CONSTRUCTION STANDARD SPECIFICATION

SECTION 15481

ULTRA HIGH PURITY GAS DISTRIBUTION SYSTEMS

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PART 1 - GENERAL

1.01 SUMMARY

A. This specification, in conjunction with the design drawings and other contract documents, specifies materials and operations for the installation and acceptance of ultra high purity gas distribution systems including tubing, fittings, valves, regulators, welding equipment and all required QA/QC acceptance testing.

B. The term ultra high purity in this specification shall be defined as meeting the acceptance criteria for particulate and residual trace impurities within any system or system components installed under this specification as detailed in Section 3.04 - Quality Control.

1.02 REFERENCES

The following list of referenced codes and/or standards are to be utilized in the execution of this specification. All codes and standards shall be the most current issue.

A. American Society for Testing and Materials (ASTM)

A269	Seamless and Welded Austenitic Stainless Steel Tubing for General Service
A370	Standard Methods and Definitions for Mechanical Testing of Steel Products
A632	Seamless and Welded Austenitic Stainless Steel Tubing (Small Diameter) for General Service

A-262 Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels

E-112 Standard Test Method for Determining Average Grain Size

B. American National Standards Institute (ANSI)

B31.1 Code for Pressure Piping, Chemical Plant and Petroleum Refinery Piping

B46.1 Surface Texture, Surface Roughness, Waviness and Lay

C. American Society of Mechanical Engineers (ASME)

Section IX Welding Qualification

1.03 SUBMITTALS

A. Prior to acceptance as a supplier, each vendor must submit for approval by the SDR the following information.

1. Manufacturer's specifications for acquisition of raw material from stainless steel tube mill.

2. Step by step cleaning, handling, polishing and testing and acceptance procedures. Include in the submittal all chemicals, cleaning agents, etc., as well as the actual recipe for cleaning. Also include material and surface finish specification as well as sample tube and fitting.

3. Manufacturer's QA/QC, inspection, packaging and shipping procedures.

4. Valve and regulator cut sheets indicating material of construction, inboard and outboard leak rates along with testing procedures, cleaning procedures, Cv, surface finish, and testing procedures.

5. Catalog information for automatic orbital butt welding machine.

B. The following certificates shall accompany all shipments of tube and fittings.

1. Mill test report of the tubing, cross referenced to the tubing heat number within each size of tube and fittings. The ASTM Specifications, grade, and heat number shall be stenciled in regular

intervals on each length of tubing. The heat number shall be stenciled on each fitting.

2. Certification shall be provided for each heat lot for each size of tube and fittings that verifies that the interior roughness is no greater than 10 micro-inches Ra (Ave) or 15 micro-inches Ra (Max) as measured in accordance with ANSI/ASME B46.1.

3. Scanning Electron Microscope (SEM) photographs at magnifications of 1000X and 3600X shall be provided for each mill heat of material for each tube size. No more than 40 pits, tears, or other surface anomalies shall be distinguishable in the 3600X field of view.

4. Electron Spectroscopy for Chemical Analysis (ESCA) survey analysis data shall be provided for each mill heat of material for each tube size to verify the surface elemental composition. Elemental composition shall be expressed in atomic percent units, and shall verify surface chromium enrichment. ESCA data shall show a minimum chrome to iron ratio of 1.5:1, and a minimum chrome oxide to iron oxide ratio of 3:1.

1.04 QUALITY ASSURANCE

A. Welding Procedures: All welding procedures shall conform to ASME Code, Section IX.

B. Contractor Qualification: The contractor shall have installed a minimum of three gas distribution systems of similar purity levels within the last five years, with the latest within the last twelve month period. Prior to the start of work, the Contractor shall provide references verifying experience.

C. Welder Qualification:

1. Operators working on ultra high purity gas distribution systems must be qualified to ASME Section IX.

2. Operators working on ultra high purity gas distribution systems shall be certified by the manufacturer of the automatic orbital Tungsten Inert Gas (TIG) welding machine to be used during fabrication and assembly. The operator shall be certified for each tube size to be fabricated, and in each weld position.

3. Operators shall have completed the Sandia National Laboratories Welding Safety Class.

4. The operator shall renew qualification(s) if:

   a. welder has not used similar procedures within the last three months

   b. welder has been employed on a different process for six months or more

   c. current certification(s) are more than two years old

   d. SNL Welding Safety Class completion is older than one year old.

D. Deviations: Any deviations from specified materials or procedures must be secured in writing from the Sandia Delegated Representative (SDR) prior to incorporating as part of work scope.

E. Sandia may send a quality control representative to the factory to observe electropolishing, cleaning, packaging and shipping procedures of all valves, fittings, and tubing.

F. The Sandia representative shall have access to all areas as required to verify compliance to specifications.

PART 2 - PRODUCTS

2.01 TUBE AND FITTINGS

A. Single Wall Systems

1. Seamless tubing , 316L stainless steel per ASTM A-269 and A-632, factory cleaned for ultra-high purity gas service. Sulfur content shall be controlled as follows:

   1/4" < Tube O.D. < 2" = 0.005% to 0.017%
   2" < Tube O.D. < 4" = 0.003% to 0.017%

   Welded and redrawn tubing is acceptable for tubing sizes 2" and larger. Heat number shall be stenciled on each length of tubing as detailed in Section 1.03.B - Submittals.

2. Tubing hardness shall be between 65 and 85 on the Rockwell B scale (or equivalent) after any straightening procedures.

3. Grain size shall be ASTM E-112 No. 6 or finer. The micro structure shall be free from carbide precipitation per ASTM A-262.

4. Prior to electropolishing, tubing shall be annealed in a 100% hydrogen atmosphere, and cleaned to the manufacturer's specification. Tubing shall be bright inside and out, without discoloration, free from all foreign oxides, oil, grease, lubricants, mill chips, and draw marks.

5. Tube and fittings shall meet the following dimensional tolerances:

O.D. (inches)	Wall Thickness (+/- 5%)	Ovality (+/- in.)
1/4"	.035"	N/A
3/8"	.035"	N/A
1/2"	.049"	0.0018
3/4"	.065"	0.010
1"	.065"	0.010
1-1/2"	.065"	0.012
2"	.065"	0.016
3"	.065"	0.016

6. Finished tube I.D. shall match finished I.D. of any fittings used in system. Fittings which have heavier wall thickness than adjoining tubing shall have ends machined to equal the tube wall thickness.

7. All fittings that are fabricated using welding, drawing, bending, machining, or cold forming processes shall be annealed in a 100% hydrogen atmosphere prior to electropolishing to remove residual stresses and carbide precipitation.

8. Tees fabricated using the drawn or pulled tee method are not acceptable. Tees shall be fabricated using milling equipment to notch or drill the main tee body. The branch shall be joined to the main tee body using automatic TIG welding. No filler materials shall be used in this process. Welds shall be flush, and contain no visible pits or crevices. A smooth radius shall be present at the welded joint on both the I.D. and O.D. of the tee after electropolishing.

9. All changes in direction shall be made with a fitting manufactured from seamless tube stock. Changes in direction in 1/4” through 1/2” tubing used in non-hazardous distribution systems may be made with a field bend with a minimum bend radius of 8 times the tube diameter. Written authorization must be obtained from the SDR prior to making any field bends.

10. All manufactured tube stock fittings shall be recleaned and electropolished at the factory after the bend is made. All processes shall be documented and reported as detailed in this section. Threaded or compression type mechanical joint fittings are not acceptable. Use Cajon VCR type face seal fittings where servicing is required. Nickel or stainless steel gaskets shall be used. Gaskets shall be replaced each time fitting seal is broken.

11. All gas wetted surfaces of fittings and tubing shall be electropolished to a 10 micro-inch Ra (Ave) or 15 micro-inch Ra (Max) finish. Prior to electropolishing all gas wetted surfaces shall have a minimum 20 micro-inch Ra mill finish.

12. Each tube and fitting shall be flushed with 18 megohm deionized water until the measured resistivity of the effluent water reaches the following levels:

    Tube O.D. $\leq$ 2" = 17.5 megohm cm
    Tube O.D. $\geq$ 2" = 17.0 megohm cm

    Flow may vary per tube diameter and number of tubes being cleaned. Each heat of tube shall be accompanied by a document that verifies compliance with the above procedure, and each individual tube and fitting shall be marked to identify compliance. The deionized water used for flushing tube and fittings shall meet the following purity criteria.

    a. Filtration - 0.2 micron at point of use

    b. Bacteria - 10 per 100 ml. Maximum

    c. Particles - 200 per liter greater than 1.0 micron before Point of Use (POU) filter

    d. Total Organic Content (TOC)- 100 ppb maximum

    Independent laboratory tests shall be provided to verify conformance to above values.

13. Particle testing shall be performed using a PMS model Micro LPC-110 (or equal) laser particle counter, a high pressure diffuser and/or an isokinetic sampling device. Fixturing shall include filtration, flow metering device, cryogenic nitrogen source, electropolished 316L stainless steel tubing and/or anti-static PFA (Teflon) tube from gas source to particle counter. Flow shall remain turbulent throughout the

test period (Re > 4000). Acceptance criteria per 20 foot length of tube or individual fitting shall be as follows:

0 particles $\geq$ 0.3 microns
$\leq$ 5 particles $\geq$ 0.1 microns

Data shall be presented in print out from a series of 1 minute samples at a sample rate of 1 scfm.

14. Moisture testing shall be performed on tube and fittings using a Meeco NEP-1 Bravo Moisture Analyzer (or equal). Fixturing shall include filtration, cryogenic nitrogen source, and anti-static PFA (Teflon) tubing from gas source to moisture analyzer. Flow shall remain turbulent throughout the test (Re > 4000). Acceptance criteria per 20 foot length of tube or individual fitting shall be less than 1 ppm moisture content. Each heat of tube and individual fittings shall be accompanied by a certificate stating results of moisture testing. Each tube and fitting package shall be marked to identify certification.

15. Manufacturer's cleaning shall be performed in a Class 100 cleanroom certified per Federal Standard 209 (latest edition). Submit written test results for all QA/QC procedures performed in the acceptance of all tube and fittings.

16. Individual tube units shall receive a positive nitrogen purge with 0.05 micron filtered nitrogen immediately following the last cleaning projectile that has been blown through the tube. At the end of the final purge cycle, the tube ends shall be covered with a polyethylene bag over a 1.75 mil polyamide (nylon) film. The bag shall be sealed with polyethylene tape at least three inches from the tube end. The bag is followed by a hard plastic cap and another polyethylene bag on the outside of the cap. This bag is also taped to provide a triple seal against contamination. After sealing, the individual tubes shall be inspected for mill identification markings. If the original mill markings are not visible, they shall be replaced using a vibratool marker prior to final packaging. After marking, the entire length of each tube will be heat sealed in polypropylene bags in an inert nitrogen atmosphere.

17. Each fitting shall be packed in an inert nitrogen atmosphere, in separate, double polyethylene bags, with the open end double folded and heat sealed.

18. Fittings and tubing shall be packed in an appropriate shipping container(s) or box(es) in a manner so as to withstand rough handling.

19. All tubing shall be furnished in 20 foot lengths +/- 1/8", unless otherwise specified.

B. Dual Containment Systems

1. Both process and containment tubing under 2" shall be seamless, 316L stainless steel per ASTM A-269 and ASTM A-632. Welded and redrawn tubing is permitted for sizes greater than 2". Sulfur content of both the process and containment tubes shall be controlled as follows:

   1/4" < Tube O.D. < 2" = 0.005% to 0.017%
   2" < Tube O.D. < 4" = 0.003% to 0.017%

   Heat number shall be stenciled on each length of process and containment tubing as detailed in Section 1.03B - Submittals.

2. Both process and containment tubing hardness shall be between 65 and 85 on the Rockwell B scale (or equivalent) after any straightening procedures.

3. Grain size shall be ASTM E-112 No. 6 or finer. The micro structure shall be free from carbide precipitation per ASTM A-262.

4. Process and containment tubing shall be annealed in a 100% hydrogen atmosphere, and cleaned to the manufacturer's specification. Tubing shall be bright inside and out, without discoloration, free from all foreign oxides, oil, grease, lubricants, mill chips, and draw marks.

5. Containment tube shall be separated from the process tube using a system of symmetrical mechanical stand-offs to insure a constant annular space throughout the length of tubing. Mechanical stand-offs shall be provided at a minimum of two feet in any length of tubing.

6. Containment tubing shall be joined in the field using a series of seamless 316L stainless steel sleeves. Welded and redrawn sleeves are acceptable for sizes 2" and larger. Sleeves shall be a minimum of 2" and maximum of 4" in length, and shall meet the same specifications, including sulfur content, as the containment tubing. Heat number shall be stenciled on each sleeve as detailed in Section 1.03B - Submittals.

7. All process gas wetted surfaces of tubing shall be electropolished to a 10 micro-inch Ra (Ave) or 15 micro-inch Ra (Max) finish. Containment tubing and sleeves shall be provided with a minimum 20 micro-inch Ra (Ave) mill finish.

8. Dimensional tolerances of process and containment tubing in dual containment systems shall be equal to those for single wall systems as detailed in Section 2.01 A.5.

9. Finished process and containment tube I.D. shall match finished process and containment I.D. of any fittings used in the system. Fittings having heavier wall thickness than adjoining tubing shall have ends machined to equal the tube wall thickness.

10. Process tube on all dual containment fittings shall be fabricated as detailed in Section 2.01A - Paragraphs 5 through 7. Threaded or compression type mechanical joint fittings are not acceptable. Use dual containment termination fittings followed by a Cajon VCR type face seal fitting within an exhausted enclosure where servicing is required. Provide a dual containment purge fitting with a VCR type face seal fitting at each end of tube runs to allow pressure testing of containment tubing.

11. All dual containment tubing and fittings shall be cleaned, tested, packaged and shipped using the procedures for single wall tubing and fittings detailed in Section 2.01.

12. All dual containment tubing shall be furnished in 20 foot lengths +/- 1/8" unless otherwise specified.

C. Acceptable Manufacturers:

1. Tubing:

   a. Valex Corporation, Ventura, CA

   b. Advanced Micro Finish, Inc., North Ridgeville, OH

   c. Precision Tube Finishing, Inc., Houston, TX

2. Fittings:

   a. Advanced Stainless Technologies, Inc., Austin, TX

   b. Cajon Co., Macedonia, OH

   c. Parker Hannifin Corporation, Huntsville, AL

2.02 VALVES

A. Valves 1" and smaller shall be packless, springless diaphragm type valves. Valves shall have a screwed bonnet with metal to metal bonnet seat. Diaphragm valves shall meet the following specifications:

1. Valve bodies shall be 316L stainless steel, or Vacuum Induction Melt/Vacuum Arc Re-melt (VIM-VAR) material.

2. Valve bodies may be drop forged, cast or fabricated from bar stock. Prior to electropolishing, valve bodies shall be free of all machining marks and clean of all foreign oxides, oil, grease, lubricants and mill chips. Gas wetted surfaces shall have a 30 micro-inch Ra (Ave) finish prior to electropolishing.

3. All gas wetted surfaces of the valve shall be electropolished to a 10 micro-inch Ra (Ave) or 15 micro-inch Ra (Max) finish.

4. Valve diaphragm shall be fabricated from 316L stainless steel or equal. Valve seat shall be Kel-F or equal. Valve stems, stem guides, and other moving parts shall be removed from the process fluid flow stream.

5. Valves shall be provided with 3" tube extensions suitable for automatic orbital TIG welding. Wall thickness of valve tube extensions shall match those for tubing and fittings as detailed in Section 2.01. Sulfur content of the valve tube extensions shall be controlled to between 0.005% and 0.017%. Manufacturer shall submit verification of elemental composition of valve tube extensions. One downstream purge port shall be provided with all valves.

6. Valves shall be pre-cleaned for use in semiconductor gas distribution systems. Final cleaning shall be done using hot (100 - 150 degree F) 18 megohm deionized water. Valve shall be dried using heated nitrogen filtered to 0.05 microns.

7. Each valve shall be packed in an inert nitrogen atmosphere, in separate double polyethylene bags, with the end double folded and heat sealed. The bags valve shall be shipped in a suitable box or other container.

8. Valves shall be tested for leakage and shall not exceed a leak rate of 1.0×10^{-8} atmos cc/sec helium between valve and ambient (inboard and outboard) and have a maximum leakage across the seat of 1.0×10^{-7} atmos cc/sec helium.

B. Valves 1-1/2" and larger shall be a packless, inverted bellows type valve. Valves shall have an "O" ring type bellows seal, and a metal to metal bonnet seal. Bellows valves shall meet the following specifications:

1. Valve bodies shall be 316L stainless steel, or Vacuum Induction Melt/Vacuum Arc Re-melt (VIM-VAR) material.

2. Valve bodies may be drop forged, cast or fabricated from bar stock. Prior to electropolishing, valve bodies shall be free of all machining marks and clean of all foreign oxides, oil, grease, lubricants and mill chips. Gas wetted surfaces shall have a 30 micro-inch Ra (Ave) finish prior to electropolishing.

3. All gas wetted surfaces of the valve shall be electropolished to a 10 micro-inch Ra (Ave) or 15 micro-inch Ra (Max) finish.

4. Valve bellows shall be constructed of 316L stainless steel. Body to bellows seal shall be a 316L stainless steel "O" ring. Valve stem tip shall be Kel-F or 316L stainless steel.

5. Valves shall be provided with 3" tube extensions suitable for automatic orbital TIG welding. Wall thickness of valve tube extensions shall match those for tubing and fittings as detailed in Section 2.01. Sulfur content of the valve tube extensions shall be controlled to between 0.005% and 0.017%. Manufacturer shall submit verification of elemental composition of valve tube extensions. One downstream purge port shall be provided with all valves.

6. Valves shall be pre-cleaned for use in semiconductor gas distribution systems. Final cleaning shall be done using hot (100 - 150 degree F) 18 megohm deionized water. Valve shall be dried using heated nitrogen filtered to 0.05 microns.

7. Each valve shall be packed in an inert nitrogen atmosphere, in separate double polyethylene bags, with the end double folded and heat sealed. The bags valve shall be shipped in a suitable box or other container.

8. Each valve shall be tested for leakage and shall not exceed a leak rate of 1.0×10^{-8} atmos cc/sec helium between valve and ambient (inboard and outboard) and have a maximum leakage across the seat of 1.0×10^{-7} atmos cc/sec helium.

C. All valves shall be rated for 250 psi pressure at 60 degrees F, with minimum flow coefficients (Cv) as follows:

Valve Size	Cv (Min.)
1/4"	0.240
3/8"	0.250
1/2"	2.8
3/4"	2.8
1"	10.0
1-1/2"	12.4
2"	32.0
2-1/2"	90.0
3"	90.0
4"	100

D. Acceptable Manufacturers:

1. Nupro Company, Willoughby, OH
2. Advanced Pressure Technology (APTech), San Rafael, CA
3. Carten Controls, Middlebury, CT
4. Veriflo Corporation, Richmond, CA
5. Tescom Corporation, Elk River, MN

2.03 SPECIAL APPLICATIONS

A. Regulators

1. Regulator bodies shall be 316L stainless steel, or Vacuum Induction Melt/Vacuum Arc Re-melt (VIM-VAR) material. Diaphragm and all wetted surfaces shall be 316L stainless steel. Regulator seat shall be Kel-F or approved equal, and designed for positive shut off unless otherwise specified.

2. Regulator bodies may be drop forged, cast or fabricated from bar stock. Prior to electropolishing, regulator bodies shall be free of all machining marks and clean of all foreign oxides, oil, grease, lubricants and mill chips. Gas wetted surfaces shall have a 30 micro-inch Ra (Ave) finish prior to electropolishing.

3. All gas wetted surfaces of the regulator shall be electropolished to a 10 micro-inch Ra (Ave) or 15 micro-inch Ra (Max) finish.

4. Regulators shall be of a threadless design and provided with extended zero clearance Cajon VCR type face seal fittings for 1/4" tubing where required.

5. Regulators shall have a screwed bonnet with metal to metal bonnet seat. Vented regulators shall be provided with a threaded port to pipe away expelled gases.

6. Regulators shall be helium leak checked to less than 1 x 10^{-8} atmos cc/sec. All other cleaning, testing and packaging shall be equal to valves as detailed in Section 2.02 - Valves.

7. Acceptable Manufacturers

   a. Tescom Corporation, Elk River, MN
   b. Advanced Pressure Technology (APTech), San Rafael, CA
   c. Veriflo Corporation, Richmond, CA

B. Pressure Gauges

1. Pressure gauges shall be bourdon tube type gauges. Bourdon tube and locket area shall be 316L stainless steel.

2. Case and remaining internal movement material shall be a 300 series stainless steel. Bezel and lens shall be one piece polycarbonate screwed on to the gauge case. Gauge dial shall be white with black lettering.

3. Gauges shall be provided with Cajon VCR type face seal fittings. Gauge accuracy must be certified to within 1% of scale and helium leak checked to 1 x 10^{-9} atmos cc/sec. Range shall be as shown on plans.

4. Acceptable Manufacturers:

   a. Ashcroft, Stratford, CT
   b. Tescom Corporation, Elk River, MN

C. Check Valves

1. Check valve bodies shall be 316L stainless steel, or Vacuum Induction Melt/Vacuum Arc Re-melt (VIM-VAR) material.

2. Valve bodies may be drop forged, cast or fabricated from bar stock. Prior to electropolishing, valve bodies shall be free of all machining marks and clean of all foreign oxides, oil, grease, lubricants and mill

chips. Gas wetted surfaces shall have a 30 micro-inch Ra (Ave) finish prior to electropolishing.

3. All gas wetted surfaces of the valve, including springs shall be electropolished to a 10 micro-inch Ra (Ave) or 15 micro-inch Ra (Max) finish.

4. All factory welds on the valve body shall be automatic orbital TIG welds and shall meet the requirements as set forth in Section 3.02 - Workmanship of this specification.

5. Valves shall be helium leak checked to less than 1×10^{-9} atmos cc/sec. All other cleaning, testing and packaging shall be equal to valves as detailed in Section 2.02 - Valves.

6. Acceptable Manufacturers: Nupro Company, Willoughby, OH

PART 3 - EXECUTION

3.01 CLEANING

A. Each bundle of tubing that arrives at the job site shall be inspected in the following manner:

1. Immediately upon arrival at the job site, each and every length of tubing shall be inspected inside and out to verify compliance with Section 2.01 - Tube and Fittings. Tube and fittings shall be bright and clean inside and out, with tube interior exhibiting a mirror finish. There shall be no stains, oxides, oils, mill chips or other visible impurities. There shall be no uncapped, split or otherwise damaged end caps. If any of these characteristics is noted, the tube shall be permanently marked, removed from the job site and returned to the manufacturer for replacement.

2. One tube out of each bundle, with not less than 2% and not more than 5%, shall have a 2" coupon cut off, labeled and given to the SDR for inspection and testing. The location on the length of tubing from which the coupon is taken shall be at the discretion of the SDR. If the coupon does not comply with the specifications detailed in Section 2.01- Tube and Fittings, the entire tube bundle shall be rejected, lot number recorded, permanently marked, and removed from the job site for return to the manufacturer.

B. All tube and fittings to be installed in field weld fabricated systems shall be inspected before assembly and installation. Inspection shall be carried out under the following conditions:

1. Inspection shall be performed in a minimum Class 1000 environment as certified per Federal Standard 209 (latest edition).

2. Area shall be adequately ventilated and provided with air moving devices to meet OSHA requirements for fume removal, but is not required to have humidity control; tubing should not be exposed to excessive moisture once end caps have been removed.

3. Personnel handling, inspecting and cleaning tubing shall wear a minimum of disposable cleanroom garments, including hair covering and latex gloves to maintain a contamination free environment.

4. Inspect each length of tubing as described below prior to assembly and/or installation:

   a. Flush with 18 megohm deionized water heated to between 100 - 150 degrees F for a minimum of three minutes. DI water flow rate shall be controlled to maintain a minimum velocity within the tube of 5 feet per second (FPS).

   b. Upon completion of DI water flushing each tube shall be blown dry using nitrogen or argon from a cryogenic source filtered to a minimum of 0.01 microns. Flow shall continue until moisture level in the tube is less than 1 ppm above the measured level of the purge gas.

   c. At the end of the final purge cycle, the tube ends shall be covered with a polyethylene bag over a 1.75 mil polyamide (nylon) film. The bag shall be sealed with polyethylene tape at least three inches from the tube end. The bag is followed by a hard plastic cap and another polyethylene bag on the outside of the cap. The entire length of each tube will then be heat sealed in polyethylene bags in an inert nitrogen atmosphere.

5. Each length of tubing accepted after inspection shall be stored in a minimum of a Class 1000 cleanroom as certified by Federal Standard 209 (latest edition).

6. Any deviations from these procedures must be secured in writing from the SDR prior to incorporating as part of work scope.

C. The following is a minimum tube recleaning procedure for tubes requiring field cutting. Contractor shall submit his own detailed cleaning procedure for approval by the SDR. Contractor shall be responsible for the cleanliness integrity of the system as specified in Section 3.04 - Quality Control.

1. Welders, fitters, and apprentices required to install the ultra high purity process piping shall wear cleanroom garments (to include gown, hair and beard covers and foot covers) while inside cleanroom. Latex, non-powdered gloves shall be worn at all times while handling any component of the UHP system, whether inside or outside cleanroom.

2. All cutting, facing, deburring and cleaning operations shall be done in a separate temporary cleanroom or portable cleanroom trailer certified at a minimum Class 10,000 level. Unless otherwise specified in the contract documents or drawings, the Contractor shall furnish and install all equipment and materials for the temporary cleanroom. The temporary cleanroom shall be certified to the following requirements:

   a. Cleanroom certification shall be per Federal Standard 209 (latest edition).
   b. Room shall have a minimum 0.05" W.G. positive pressure at all times.
   c. Provide adequate ventilation at solvent cleaning stations to meet state and Federal OSHA regulations.

3. All tools used within a cleanroom environment for UHP cleaning and installation shall be kept separate from other tools, and shall be used exclusively for UHP systems. They shall be cleaned each and every time prior to entry into the cleanroom with a solution of 25% isopropyl alcohol (IPA) and 75% 18 megohm deionized water, and blown dry with 0.01 micron filtered nitrogen or argon from a cryogenic source.

4. Once tube is cut and squared, fill the tube with a solution of 25% IPA and 75% 18 megohm deionized water, drain, and blow dry with 0.01 micron filtered nitrogen or argon from a cryogenic source. Complete cleaning by blowing a lint free swab soaked in the solution described above through the tube with 0.01 micron filtered nitrogen or argon from a cryogenic source. Delivery pressure shall be between 40-50 psig.

5. Cleaning solutions and nitrogen or argon shall be used only once and then shall be disposed of in accordance with all applicable local, state and federal regulations.

6. Final cleaning of tubing, spool pieces or system sub-assemblies as described above shall be performed under a Class 100 laminar flow station.

7. All cleaned components shall be protected against contamination as follows:

   a. Small parts shall be placed in clean polyethylene bags and heat sealed.

   b. Tube ends shall be sealed under a positive 0.01 micron filtered nitrogen purge with polyethylene bags, sealed and covered with plastic caps.

   c. All tubing and fittings cut in the field and not immediately installed shall be stored in a Class 100 environment.

8. Ends of systems and components shall not be left open to ambient conditions when unattended or when work has been delayed.

D. Valve preparation shall be per the following procedures:

1. Valves to be purchased precleaned and bagged for ultra high purity service as detailed in Section 2.02 - Valves.

2. Valves contaminated during construction or fabrication of subsystems shall be returned to the vendor for replacement or recleaning. Any valve whose original bag has been opened, torn, or in any other manner has lost its inert atmosphere prior to entering the cleanroom for installation shall be considered contaminated.

E. All submicron filters used in the execution of this section shall be membrane type.

F. Contractor shall purchase and use only semiconductor grade isopropyl alcohol for use in all cleaning solutions detailed in this section.

G. Contractor shall submit Material Data Safety Sheets (MSDS) for all solvents, chemicals and cleaning solutions used in the execution of this specification.

3.02 WORKMANSHIP

A. Tube Preparation

1. To cut tube, scribe with wheel type tube cutter, and complete cut with wheel cutter. Deburr and rinse with semiconductor grade isopropyl alcohol, and bag ends.

2. For butt welds, ends must be squared with a squaring tool such as Tri-Tool, rinsed with isopropyl alcohol and bagged. Face tolerances of all butt weld ends shall be no greater than 0.008 inches from a plane perpendicular to centerline of tube or fitting.

B. Welding

1. Welding Procedure

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 to the following schedule, and then a test coupon produced. Field profiling of tungsten shall not be permitted.

Tube Size	No. of Welds
1/4" - 3/8"	30
1/2" - 3/4"	25
1" - 1-1/2"	15
2" and up	10

The schedule of welds above lists only the maximum number of welds allowed before replacing the tungsten electrode. The tungsten electrode may also be replaced at any time if it is determined by the SDR that the tungsten is showing sufficient wear as to produce faulty welds. A test coupon shall be produced after the new electrode is installed.

b. Voltage at the power source for the welding machine shall be measured and recorded in the daily log before any welds may be performed.

c. An argon back purge is required inside the tubing during welding. This purge shall be performed as follows:

(1) A gas vendor guaranteed and certified analysis shall be required on each purge source at the Contractor's expense. The Contractor shall be responsible for additional

purification and filtering required to deliver the purge gas at 0.01 microns, with less than 100 ppb moisture, 100 ppb oxygen, and 100 ppb total hydrocarbons (TOC).

(2) Purge manifold shall be fabricated to the same specification as the UHP system being installed.

(3) For continuous runs of tubing, welding shall begin at the purge port area and continue through the system. The purge connection shall not be changed. Use purge restrictor at the end of tubing runs. Stainless steel compression fittings with nylon ferrules can be used for temporary restriction on tees and tube ends.

(4) While welding, the minimum purge rate shall be 15 scfh for 1/4" tubing, and 25 scfh for all tubing 3/8" and larger.

(5) Do not begin welding until oxygen and moisture content in the tubing has been measured at less than 1 ppm. Allow a minimum of 5 minutes purge time per 20 feet of tubing.

(6) Continue purge after completion of weld until joint is cool to touch.

(7) Minimum purge extension of 12 inches is required for all joints.

d. At the completion of each work day, the Contractor shall continue the argon purge in any uncompleted tubing runs, or cap and seal the tubing runs using stainless steel compression fittings with nylon ferrules. Any tubing run which has been bedded down using this procedure shall be re-purged until the oxygen and moisture content have been measured at less than 1 ppm before the resumption of work on the system. The results of all oxygen and moisture analyses shall be recorded in the daily log.

e. If contaminants (oxides, etc.) are discovered at any time inside tubing, the contaminated sections shall be removed. All cut tubing ends must be squared, deburred, faced and cleaned as described in Section 3.02A - Tube Preparation.

f. An argon purge is required around the weld head during the welding process. This purge shall be performed as follows:

(1) The purge gas shall be of the same quality as that used to purge the inside of the tubing.

(2) Purge rates shall be per the welding machine manufacturer's recommendations.

(3) The pre-weld purge shall be of a duration as recommended by the welding machine manufacturer.

(4) The post-weld purge shall be maintained for a minimum period of thirty (30) seconds after completion of the weld.

g. Maintain alignment of tube and fittings during welding. No misalignment is acceptable.

h. All welds shall be exposed on installed tubing. Do not cover welds with saddle, jacket, pad or supports. Welds performed on the process tube of a dual containment system shall have all tests performed and the complete system approved as detailed for single wall systems in Section 3.04 - Quality Control before sleeves may be welded on the containment tubing.

i. All welding operations shall be performed in a Class 100 or cleaner environment. Welds made outside of a cleanroom shall be made inside a local clean environment such as the Process Isolation Bubble, manufactured by Scottmark, Inc.

2. Welder Requirements:

a. A qualification test for both the welding machine and the welder operator shall be conducted in the presence of the manufacturer's representative and approved by the SDR prior to assembly of any work.

b. Each welder operator shall be certified and identified per ASME Section IX and the welding machine manufacturer's instructions.

c. A sample weld from each welder operator, for each size of tubing diameter required, for vertical and horizontal positions shall be required, and given to the SDR for testing. Contractor shall bear the cost of welder operator testing and certification.

d. Contractor to submit to the SDR a written copy of the welding machine manufacturer's operating instructions.

3. Each weld shall be given a number, recorded on the project drawing with the welding machine schedule used, and the welder operators' identifying mark or symbol.

4. Upon completion of all testing and acceptance, tubing system shall be labeled in accordance with Sandia Standard Specification 15050, General Material & Work Requirement - Mechanical. The Contractor shall not paint over or remove any mill markings or welder identification markings.

3.03 PRESSURE TEST PROCEDURE

A. System Protection

1. Remove or disconnect from system all:

a. instruments and equipment which are not rated for test pressure
b. filters which are not rated for test pressure
c. any other items subject to damage by test pressure as designated by the SDR

2. Provide all necessary fittings and spool pieces required to maintain system integrity during pressure test

3. Protect tubing and equipment against over pressure

4. Do not subject closed valves left in system to pressures greater than their pressure rating

B. Apply 250 PSIG pressure to system and record ambient temperature in the daily log. Use semiconductor grade nitrogen or argon, filtered to 0.01 micron, and of the same purity as the gas used to purge tubing during the welding process for pressure testing of all lines.

C. System shall be considered passed if the 250 PSIG pressure is maintained for 8 consecutive hours with no drop in pressure (temperature compensated).

D. Upon completion of 250 PSIG pressure test, replace all valves, filters, regulators and other fittings not rated for the 250 PSIG pressure test. A second pressure test shall then be performed at the pressure of the lowest rated fitting in the system. The procedure and acceptance criteria for this test shall be the same as the 250 PSIG test.

E. Dual containment systems shall be pressure tested in the following sequence:

1. Pressure test process tube following the procedures for single wall systems prior to welding sleeves on containment tubing

2. Upon completion of residual trace gas, particulate and helium leak testing by Sandia, the sleeves on the containment tubing shall be welded into place following the procedures detailed in Section 3.02B - Welding.

3. The procedure and acceptance criteria for pressure testing of the containment tubing shall be the same as the 250 PSIG test for single wall systems.

F. If pressure test fails, bubble test all joints with ionic free agent to detect gross leaks. Submit MSDS for approval of ionic free agent to be used. All joints failing pressure test shall be marked for replacement.

G. All joints failing pressure test shall be cut out and replaced while under purge following the procedures detailed in Section 3.02B - Welding.

H. All tests shall be witnessed and verified by the SDR.

I. Check all pressure relief valves and regulators for pressure settings. Pressure relief valves shall be reset and documented following procedures outlined in the Sandia Pressure Safety Manual.

J. Comply with all applicable codes and regulations to insure personnel safety during pressure tests.

K. At the conclusion of testing, the Contractor shall provide a certified statement reporting the following:

1. brief test description;

2. extent of systems tested;

3. test results and date(s) performed

4. note all failed joints, and all corrective action taken;

5. signatures of all persons witnessing the tests

L. Maintain system at positive pressure until system is placed in service. Pressure shall be maintained using 0.01 micron filtered nitrogen or argon from a cryogenic source. Gas shall be of the same purity as that used to purge tubing during the welding process.

M. Any deviations from approved testing procedures must be secured in writing from the SDR prior to incorporating as part of work scope.

3.04 QUALITY CONTROL

A. The Contractor shall notify the SDR a minimum of three working days prior to the completion of work to allow scheduling of analytical testing. Analytical testing shall not begin until the system has been pressure tested by the Contractor and accepted by the SDR.

B. Contractor shall provide all necessary equipment, materials and labor as required to commence and complete all tests designated as Contractor responsibility.

C. Contractor shall be responsible for performing and certifying pressure test per Section 3.03 - Pressure Test Procedure at the completion of system installation.

D. Contractor shall verify the operation of emergency hydrogen and toxic gas shutoff systems in the presence of the SDR.

E. Contractor shall test welder, welding machine, and machine program on size of tubes to be joined and installed by preparing longitudinally sectioned sample of joints for review by the SDR. Samples shall be bagged, dated and identified per Section 3.02B - Welding. Tests shall be performed at:

1. the beginning of each shift;

2. the end of each shift;

3. each change of tubing size, or change of tube or fitting heat number;

4. any change in welding procedure, materials, equipment or equipment adjustments, interruption of power, or change of power source.

F. Samples shall be examined for soundness of joints and weld contamination. Contractor shall not clean or polish any welds prior to submitting to the SDR. Joints shall have 100% penetration.

G. Submit samples of welded joints, as required by Section 3.05 - Inspection, for evaluation and/or testing. If required by the SDR, up to 5% of the installed welded joints may be cut out for inspection and testing. Failure to comply to the specified requirements may require additional samples or removal of installed welded joints or tubing. All cost associated with

preparation, fabrication and removal of samples will be at the expense of the Contractor. All joints and/or tubing removed for failure to meet the specified requirements shall be replaced at the Contractor's expense.

H. Any deviations from specified procedures must be secured in writing from the SDR prior to incorporating as part of work scope.

I. Sandia will perform a helium leak test on all welded and mechanical joints, and miscellaneous components upon completion of the pressure test performed as detailed in Section 3.02 - Pressure Test Procedure. The test shall be performed as follows:

1. Using the turbo molecular pump on the helium leak detector, the system shall be evacuated to a maximum pressure of 1×10^{-4} mbar.

2. The background level of the leak detector shall be measured and recorded at less than 1×10^{-8} atmos cc/sec prior to beginning testing.

3. Each weld, fitting, valve, and miscellaneous component shall be flooded with helium gas. Allow a minimum of 1 minute per 100 feet of tubing from the helium leak detector for leak detection. The joint, fitting, or component shall be considered passed if there is no single leak greater than 1×10^{-8} atmos cc/sec above the recorded background level. All joints, fittings, or components not passing the helium leak test shall be repaired or replaced at the Contractor's expense, and a second test performed.

4. The entire system shall be considered passed if the sum of all recorded leak rates at individual joints, fittings, and miscellaneous components does not exceed 3×10^{-8} atmos cc/sec.

J. Sandia shall perform a particulate analysis on all UHP gas lines installed under this specification. All particulate testing shall be performed in the following manner:

1. A background count shall be determined by connecting the particle counter inlet to a 0.1 micron absolute filter and observing the number of counts per volume. Background counting shall begin at least 8 hours prior to beginning particulate analysis.

2. Samples shall be withdrawn from each valved outlet in the system, as well as the end point of all UHP gas lines. Samples shall be taken by connecting the particle counter to the system using a Cajon VCR type face seal fitting. Sample gas flow rate shall be sufficient to produce and maintain turbulent flow (Re > 4000).

3. Particle counts shall not exceed the following limits:

0.01 micron	< 50 per scf
0.1 micron	< 10 per scf
0.2 micron	< 5 per scf
0.3 micron	0
0.4 micron	0
0.5 micron	0
1.0 micron	0

4. The duration of each individual test shall be such that a total of 10 scf of effluent is sampled by counter per test point, or effluent is sampled for a 10 minute period per point, whichever is greater. Each test shall be terminated upon conformance to the specification and approval by the SDR. A test shall be considered failed if the gas sample does not meet specification within a 30 scf sample or a 30 minute period, whichever is greater. Failed lines shall be turned over to the installing Contractor for purging before a retest is begun. All additional purging required for retesting shall be at the Contractor's expense.

5. Each system shall be documented as acceptable and certified as such in accordance with specification at each outlet.

K. Sandia shall perform a residual impurity analysis on the UHP system to detect residual moisture, oxygen, and total hydrocarbon content (THC) which may have been physisorbed or chemisorbed by the interior walls of the distribution piping or miscellaneous components. The tests shall be done with nitrogen from a cryogenic source filtered to 0.01 microns. The cryogenic source gas shall be certified by the supplier as having no impurities in excess of 100 ppb. All residual testing shall be performed in the following manner:

1. For comparative analysis, the nitrogen purge source shall be tested before trace gas analysis of the systems. If the nitrogen purge source is from dewars, these tests shall be repeated daily during the use of the dewar to detect possible changes in contaminant levels. Nitrogen shall be used as the purge gas for all tests unless otherwise specified in writing by the SDR.

2. Sample gas shall flow continuously throughout the sampling period at a rate no greater than 10 scfh to eliminate any dilution of sample contamination due to excess flow.

3. The system shall be certified as acceptable and documented as such if in accordance with specification, the delta increase from source to sample point of each impurity does not exceed the following levels:

Oxygen	< 10 ppb
Moisture	< 10 ppb
Total hydrocarbon content	< 10 ppb

4. A test shall be considered failed if the sample gas does not meet specification within one hour. Failed lines will be turned over to the installing Contractor for cycle purging before a retest is begun.

L. Instrument calibration certification for all test equipment shall be submitted in writing to the SDR for approval prior to beginning any testing.

M. All tests shall be witnessed and documented by the SDR. Upon completion of testing, all test documents shall be submitted to the SDR for approval.

N. At completion of testing, all systems and components shall be restored to normal operating conditions. All mechanical joints and fittings shall be marked in a manner which will provide a tamper-proof indicator that the joint or fitting has been checked and certified as helium leak tight. The method for marking joints shall be approved in writing by the SDR prior to the start of testing.

O. The Contractor shall incorporate the following minimum quality control provisions:

1. Workers shall check in daily with signature

2. Provide a clean, controlled material authorization point

3. Maintain a daily log reflecting work performed and personnel assigned to each task

P. The Contractor is responsible for any and all retesting, recleaning, or replacement required to meet leak, particle, and residual gas testing.

3.05 INSPECTION

A. Sandia may retain an independent inspector to monitor the installation of the UHP systems. His responsibilities and observation shall include:

1. Select samples of tubing joints which may be removed from installed systems or fabricated samples 6" in length for quality check;

2. A duplication master plan shall be maintained by the special inspector and Contractor which identifies daily work progress, welds accomplished, and name of welding machine operator;

3. Verify and document purge gas pressure and purity at source and run outs;

4. Verify and document that only approved materials are used;

5. Verify and document that installation methods and technologies conform to manufacturer's installation instructions;

6. Assure cleanliness of conditions of work area;

7. Document workers daily attitude.

B. The special inspector shall be authorized to stop work when non-conforming work is observed or results of tests indicate improper execution of the installation. Additional samples, testing procedures, or modifications required to restore the system to specified requirements shall be at the installing Contractor's expense.

END OF SECTION