomenclature. Provide single-channel panel for a single monitored cylinder or multi-channel panel for multiple monitored gas cylinders arranged adjacent to each other.

C. Regulator Assembly for Cryogenic Gases From Dewars:
1. Application:
   a. Nitrogen (N2): Labs 211, 311
2. General: Dual-stage regulator assembly consisting of inlet regulator, line regulator, accessories, and mounting plate. Assembly shall incorporate cryogenic regulators with heaters to prevent regulator freeze-up under flow conditions. Assembly shall be complete and ready for use upon dewar hookup. Inlet pressure rating of 350 psig; assembly line delivery pressure range 40 – 90 psig (unless otherwise noted).
3. Regulator: High purity diffusion resistant type regulator, Type 316 stainless steel body, bonnet, and diaphragm, Teflon or Kel-F seats, metal-to-metal seals on the diaphragm.
4. Check Valves: Check valves shall be integral to the CGA connection, Type 316 stainless steel, and furnished with Viton O-rings.
5. Gauges: Bourdon tube type, Type 316 stainless steel, 2-inch face for inlet and outlet pressures. Accuracy ±2% of full scale. Inlet pressure: 0 – 500 psig range. Outlet pressure: 0 – 200 psig or 1.25 times system operating pressure.
6. Relief Valve: Seat-type, Type 316 stainless steel relief valve with Teflon-coated Viton O-ring and adjustable setting.
7. Isolation Valve: Type 316 stainless steel, high purity packless diffusion resistant diaphragm valve with multi-turn handle.
8. Flexible Hose Inlet Assembly: Provide 72-inch cryogenic pigtails constructed with nylon inner core with polyester braid with check valve. Rated working pressure of 1,375 psig.
9. Pressure Switch: Switch senses decreasing cylinder pressure downstream of regulator to activate alarm; non-powered, double-pole, double-throw, 125 vac, 5 amp, 60 Hz. Contractor shall provide required conduit and wiring for system operation.
10. Mounting Plate: Regulator assembly shall be attached to an anodized aluminum or stainless steel mounting plate (No. 4 finish or better), functionally labeled, pre-drilled and ready for wall mounting.
11. Entire assembly helium leak checked to 1 x l0-9 scc/sec out board with a mass spectrometer. Dead end pressure tested for 12 hours creep test.
12. Alarm Annunciator Panel: Provide alarm annunciator panel equipped with red (alarm) and green (normal) system status lights, minimum 80 dB audible alarm, audible alarm silence button, and test button. Panel shall include power cord to plug into a 120vac 60 Hz electrical supply receptacle and be equipped with integral 120vac/24vac step-down power transformer as required. Provide permanent engraved labeling to identify alarm channel gas nomenclature. Provide single-channel panel for a single monitored cylinder or multi-channel panel for multiple monitored gas cylinders arranged adjacent to each other.

2.4 MANIFOLDS

A. Manufacturers: Products, which comply with this specification section as judged and approved by the Owner's representative, may be provided by the following manufacturers. All products specified in this section shall be the provided by a single manufacturer.
1. Spectra Gases, Inc. (Linde), http://www.spectragases.com
2. Advanced Specialty Gas Equipment, http://www.asge-online.com

3. Applied Energy Systems, Inc., http://www.appliedenergysystems.com
4. Or approved equal.

B. Semi-Automatic Cylinder Manifold System Assembly for Multiple Cylinders (Flammable or High Purity Gases):
1. Application:
   a. NanoFab SG1: Nitrogen (N2)
   b. NanoFab SG2: Argon (Ar)
   c. NanoFab SG3: Oxygen (O2)
   d. NanoFab SG4: Forming Gas (<5% Hydrogen in Nitrogen)
2. General: Provide semi-automatic changeover assembly for continuous supply of gas from active and reserve cylinder banks. Dual-stage regulator assembly consisting of inlet regulator, selector knob, line regulator, accessories, and mounting plate. Assembly shall be complete and ready for use upon cylinder hookup. Inlet pressure rating of 3,000 psig; assembly line delivery pressure range 0 – 125 psig (unless otherwise noted).
3. Regulator: High purity diffusion resistant type regulator, Type 316 stainless steel body, bonnet, and diaphragm, Teflon or Kel-F seats, metal-to-metal seals on the diaphragm.
   a. Regulators for halogenated corrosive gases shall have Hastelloy internal components.
   b. Provide sub-atmospheric regulator for gases with low operating vapor pressure.
   c. Provide gas heater for CO2 regulators and other gases subject to excessive cooling.
4. Check Valves: Check valves shall be integral to the CGA connection, Type 316 stainless steel, and furnished with Viton O-rings.
5. Gauges: Bourdon tube type, Type 316 stainless steel, 2-inch face for inlet and outlet pressures. Accuracy ±2% of full scale. Inlet pressure: 0 – 4,000 psig range. Outlet pressure: 0 – 200 psig 1.25 times system operating pressure. Changeover assembly shall include pressure gauges to indicate pressures for service bank, reserve bank, and delivery.
6. Relief Valve: Seat-type relief valve, Type 316 stainless steel with Teflon-coated Viton O-ring and adjustable setting.
7. Isolation Valve: Type 316 stainless steel, high purity packless diffusion resistant diaphragm valve with multi-turn handle. Provide at outlet, inlets to allow isolation of either side of the changeover assembly, and at each cylinder connection.
8. Manifold Piping: Install manifold headers consisting of seamless Type 316 stainless steel tube rated for 3,000 psig with individual station isolation valves. Provide Type 316 stainless steel tees and couplers.
9. Cylinder Pigtails:
   a. Stainless Steel Tubing: Type 316L ¼-inch O.D. electropolished stainless steel tubing type with check valve and orbitally welded / VCR connections, Type 316 stainless steel CGA connection with integral check valve, 3,000 psig inlet working pressure.
10. Mounting Plate: Manifold assembly shall be attached to an anodized aluminum or stainless steel mounting plate (No. 4 finish or better), functionally labeled, pre-drilled and ready for wall mounting.
11. Pressure Switch: Explosive proof switch senses decreasing cylinder pressure to activate alarm; non-powered, single-pole, double-throw, 125 vac, 5 amp, 60 Hz. Contractor shall provide required conduit and wiring for system operation.
12. Entire assembly helium leak checked to 1 x $l0^{-6}$ scc/sec out board with a mass spectrometer. Dead end pressure tested for 12 hours creep test.
13. Alarm Annunciator Panel: Provide alarm annunciator panel equipped with red (alarm) and green (normal) system status lights, minimum 80 dB audible alarm,

audible alarm silence button, and test button. Panel shall include power cord to plug into a 120vac 60 Hz electrical supply receptacle and be equipped with integral 120vac/24vac step-down power transformer as required. Provide permanent engraved labeling to identify alarm channel gas nomenclature. Provide single-channel panel for a single monitored cylinder or multi-channel panel for multiple monitored gas cylinders arranged adjacent to each other.

2.5 VALVE SCHEDULE FRAMES

A. Provide a separate valve schedule for each system; include tag number, size and location by room and column. For each page of valve schedule, provide glazed display frame, with screws for removable mounting on framed or masonry walls. Provide frames of finished hardwood or extruded aluminum, with SSB-grade sheet of glass.

PART 3 - EXECUTION

3.1 GENERAL

A. All materials and installation work shall conform to all applicable codes and regulations. All work shall be done in a competent and workmanlike manner using the best practice and latest techniques of the trade.
   1. The Contractor shall employ for this work only labor which has been qualified by training and experience to capably perform the specified activities required to accomplish the work in a satisfactory manner.

3.2 QUALITY ASSURANCE

A. All material shall be reviewed by the contractor. Any valve that does not conform to the specified requirements shall be rejected.

B. High Purity Valves
   1. Inspect all valves to verify bags are not punctured. Valves with open bags or caps will be rejected and returned to the manufacturer for recleaning. Inspect valves for interior contamination.
   2. No high or ultra high purity valves will be cleaned on site or shop cleaned.

3.3 INSTALLATION

A. General Service Valves
   1. Install general service valves per Section 221000.

B. Reverse Osmosis (RO) Water:
   1. Install valves on services as indicated on plumbing drawings.
   2. Fixture Connection: Install supply shutoff valve for each fixture as indicated on plumbing drawings. Install flexible tubing from valve to fixture supply water connection.
   3. Cleaning:
      a. Refer to corresponding sections of Division 22 for system cleaning and disinfecting requirements.
      b. If not specified elsewhere, minimum requirements shall be to flush and disinfect new water lines with “MINNCARE” or equal cleaning solution.

C. Laboratory Vacuum:
   1. Install valves on services as indicated on plumbing drawings.

2. Fixture Connection: Install flexible connector from piping to fixture connection as indicated on plumbing drawings.
3. Cleaning:
   a. Refer to corresponding sections of Division 22 for system cleaning requirements.

D. Compressed and Laboratory Air:
1. Install valves on services as indicated on plumbing drawings.
2. Fixture Connection: Install flexible connector from piping to fixture connection as indicated on plumbing drawings.
3. Copper Valve:
   a. Brazed joints shall be made using a brazing alloy that exhibits a melting temperature in excess of 538°C (1000°F). Copper-to-copper joints shall be brazed using a copper–phosphorus–silver brazing filler metal (BCuP series) without flux. Flux shall only be used when brazing dissimilar metals such as copper and bronze or brass, using a silver (BAg series) brazing filler metal. Brazing alloy comply with ANSI/AWS A.5.8 Specification for Brazing Filler Metal. Residual flux on interior surfaces of tubing and fittings must be completed removed with cleaning processes.
   b. While being brazed, all piping joints shall be continuously purged with oil-free, dry Nitrogen to prevent the formation of copper oxide on the inside surfaces of the joint. The purge shall be maintained until the joint is cool to the touch.

E. Laboratory (Natural) Gas:
1. Install valves on services as indicated on plumbing drawings.
2. Fixture Connection: Install flexible connector from piping to fixture connection as indicated on LP-series drawings.
3. Installation Standards: Install valves in accordance with recommendations of NFPA 54.
4. Install in-line shutoff valves at locations and per details shown on plumbing drawings.

F. Specialty Gases:
1. Comply with NFPA 45-2011. Install valves specified and as shown on drawings.
2. Provide and install pressure regulators and cylinder manifolds where shown on drawings.
3. Provide valves for cylinder manifold systems within laboratory room to services as shown on plumbing drawings. Provide threaded couplings at final connection to service fittings.
4. Copper Valve:
   a. Brazed joints shall be made using a brazing alloy that exhibits a melting temperature in excess of 538°C (1000°F). Copper-to-copper joints shall be brazed using a copper-phosphorus-silver brazing filler material (BCuP series) without flux. Flux shall only be used when brazing dissimilar metals such as copper and bronze or brass, using silver (Bag series) brazing filler metal. Brazing alloy comply with ANSI/AWS A5.8 Specification for brazing Filler Metal. Residual flux on interior surfaces of tubing and fittings must be completely removed with cleaning process.
   b. While being brazed, all piping joints shall be continuously purged with oil-free, dry Nitrogen to prevent the formation of copper oxide on the inside surfaces of the joint. The purge shall be maintained until the joint is cool to the touch.

c. The outside of all tubes, joints, and fittings shall be cleaned by washing with hot water after assembly to remove any excess flux and provide for clear visual inspection of brazed connections.

5. Stainless Steel Valve
   a. Systems shall be welded with an automatic orbital TIG welding machine with a fully enclosed weld head. Welding process shall utilize Gas Tungsten Arc (GTA). Tungsten electrodes shall be replaced at regular intervals by procedure to produce high quality welds. An Argon back purge is required inside the tubing during welding and an Argon purge is required around the weld head during the welding process. Argon quality shall meet or exceed 100 ppb moisture, 100 ppb oxygen, and 100 ppb total hydrocarbons (TOC).
   b. Welding shall be performed by qualified welders certified on the welding machine being used. Submit welder's qualification and current certifications.
   c. At completion of work day, all uncompleted tubing runs shall be capped and sealed with stainless steel compression fittings with nylon ferrules.
   d. All welds should be performed in a clean environment, free of construction dirt, dust, and debris. Provide temporary enclosures with HEPA filtration supply air for fabricating welded subassemblies. Workers in clean environment shall wear appropriate garments (gloves, hair nets, booties, smocks, etc…) for welding procedures to ensure tubing system cleanliness is maintained. Welded connections of subassemblies in the final locations shall be made within a purged atmosphere to prevent entrainment of contamination in the tubing system during the welding process.
   e. Each weld shall be given a unique identification number indicating weld date, machine used, and welder's identification recorded on the piping and as-built project drawings.
   f. Weekly pipe segment coupon welds shall be performed at the start of each work week and immediately following electrode replacement for each pipe size weld. The coupons shall be cut open and inspected for satisfactory welding machine performance by qualified welding inspector. The inspection shall be documented with digital photographs and checklist with observed results. Include the coupon test inspection records as part of the O&M's.
6. Cleaning:
   a. General: All valves shall be delivered to the site cleaned, capped, and protected. If contamination occurs, the item shall be replaced at no additional cost to the Owner. Mass cleaning and/or re-cleaning on site will not be permitted. Cleaning components on site shall be restricted to that required when tubing is cut. Items shall be cleaned in strict compliance with the provisions of the purity level of the piping system. Valves and fittings which become contaminated shall be replaced at no cost to the Owner.
   b. General Purity Specialty Valves: Items shall be cleaned by the supplier in strict compliance with the provisions of "Oxygen" services.
   c. Ultra-High Purity Specialty Valves: Items shall be cleaned and purged by the supplier in strict compliance with the provisions of the manufacturer's ultra-high purity cleanliness standards.

3.4 TESTS

A. Contractor shall thoroughly test all Work prior to operation in the presence of Owner's Representative. Any Work showing faults under test shall be replaced. Contractor shall

maintain an accurate written record of all tests and test results, and shall submit three copies of all final tests to the Owner's Representative.

B. Refer to Division 22 specifications for system test requirements. If not specified elsewhere, minimum requirements shall be as follows:
   1. RO Water Valves: Do not conceal any valves and piping until satisfactorily tested. Test and prove tight under a hydrostatic pressure of 100 psi for a period of four (4) hours and carefully check for leaks. Repair all leaks and retest system until proven watertight with no loss of pressure or leakage allowed.
   2. Laboratory Vacuum: Test and prove valves airtight under an air pressure of 50 psig for a period of four (4) hours and bubble test all joints with a soap solution. Following pressure test, perform vacuum hold test pressure of -25" Hg for a period of four (4) hours with a maximum vacuum degradation of 1.25" Hg allowed. Repair all leaks and retest system until proven airtight.
   3. Compressed and Laboratory Air Valves: Test and prove airtight under an air pressure of 150 psig for a period of four (4) hours and bubble test all joints with a soap solution. Repair all leaks and retest system until proven airtight with no loss of pressure or leakage allowed.
   4. Laboratory (Natural) Gas Valve: Test and prove gas-tight under an air pressure of 50 psig for a period of four (4) hours and bubble test all joints with a soap solution. Repair all leaks and retest system until proven gas-tight with no loss of pressure or leakage allowed. Make a final 24-hour standing pressure test with air at 20 psig before connecting equipment. Retest the system until it is proven free of leaks.

C. General Purity Specialty Non-Toxic, Non-Flammable Valves:
   1. General:
      a. Prior to testing operation, open valves and blow out pipelines to remove foreign matter.
      b. Perform testing in presence of the Owner's Representative.
      c. Use 99.995% purity Nitrogen for purging and for pressure and leak testing.
      d. Observe safety procedures at all times.
      e. Use gauges cleaned for "Oxygen" service.
   2. Pressure Tests:
      a. Nitrogen Pressure Test: The line shall be pressure-tested at 200 psig of 1 ½ times the operating pressure (whichever is higher) for 24 hours. The line pressure shall be monitored and corrected for ambient temperature.
   3. Leak Tests:
      a. Nitrogen Pressure Test: The line pressure shall be brought upto test pressure. Perform bubble test of all joints with a soap solution. Repair all leaks and retest system until proven gas-tight with no loss of pressure or leakage allowed.

D. High Purity Specialty Valves:
   1. General:
      a. The Owner's Representative has the option to cut out several brazed or welded joints of each system to visually inspect the cleanliness and workmanship of the joint. For any joint section that is unacceptable, the replacement cost will be borne by the Contractor.
      b. Prior to testing operation, open valves and blow out pipelines to remove foreign matter.
      c. Perform testing in presence of the Owner's Representative.
      d. Use 99.999% purity Argon or Nitrogen for purging and pressure testing.
      e. Observe safety procedures at all times.
      f. Use gauges cleaned for High Purity service.
   2. System Integrity Test:

a. Pressure test: The line shall be pressure-tested at 200 psig or 1 ½ times the operating pressure (whichever is higher) for 24 hours. The line pressure shall be monitored and corrected for ambient temperature. A pressure drop that cannot be temperature compensated shall require corrective action and retesting.

SYSTEM	TEST MEDIUM	TEST PRESSURE	TOLERANCE TEST PERIOD
Purified Water	Water	100 psi	4 Hours
Lab Vacuum	Air	50psi -25” Hg	4 Hours 4 Hours
General Purity Specialty Non-Toxic Non Flammable	Nitrogen	200 psig or 1 ½ times operating pressure	24 Hours
High Purity Specialty Gases	Nitrogen	200 psig or 1 ½ times operating pressure	24 Hours
Compressed Air/ Lab Air	Air	50 psi	4 Hours

END OF SECTION