SSTD-8070-0069-PIPE
Revision C
AUGUST 2019

National Aeronautics and
Space Administration

John C. Stennis Space Center
Stennis Space Center, MS 39529-6000

COMPLIANCE IS MANDATORY

John C. Stennis Space Center
Low Pressure Vacuum Jacketed Pipe

Approved in DDMS by:

C. Brennan Sanders	8-28-19
NASA SSC Center Operations Facilities Engineering Test Complex Support	Date

Concurrence in DDMS by:

Bartt J. Hebert	8-23-19
NASA SSC Engineering & Test Directorate	Date
Son K. Le	8-15-19
NASA SSC Safety & Mission Assurance	Date
Gina H. Ladner	8-15-19
NASA SSC Facility Services	Date

Issued by

ISSUED CEF	8-28-19
Central Engineering Files	Date

Document History Log

Revision	Date	Originator / Phone	Description
Basic	11/21/08	D. Dike, x8-2803	**John C. Stennis Space Center (SSC) Central Engineering Files (CEF) Archive Note: This standard supersedes: COE Contracts 1544, Section 47; 1550, Section 54; 1580, Section 4; 2090, Section 49; 2876, Section 51; and 2899, Section 27.** Initial release of standard in document format corresponding to Stennis Document Numbering System (SDNS) and Stennis Space Center Procedural Requirement (SPR) 1400.1, *John C. Stennis Space Center Document Preparation, Numbering, and Management Procedural Requirements*. This standard supersedes SSC STD 47-044 Rev. A. Added/specified sections per SPR 1400.1 where appropriate throughout the document. Updated documentation references to reflect current SSC Standards and SPRs. Updated type/size of materials and testing requirements as needed.
A	7/01/14	D. Dike, x8-2803	Regular five year review. References updated. Added "limits specified by the EJMA Standard. Where liners are required, they shall be designed and fabricated in accordance with the EJMA Standard" to 5.1.4o. Added "[This required surface finish is smoother than the 63 micro-inch roughness required by ASME B16.5.]" to 5.1.5d. Added "Class 2 is permitted if the minimum service media temperature is no less than -325°F or if minimum temperature of stud/bolt material is determined to be no less than -325°F by FEA and in accordance with ASME B31.3 Paragraph 301.3.3. Otherwise Class 1 stud/bolt material is required. [Fluids other than cryogenic hydrogen and helium have minimum service temperatures that are -325°F or higher. Liquid and slush hydrogen and helium have minimum service temperatures below -325°F.] Stud/bolt torqueing or tensioning sequence and procedures shall be developed and used in accordance with ASME PCC-1 for each flange joint size and type to assure proper joining of flanges without overstressing studs/bolts." to 5.1.7a. Added 5.1.12.5 Inner Pipe Leakage Tests. Deleted "All inner pipe segments, sections, and spools which have surfaces precision-cleaned to RPTSTD-8070-0001 shall be packaged and preserved at their specified cleanliness levels in accordance with NASA/SSC Drawing 54000-GP11 *Packaging and Preservation of Cleaned Components*. All

A (Cont.)	7/01/14	D. Dike, x8-2803	hardware that is precision cleaned to RPTSTD-8070-0001 Cleanliness Levels 1, 1X, 1XX, 1XXX, or 2A shall be treated as LO/GO components with respect to packaging requirements (section 3.3 of NASA/SSC Drawing 54000-GP11 applies). All hardware that is precision cleaned to RPTSTD-8070-0001 Cleanliness Levels 2, 2X, 2XX, or 4 shall be treated as NON-LO/GO components with regards to packaging requirements (section 3.4 of NASA/SSC Drawing 54000-GP11 applies) from 5.1.13. Multiple changes to 5.2.14.5 Outer Pipe Leakage Test including adding sections f-i. Added "For vacuum jacketed pipe sections and spools fabricated, inspected, and tested by a commercial manufacturer at a facility outside of NASA/SSC, the field joints of the inner pipe shall be tested for leakage in accordance with Section 5.1.12.5 prior to installation or connection of the field-installed vacuum closures. The field-installed vacuum closures shall then be leak tested in accordance with the above paragraph or in accordance with Section 5.2.14.5, Parts b. through I" to 5.2.14.7. Reworded 5.3a to say: "Unless stated otherwise in contract specifications or drawings, the contractor/vendor shall furnish the Contracting Officer with information included in Table 2 below and in accordance with requirements shown on this table. Where there is a conflict between requirements of Table 2 and those of contract specifications or drawings, the latter requirements govern."
A-1	7/8/14	D. Dike x8-2803	Administrative changes for formatting issues.
A-2	02.12.16	R. Carol Wolfram x8-1164	Administrative change. Replaced "FOSC" with "SACOM" throughout document.
B	5.01.19	D. Dike X8-2803	Five-year review. Updated cover sheet to reflect approval by CO PMD, with concurrence by E&TD and SMA. Updated references and acronyms. 5.1.2, Inner Pipe: Revised to allow Sch 10S instead of Schedule 5S pipe for cases where additional stiffness or strength is required or where material availability provides a viable option for cost or schedule savings. 5.1.7, Inner Pipe Flange Bolting: Revised to add Monel K500 Alloy bolts, studs and nuts as an allowed option to the typical stainless steel bolts, studs, and nuts.

C	8.21.19	Larry DeQuay Ext. 8-1956	Section 5.1.12.4-c: Changed "ASME PCC-2, Part 5, Section 6.2" changed to "ASME PCC-2, Part 5, Article 501, Sub-article 501-6.2." Also, "subsection 6.2 *(k)*" changed to "Sections *(i)* and *(l)* of this sub-article."

Table of Contents

1.0 PURPOSE

This John C. Stennis Space Center (SSC) standard (SSTD) specifies materials and construction criteria for the inner and outer piping for cryogenic service vacuum jacketed piping. The nominal size range for the inner piping is ½-inch through 16-inches. The maximum internal operating/service pressure for the inner piping is 275 psig.

2.0 APPLICABILITY

This SSTD applies to all personnel at SSC involved with performing and/or supervising vacuum jacketed piping for cryogenic service at service pressures that do not exceed 275 psig.

3.0 REFERENCED DOCUMENTS

All references are assumed to be the latest version unless otherwise indicated.

ASME BPV Code, *Boiler and Pressure Vessel Code, Sections II, V, VIII, and IX*

ASME B16.20, *Metallic Gaskets for Pipe Flanges - Ring-Joint, Spiral-Wound, and Jacketed*

ASME B16.21, *Non-Metallic Flat Gaskets for Pipe Flanges*

ASME B16.25, *Buttwelding Ends*

ASME B16.28, *Wrought Steel Buttwelding Short Radius Elbows and Returns*

ASME B16.5, *Pipe Flanges and Flanged Fittings*

ASME B16.9, *Factory-Made Wrought Buttwelding Fittings*

ASME B18.2.1, *Square, Hex, Heavy Hex, and Askew Head Bolts, and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)*

ASME B18.2.2, *Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex, Flange, and Coupling Nuts (Inch Series)*

ASME B31.3, *Process Piping*

ASME PCC-1, *Guidelines for Pressure Boundary Bolted Flange Joint Assembly*

ASME PCC-2, *Repair of Pressure Equipment and Piping*

ASTM A182, *Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service*

ASTM A194, *Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both*

ASTM A240*, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and General Applications*

ASTM A312, *Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes*

ASTM A320, *Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low-Temperature Service*

ASTM A358, *Standard Specification for Electric-Fusion-Welded Austenitic Chromium-Nickel Stainless Steel Pipe for High-Temperature Service and General Applications*

ASTM A403, *Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings*

ASTM F467, *Standard Specification for Nonferrous Nuts for General Use*

ASTM F468, *Standard Specification for Nonferrous Bolts, Hex Cap Screws, Socket Head Cap Screws, and Studs for General Use*

DRD SA01-3.0, *Safety and Health Plan*

EJMA Standards, *Standards of the Expansion Joint Manufacturers Association, Inc. with Addenda*

MIL-I-24768, *Military Specification: General Specification for Insulation, Plastics, Laminated, Thermosetting*

MSFC-STD-3535, *Standard for Propellants and Pressurants used for Test and Test Support Activities at SSC and MSFC*

MSS SP-6, *Standard Finishes for Contact Faces of Pipe Flanges and Connecting- End Flanges of Valves and Fittings*

RPTSTD-8070-0001, *Surface Cleanliness Standard of Fluid Systems for Rocket Engine Test Facilities of the NASA Rocket Propulsion Test Program*

SAE AS4395, *Fitting End, Flared Tube Connection, Design Standard*

SAE AS5202, *Port or Fitting End, Internal Straight Thread, Design Standard*

SNT-TC-1A, *ASNT's guideline to Personnel Qualification and Certification in NDT*

SQP-5300-0016, *Certification of NDT Personnel*

SPR 1400.1, *John C. Stennis Space Center Document Preparation, Numbering, and Management*

SPR 1440.1, *John C. Stennis Space Center Records Management Program Requirements*

SPR 8715.1, *John C. Stennis Space Center Safety and Health Program Requirements*

SSC Drawing 54000-GM00, *Flange Gasket, LO/GO Compatible*

SSC Drawing 54000-GM30, *Specifications for Material Used in LOX and GOX Service Exempt from Batch Test Requirements*

SSC Drawing 54000-GP11, *Packaging and Preservation of Cleaned Components*

SSTD-8070-0005-CONFIG, *Preparation, Review, Approval, and Release of SSC Standards*

SSTD-8070-0013-WELD, *Classes of Welding Inspection*

SSTD-8070-0017-WELD, *Gas Tungsten Arc Welding of Austenitic Stainless Steel Pipe/Plate*

4.0 RESPONSIBILITIES

Responsibilities for use and control of this SSTD and for the review and approval of revisions or cancellation of this SSTD shall be as specified in SSTD-8070-0005-CONFIG and the applicable documents referenced herein.

5.0 REQUIREMENTS

a. Requirements for design, fabrication, inspecting, and testing of inner pipelines shall conform to ASME B31.3, except where stated otherwise in this SSTD, and all subsections under section 5.1 in this SSTD.

b. Requirements for design, fabrication, inspecting, and testing of outer pipelines and vacuum closures/annuluses shall conform to ASME B31.3, except where stated otherwise in this SSTD, and all subsections under section 5.2 in this SSTD.

5.1 Inner Pipelines

Inner pipelines are defined as pipe, pipe fittings, pipe spools, tubing, and tube fittings that contain and convey the service media which in turn are enclosed by outer vacuum jacketing (outer vacuum jacket pipelines).

5.1.1 Inner Pipeline General Requirements

a. Allowed service media for the inner pipelines is cryogenic, slush, liquid and gaseous air, helium, hydrogen, methane, natural gas, nitrogen, and oxygen. Non-cryogenic liquid hydrocarbons may also be contained in and conveyed through inner pipelines in cases where minimal heat leakage from environment to service media is required.

b. Inner line design pressure shall not exceed 275-psig, except where flange materials require down-rating of inner pipelines to 230-psig (reference section 5.1.5 below).

c. Allowed service media temperature range is from -423°F to +130°F.

5.1.2 Inner Pipe

a. Inner pipe shall be seamless or seam welded Schedule 5S stainless steel in accordance with ASTM A312, TP 304L, dual rated TP 304/304L, TP 316L, or dual rated TP 316/316L; or ASTM A358, Gr. 304L, dual rated Gr. 304/304L, Gr. 316L, or dual rated Gr. 316/316L.

b. Schedule 10S pipe may be used instead of Schedule 5S pipe for cases where additional stiffness or strength is required or where material availability provides a viable option for cost or schedule savings. When and where Schedule 10S pipe is used, drawings shall show specific pipe spool and system locations where this pipe schedule is used.

c. Where Schedule 10S pipe is buttwelded to Schedule 5S pipe and fittings, weld end transitions shall be provided at the effected buttweld end preparations of the Schedule 10S pipe so that these end preparations match those of the Schedule 5S fittings.

d. Weld end transitions shall conform to requirements of ASME B16.25.

e. The inside diameter counterbore at each transition shall have a 3-to-1 taper minimum (18.4-degree maximum included cone half angle).

f. The surface finish on all internal, service media wetted surfaces and on all weld end preparations of pipe shall be 250 Root Mean Square (RMS) or smoother.

5.1.3 Inner Pipe Fittings

a. Inner pipe fittings shall be seamless or seam welded Schedule 5S stainless steel in accordance with ASTM A403, TP 304L, dual rated TP 304/304L, TP 316L, dual rated TP 316/316L, or TP 347; or ASTM A182 Gr. F304L, dual rated Gr. 04/304L, Gr. F316L, dual rated Gr. F3016/316L, or Gr. F347.

b. Fittings shall be buttweld type with dimensions conforming to ASME B16.9 or ASME B16.28.

c. Short radius elbow and return fittings per ASME B16.28 shall be used only where specified on pipe system or spool drawings.

d. Schedule 10S fittings may be used instead of Schedule 5S fittings for cases where additional stiffness or strength is required or where material availability provides a viable option for cost or schedule savings. When and where Schedule 10S fittings are used, drawings shall show specific pipe spool and system locations where these fittings are used.

e. Where Schedule 10S fittings are buttwelded to Schedule 5S pipe and fittings, weld end transitions shall be provided at the effected buttweld end preparations of the Schedule 10S fitting so that these end preparations match those of the Schedule 5S fittings.

f. Weld end transitions shall conform to requirements of ASME B16.25.

g. The inside diameter counterbore at each transition shall have a 3-to-1 taper minimum (18.4-degree maximum included cone half angle).

h. The surface finish on all internal, service media wetted surfaces and on all weld end preparations of pipe fittings shall be 250 RMS or smoother.

5.1.4 Inner Pipe Flexible Convolute Sections

a. The use of flexible convolute sections (bellows) on inner piping shall be used only where design constraints on pipe routing, length, or pressure drop precludes the use of other methods to prevent overstress conditions due to thermal displacements and strains of pipe systems and sections.

b. The design and fabrication of each convolute section shall conform to all applicable requirements of Expansion Joint Manufacturers Association, Inc. (EJMA) standards and rated for no less than 5000 cycles at the full rated axial, lateral, and angular displacements expected for the respective convolute section.

c. All convolute sections shall be made of Type 321 stainless steel in accordance with ASTM A240, ASTM A312, or ASTM A358.

d. Single- or multi-ply convolute sections may be used, but the multi-ply sections shall have no less than three (3) plies.

e. Convolute sections shall have buttweld ends and be buttwelded to pipe and pipe fittings in accordance with section 5.1.11.

f. The inside diameters, outside diameters, and wall thickness of the convolute section stub ends shall match those of the adjoining pipe or pipe fitting within required dimensional tolerances.

g. All tube, pipe, or cylinders with longitudinal seam welds used for the fabrication of convolute sections shall have these welds 100% radiographically inspected in accordance with ASME B31.3 prior to forming the convolutes.

h. These welds and inspection of these welds shall fully conform to ASME BPV Code section VIII and IX requirements.

i. The seam welds shall be planished after welding to within 10% of the original sheet/wall thickness.

j. The surface finishes on all tube, pipe, or cylinders used for the fabrication of flexible convolute sections shall be 125 RMS or smoother.

k. Convolutions shall be "U" shaped and formed with uniform pitch and matching height.

l. Convolute sections shall be provided and installed into the pipe system, section, or spool in the as-formed condition.

m. Where determined by calculations and manufacturer data as being needed, sections of pipelines containing flexible convolute sections shall be equipped with external supports, such as tie rods, to contain axial loads applied to the convolute section that result from internal service media pressure.

n. Circumferential welds joining one convolute section to another are not permitted.

o. Convolute sections shall be equipped with internal flow liners when fluid line flow velocities are expected to exceed limits specified by the EJMA Standard. Where liners are required, they shall be designed and fabricated in accordance with the EJMA Standard.

p. Convolute section liners shall be equipped with external ports having SAE AS5202 thread connections, internal drain holes, and dimensional clearances that enable pressure spray and complete gravity draining of solvents used for precision cleaning of all surfaces in annular region between each liner and convolute section.

q. External ports, if provided, shall be of sufficient length to penetrate through the outer (vacuum jacket) piping.

r. For each convolute section equipped with a liner, the adjacent pipe or pipe fitting buttwelded to each end of the convolute section shall be permanently marked with a flow direction arrow.

s. For each flexible convolute section, the manufacturer shall provide calculations in accordance with EJMA standards as proof that the respective convolute section fully conforms to requirements in this section.

5.1.5 Inner Pipe Flanges

a. Unless specified otherwise on drawings at specific flange joint locations, flange connections used on inner pipe spools shall be ASME B16.5 150# Class Weld Neck Raised Face or Weld Neck Ring Type Joint (RTJ) Flanges made of either:

1. ASTM A182 Gr. F304/F304L or Gr. F316/316L dual rated stainless steel where material fully conforms to ASME B31.3 requirements and meets chemical composition requirements for both type 304 and 304L or both type 316 and 316L stainless steels. Furthermore, certified material test reports, showing that the ultimate tensile and yield stresses are no less than 75-ksi and 30-ksi respectively, are required for all flange materials.
2. ASTM A182 Gr. F304L or F316L stainless steel. In this case, all pipe sections and spools containing flanges made of this material shall be down-rated to pressures of 230-psig or lower.

b. The surface finish on all flange bores and weld end preparations shall be 250 RMS or smoother.

c. Raised face flanges shall have concentric 90-degree V-groove ring serrations in the flange face in accordance with MSS SP-6.

d. RTJ flanges shall have 16 RMS or smoother surface finish on the seal ring contact surfaces. (This required surface finish is smoother than the 63 micro-inch roughness required by ASME B16.5.)

e. RTJ flanges shall be used only at specific locations as indicated on pipe system, section, and spool drawings.

f. Raised face flanges shall be used where RTJ flanges are not used.

5.1.6 Inner Pipe Flange Gaskets and Seals

a. Gaskets used for Raised Face Flanges shall be per SSC Drawing 54000-GM00 or be 304L or 316L Flexitallic Style CGI, Class 150, spiral wound with stainless steel and pure Virgin Tetrafluoroethylene (TFE) filler 0.175" thick with 0.125" thick stainless steel inner and outer gauge rings.

b. Gaskets shall compress to 1/8" thickness.

c. For oxygen service rated piping systems, the TFE used in gaskets and seals shall be certified from the TFE manufacturer and in conformance with requirements of NASA/SSC Drawing 54000-GM30.

d. Seals used for Ring Type Joint Flanges shall be octagonal type per ASME B16.20 made of type 304 or 316 stainless steel conforming to properties required by ASME B16.20.

5.1.7 Inner Pipe Flange Bolting

Bolting shall consist of:

a. Studs: ASTM A320, Grade B8 (AISI Type 304 stainless steel) or ASTM F468, Alloy 500 (Monel Alloy K500, UNS No. N05500).

b. For ASTM A320, Grade B8 studs/bolts, Class 2 is permitted if any of the following requirements are satisfied:

1. The minimum service media temperature is no less than -325°F,
2. Minimum temperature of stud/bolt material is determined to be no less than -325°F by Finite Element Analysis (FEA) and in accordance with ASME B31.3 Paragraph 301.3.3,
3. Studs/bolts are Charpy impact tested in accordance with ASTM A320 Supplemental Requirement S1 at test temperatures of -325°F or lower. Furthermore, these studs/bolts shall also be permanently marked with material heat number traceable to Certified Material Test Reports (CMTRs) that include the Charpy impact test results.

If all conditions above are not satisfied, Class 1 stud/bolt material is required. (Fluids other than cryogenic hydrogen and helium have minimum service temperatures that are -325°F or higher. Liquid and slush hydrogen and helium have minimum service temperatures below -325°F.) Stud/bolt torqueing or tensioning sequence and procedures shall be developed and used in accordance with ASME PCC-1 for each flange joint size and type to assure proper joining of flanges without overstressing studs/bolts.

c. Nuts: ASTM A194, Grade 8 or 8F (AISI Type 304 or 303 stainless steel) used with stainless steel studs/bolts; or ASTM F467, Alloy 500 (Monel Alloy K500, UNS No. N05500) used with Monel Alloy K500 studs/bolts.

d. If ASTM F468 studs/bolts and ASTM F467 nuts are used for flanged and other mechanical joints not inside vacuum closures, provisions to prevent galvanic corrosion of contacting dissimilar metals in a moist environment, such as installation of insulating grommets and spacers, shall be applied.

e. ASTM A194, Grade 8F nuts shall only be used for flanged joints inside vacuum closures.

5.1.8 Inner Pipe Boss Connections

a. SAE AS5202 (formerly MS33649) threaded bosses shall be welded to pipe and pipe fittings.

b. These bosses shall be used for all locations where instrumentation or tubing systems connect to pipe systems, sections, and spools.

c. The thread connection seal shall be located no less than 6-inches from the root pass of the boss-to-pipe or boss-to-fitting weld joint.

d. Boss thread connections shall be accessible without removal of vacuum closures around the inner pipeline.

e. Boss connection fittings shall be made of type 304L, dual rated 304/304L, 316L, dual rated 316/316L, or 347 stainless steel conforming to ASTM A182, A403, or A312.

f. The surface finish on all internal, service media wetted surfaces and weld end preparation surfaces of boss fittings shall be 250 RMS or smoother.

g. The surface finish on all seal contact surfaces shall be 16 RMS or smoother.

h. The minimum wall thickness of each boss fitting shall be no less than two-times that required by ASME B31.3 with 275-psig internal pressure to accommodate external loads that could potentially be applied to these fittings.

i. The outside diameter on the full axial length of thread connection end of the boss fittings shall be no less than the “G” minimum diameter dimension required in SAE AS5202.

j. All tubing systems, tube fittings, and instruments that are connected to pipeline bosses shall not be vacuum jacketed.

5.1.9 Inner Pipe Boss Connection Seals

a. For SAE AS5202 threaded bosses, virgin TFE coated type 304 or A286 stainless steel or virgin TFE coated Inconel X-750® Stanley Harrison K-Seals® or equivalent shall be used.

b. For oxygen service rated piping systems, the TFE used for seals shall be certified from the TFE manufacturer and in conformance with requirements of NASA/SSC Drawing 54000-GM30.

5.1.10 Inner Pipe Standoffs

a. The inner pipe shall be supported within the jacket by a support system designed to absorb all loads on the inner pipe when completely filled with water or service media, minimize heat gain to be within limits shown in Table 1 of section 5.2.2, and withstand loading as listed below during shipping of the empty pipe sections.

1. Three "g" load applied vertically downward.
2. Two "g" load applied vertically upward.
3. Two "g" load applied horizontally (longitudinally or laterally) combined with one "g" load vertically downward. In addition, it shall be designed to accept external loads furnished by others resulting from stress analysis of the system. (Refer to individual isometric drawings for load information and pipe support locations.)

b. All metallic standoffs and components thereof shall be type 304 or 304L stainless steel conforming to one or more of the applicable ASTM specifications listed in section 3.0 of this SSTD.

c. Standoff fastener materials shall conform to section 5.1.7 of this SSTD.

d. Non-metallic thermal insulating materials, including TFE, micarta, and G-10 CR plastic may be used in standoffs provided that these materials are subjected to only compression loads and minimal shear loads due to friction between sliding parts. The G-10 CR insulation material shall conform to requirements of MIL-I-24768 Type GEE.

5.1.11 Inner Pipe Welding and Weld Joints

a. Weld end preparations shall be in accordance with ASME B16.25 and SSTD-8070-0017-WELD.

b. All welds shall conform to SSTD-8070-0017-WELD.

c. Inspect all pressure containing weldments, except for longitudinal weldments on flexible convolute sections (bellows), in accordance with applicable section 5.1.12 requirements and SSTD-8070-0013-WELD, Class 1. Pressure containing weldments include all longitudinal seam welds on pipe and fittings.

d. Inspect all longitudinal weldments on flexible convolute sections in accordance with applicable requirements of section 5.1.4 of this SSTD.

e. Inspect all other weldments, including those joining standoffs to the inner pipelines, in accordance with applicable requirements of section 5.1.12.

f. Invar 36 that may be present in selected locations of previously fabricated vacuum jacketed piping system shall be replaced with type 304L stainless steel materials conforming to requirements of this SSTD if welded construction is required.

g. When Invar 36 materials are replaced with type 304L or 316L stainless steel, analyses shall be performed and all required geometric modifications, supported by the same analyses, be implemented to provide the needed mechanical strength properties for pressure containment and other applied loads as required by ASME B31.3.

CAUTION

Observe pipe marking before welding or cleaning of vacuum jacketed (VJ) inner pipe. Invar 36 material was originally installed in some lines.

5.1.12 Inner Pipe Inspections and Tests

5.1.12.1 Inner Pipe Visual Inspections

Perform 100% visual inspection of all weldments in accordance with ASME B31.3. Repair or replace and then re-inspect welds found to be defective. These processes shall be repeated at no additional cost to the government until all welds pass inspection.

5.1.12.2 Inner Pipe Radiographic Inspections

A 100% radiographic inspection per ASME B.31.3 is required for 100% of the pressure containing welds accessible to this type of inspection.

a. 100% dye-penetrant inspection at root and cover pass or ultrasonic inspection per ASME B31.3 is required for all pressure containing welds not accessible to radiographic inspection. If ultrasonic inspection is used, it shall cover 100% of welds not inspected by radiographic and dye-penetrant inspections.

b. 100% radiography of all pressure containing castings is required.

c. Pipe, tube, or cylinders that will be formed into convolutions for flex hoses and expansion joints shall be radiographically examined in accordance with ASME B31.3 prior to the convolutions being formed.

d. Radiographic inspection shall include 100% of pressure containing buttwelds, including seam welds.

e. Radiographic film shall be submitted for NASA's review and approval. NASA will retain control of the film.

f. All weld inspections and tests shall be performed in accordance with the ASME Boiler and Pressure Vessel Code and SNT-TC-1A.

g. Personnel performing inspections shall be qualified in accordance with SNT-TC-1A.

h. Repair/replace and reinspect welds found to be defective.

i. All processes and requirements stated in this section shall be repeated at no additional cost to SSC until all welds pass inspections.

5.1.12.3 Inner Pipe Dye-Penetrant Inspections

a. All pressure containing welds that cannot be radiographic examined shall be 100% dye-penetrant inspected.

b. All multi-pass pressure containing welds that are dye-penetrant inspected shall be inspected at the root and cover pass.

c. Inspection results shall be submitted to National Aeronautics and Space Administration (NASA) for review and approval.

d. 100% of welds that are not pressure containing, including those joining standoffs to the inner pipeline, shall be dye-penetrant inspected.

5.1.12.4 Inner Pipe Pressure Tests

a. The inner line and drain pipe shall be hydrostatically or pneumostatically pressure tested in accordance with ASME B31.3 requirements for "leak testing." [ASME B31 Code Case 180 may be applied where it is impractical to leave welds accessible for visual inspection during pressure tests.]

b. Water with a maximum chloride content of 100 ppm shall be used for hydrostatic pressure tests.

c. Pneumostatic pressure tests are permitted only for cases where:

1. All safety precautions stated in ASME PCC-2, Part 5, Article 501, Sub-article 501-6.2 have been reviewed with supporting documentation and implemented to the

maximum extent practicable and where they do not conflict with allowances and requirements of this SSTD,

2. All safety precautions mandated by ASME PCC-2, Part 5, Article 501, Sub-article 501-6.2, with the exception of Sections *(i)* and *(l)* or this sub-article, have been implemented and documented, and
3. The NASA/SSC safety organization has approved this type of test.

d. Air, helium, or nitrogen gas at a test pressure of no less than 125% of design pressure shall be used for pneumostatic pressure tests.

e. In most cases, the pneumostatic pressure test is performed in lieu of hydrostatic pressure tests where the tested pipe system, section, or spool has been precision cleaned in accordance with RPTSTD-8070-0001. For these cases, the test gas shall conform to purity requirements of MSFC-STD-3535. If pressure tests are performed in conjunction with leakage tests per section 5.1.12.5, the test gas shall be helium conforming to purity requirements of MSFC-STD-3535.

f. The test pressure shall be maintained for a minimum of ten (10) minutes for all pressure tests.

g. There shall be no observable or visible leaks and there shall be no permanent deformations during and after pressure tests.

5.1.12.5 Inner Pipe Leakage Tests

a. Helium gas mass spectrometer leak tests of each inner pipeline system, section, and spool shall be performed after completion of pressure testing or in conjunction with pneumostatic pressure testing.

b. All standoffs or components thereof that are welded to the inner pipeline, including anchors, doubler plates, spacers, and guides, shall be joined to the inner pipeline prior to performance or leakage tests.

c. All field weld joints shall be exposed and uninsulated for examination during testing and shall be left unprimed and unpainted prior to and during testing.

d. If inner pipe leak tests are performed before installation of the outer piping, bag completed spools in polyethylene sheeting. The inner lines shall also be externally loaded or supported to simulate actual loads that will exist after installation of the outer piping.

e. If inner pipe leak tests are performed after installation of the outer piping, bag completed spools in polyethylene sheeting such that both inner and outer lines are soaked with gaseous helium. Gaseous helium should not be directly introduced into the annular space between inner and outer pipe (from past engineering experience, helium introduced into this space has been found to be difficult to remove).

f. If inner pipe leak tests are performed after installation of the outer piping, evacuate the annular space of the vacuum jacket of each inner pipeline system, section, and spool to 10 microns or less of mercury and maintain at that level by a mass spectrometer pump.

g. Helium test gas conforming to MSFC-STD-3535 shall be used. The inner pipe of each pipe system, section, spool shall be pressurized with the test gas to no less than its design pressure.

h. The test pressure shall be held for no less than 10 minutes or the minimum "leak test" time required by ASME B31.3, whichever is longer.

i. A leak indication less than 3×10^{-9} scc/sec helium with the mass spectrometer calibrated at 1×10^{-10} scc/sec. constitutes a successful test.

j. If the test is not successful and leakage is detected, the leak(s) shall be repaired and the effected pipeline system, section, or spool shall be retested for leakage in accordance with section 5.1.12.5 of this SSTD. If repairs are required for any welded joints, all repaired welds shall be re-inspected in accordance with Sections 5.1.12.1, 5.1.12.2, and 5.1.12.3 of this SSTD. If any pressure retaining and sealing welds need to be repaired, pressure and leakage tests shall be redone in accordance with Section 5.1.12.4 and this section.

k. A certificate of inspection and testing shall be provided by the organization(s) or entity/entities performing the leakage tests and those witnessing these tests.

5.1.13 Inner Pipe Precision Cleaning

All service media wetted surfaces of the inner pipeline shall be precision cleaned, certified as precision clean, and packaged and preserved in accordance with RPTSTD-8070-0001 and the cleanliness level (in this SSTD) required for the service media and the applicable pipe system, section, or spool location.

CAUTION

Observe pipe marking before welding or cleaning of VJ inner pipe. Invar 36 material was originally installed in some lines and special precision cleaning processes are required for this material. Consult NASA/SSC Engineering & Test Directorate, for cleaning of Invar 36 material.

5.2 Outer (Vacuum Jacket) Pipelines and Vacuum Annuluses/Closures

Outer (vacuum jacket) pipelines are defined as pipe, pipe fittings, and pipe spools which enclose inner piping, specified in section 5.1 of this SSTD, and which provides a vacuum environment around this piping in order to thermally insulate it from the ambient environment.

5.2.1 Outer Pipeline General Requirements

a. All materials used for outer pipelines shall be compatible with service media allowed for inner pipelines (reference section 5.1.1).

b. Requirements for design, fabrication, inspecting, and testing of outer pipelines shall conform to all subsections under section 5.2 in this SSTD.

c. Outer (vacuum jacket) pipeline internal operating/service pressure shall be 20-psig in accordance with ASME B31.3.

d. Outer pipeline shall be designed to withstand external pressures of 15-psig or higher per ASME B31.3.

e. Although the outer pipeline will normally be subjected to service temperatures between -20°F and +130°F, materials used for outer pipeline shall be rated for temperatures ranging from -423°F to +130°F in accordance with ASME B31.3.

f. When pipe supports for the outer pipeline are attached by others, these supports will be rated for a service temperature range of -20°F to +130°F.

g. The design and fabrication of the outer pipelines shall provide the required accommodations for others to install these supports.

h. Accommodations shall include external permanent markings that show required support locations with the type of supports, allowed pipeline movements, and maximum allowed loads as applicable at each location.

i. The outer piping shall include design features and provisions that enable others to weld or mechanically attach external supports, as necessary, to this piping with minimal risks of damage to or fluid leakage through the respective piping. These design features and provisions may include doubler plates, attachment brackets, and rings that are welded to the outer piping.

j. All metallic materials used for attachment of pipe supports to outer piping shall be a 300-series austenitic stainless steel, except type 303 stainless steel.

5.2.2 Allowed Heat Leakage

The allowed heat leakage from ambient atmosphere to the inner pipeline at a temperature of -423°F shall not exceed values shown on Table 1 below:

Table 1 – Allowed Heat Leakage

Inner Pipe Nominal Size	Straight Pipe Heat Leak BTU/HR-FT	Field Joint Heat Leak BTU/HR	Fittings Heat Leak BTU/HR
2.5" and smaller	0.86	9.5	4.5
3" and 4"	1.10	19	5.7
6"	1.90	33	9.0
8"	2.25	40	11.0
10"	2.65	50	13.5
12"	3.00	60	16.5
14" and 16"	3.50	75	21.0

5.2.3 Outer Pipe

a. For inner pipeline sizes that have a nominal size less than 4-inches, the outer vacuum jacket pipe shall be of a nominal size that is no less than 1.5-inches larger than that of the enclosed inner pipeline.

b. For inner pipeline sizes that have a nominal size of 4-inches and larger, the outer vacuum jacket pipe shall be of a nominal size that is no less than 2-inches larger than that of the enclosed inner pipeline.

c. Outer pipe shall be ASTM A312, TP 304 or TP304L seamless or seam welded stainless steel pipe or ASTM A358 Gr. 304 or 304L stainless steel pipe.

d. Schedule 5S wall thickness is adequate in all sizes; however, where physical abuse or heavy or concentrated external loading is predicted, either protective shields, doubler plates, or heavier walled pipe shall be used.

e. Heavier Schedule 10S or 40S pipe, spacers between inner and outer pipelines, or stiffening members shall be used where needed to prevent collapse or buckling of outer pipe when subjected to external and dead weight loads.

5.2.4 Outer Pipe Fittings

a. Outer vacuum jacket pipe fittings shall be seamless or seam welded Schedule 5S stainless steel in accordance with ASTM A403, TP304 or TP304L.

b. Fittings shall be buttweld type with dimensions conforming to ASME B16.9 or ASME B16.28.

c. Short radius elbow and return fittings per ASME B16.28 shall be used only where specified on pipe system or spool drawings.

d. Mitered pipe sections that are buttwelded together may be used for outer pipeline fittings that enclose inner pipeline fittings.

e. Heavier Schedule 10S or 40S pipe and pipe fittings, spacers between inner and outer pipelines, or stiffening members shall be used where needed to prevent collapse or buckling of outer pipeline fittings when subjected to external and dead weight loads.

5.2.5 Outer Pipe Flexible Convolute Sections

a. The design and fabrication of each convolute section shall conform to all applicable requirements of EJMA standards and rated for no less than 5000 cycles at the full rated axial, lateral, and angular displacements expected for the respective convolute section.

b. All convolute sections shall be made of type 304, 304L, 316, 316L, or 321 stainless steel in accordance with ASTM A240, ASTM A312, or ASTM A358.

c. Single or multi-ply convolute sections may be used, but the multi-ply sections shall have no less than three plies.

d. Convolute sections shall have buttweld ends and be buttwelded to pipe and pipe fittings in accordance with section 5.2.13.

e. The inside diameters, outside diameters, and wall thickness of the convolute section stub ends shall match those of the adjoining pipe or pipe fitting within required dimensional tolerances.

f. All tube, pipe, or cylinders with longitudinal seam welds used for the fabrication of convolute sections shall have these welds 100% dye-penetrant inspected in accordance with ASME B31.3 prior to forming the convolutes.

g. These welds and inspection of these welds shall fully conform to ASME B31.3 requirements.

h. The seam welds shall be planished after welding to within 10% of the original sheet/wall thickness.

i. After formation of the convolutes, all visible external surfaces of seam welds shall again be dye-penetrant inspected in accordance with ASME B31.3.

j. Convolutions shall be "U" shaped and formed with uniform pitch and matching height.

k. Convolute sections shall be provided and installed into the pipe system, section, or spool in the as-formed condition.

l. Where determined by calculations and manufacturer data as being needed, sections of pipelines containing flexible convolute sections shall be equipped with external supports, such as tie rods, to contain axial loads applied to the convolute section that result from internal service media pressure.

m. Circumferential welds joining one convolute section to another are not permitted.

n. For each flexible convolute section, the manufacturer shall provide calculations in accordance with EJMA standards as proof that the respective convolute section fully conforms to requirements in this section.

5.2.6 Vacuum Annulus/Closure Gettering System

a. A chemical gettering system shall be supplied for each enclosed vacuum annulus or closure of each fabricated spool assembly, with the exception of field welded joints and mechanically connected closures over inner pipeline flange joints.

b. The required material for installing this system in each joint sleeve along with detailed installation procedures shall be shipped as a contract requirement.

c. The system shall be capable of removing the majority of the mobile gases from out-gassing of components, along with atomic hydrogen gas, due to disassociation of materials.

d. The sorption materials shall be capable of rejuvenation.

e. The gettering system shall consist of a calcium zeolite desiccant (Linde® Type 5A or equivalent molecular sieve) and a hydrogen absorber such as palladium oxide.

f. The molecular sieve shall be securely attached to the inner pipe.

g. A procedure shall be developed and submitted for approval which gives the methods and design features for installation of molecular sieve and maintenance of this material in as dry as possible condition until the vacuum space is closed.

h. The contractor shall be responsible for determining the amounts of gettering materials required and substantiating this by calculation or rationale.

5.2.7 Thermal Insulation

a. Laminar radiation shielding shall be wrapped around all inner pipeline sections to be contained within vacuum closures/annuluses, with the exception of flanges and segments of pipeline contained within mechanically connected removable (mechanical) closures. For field weld joints, this shielding is to be applied after completion and acceptance of field welds on the inner pipeline.

b. The shielding shall consist of no less than fifteen (15) alternate layers of aluminized mylar, aluminized on both sides (for 30 total reflective surfaces), and Dexter paper (glass fiber insulation cloth).

c. The shielding shall enable heat leakage rates to be below values shown in Table 1 of section 5.2.2 with vacuum level equal to 200-microns of mercury, outer piping at +130°F, and inner piping at -423°F.

5.2.8 Outer Pipe Mechanical Closures

a. Unless shown or stated otherwise on pipe system, section, and spool drawings, all flange connections on the inner pipeline shall be enclosed in a mechanical (mechanically connected removable) closure that is isolated and separate from the vacuum annuluses/closures on the remaining sections of inner pipelines. These include pipeline connections to components, such as valves, filters, and flow meters, with wafer bodies or flange end connections.

b. Each mechanical closure shall enable access to inner pipeline flange connections without cutting of any inner or outer pipeline hardware.

c. Mechanical closures shall enable the vacuum closure/annulus around each flange connection to be re-closed and sealed off without any welding.

d. Mechanical closures shall consist of bolted inner flanges, external flanges, Voss® type or equivalent band clamp connections, or combinations of these.

e. The pipeline mechanical closures shall be designed and fabricated such that they are compatible with mating vacuum closure connections on valves, filters, and other components installed in the pipe system.

f. Dual inner and outer O-rings shall be used when and where there is sufficient radial distance across mating surfaces of the flanged or clamped connection to provide redundant sealing.

g. Where the vacuum closure connection on a connected component does not have a trapezoidal groove to contain each required O-ring seal, the mating surface of the pipeline mechanical closure shall contain these grooves.

h. All seal contact surfaces on these closures shall have 16 RMS or smoother surface finish.

i. Mechanical closures shall be designed and fabricated such that reduction of pressure inside the vacuum closure/annulus has the effect of increasing compression loads on the closure seals.

j. The design of pipe spools and sections shall provide sufficient clearances for mechanical closures to be unbolted/unclamped and moved to provide unobstructed access to O-Ring seals where these seals can be removed and replaced by hand and without the use of special tools.

k. Where possible and where it is not necessary to have identical vacuum closure connections on both ends of a valve/component, mechanical closures in vertical pipe runs should have O-Ring seal grooves on the lower closure mating surface for ease of O-ring seal installation.

l. All metallic parts of the mechanical closures shall be made of type 304, 304L, 316, 316L, 321, or 347 stainless steel in accordance with applicable ASTM specifications listed in section 3.0.

m. At each mechanical closure location, no less than one of the mechanical closures shall be equipped with an evacuation and vacuum measurement system as specified in section 5.2.11.

5.2.9 Outer Pipe Mechanical Closure Seals

Unless otherwise specified, mechanical closure seals shall be Viton® O-rings.

5.2.10 Boss Connection Vacuum Closures

a. Each boss fitting welded to pipe or pipe fittings shall be enclosed in a vacuum closure over its full length, except for the last one-inch or less axial length of the boss at the threaded connection.

b. The vacuum closure around each boss shall be integral (in communication) with the vacuum closure around the adjacent inner pipe or fitting welded to the respective boss fitting.

c. Lateral and axial clearances between each boss and its surrounding vacuum closure shall be one-inch or 1.5 times the minimum required to accommodate all calculated differential displacements between inner and outer pipelines at the respective boss location, whichever is greater.

d. If flexible convolute sections are used for boss vacuum closures, they shall have no less than three convolutions and they shall conform to requirements of section 5.2.5 of this SSTD.

5.2.11 Evacuation and Vacuum Measurement System

a. A one-inch vacuum seal-off valve assembly shall be located on each individual vacuum space including the field welded spool joint sleeves, which shall be contractor-supplied, and the mechanically connected vacuum closures over inner pipe flange joints.

b. Each seal-off valve assembly for all newly fabricated pipe segments and spools shall be one-inch weld-on PHPK VR-46-M® or approved equal.

c. Seal-off valve assemblies that are reused or acquired from previously existing pipe spools, segments, and systems shall be one-inch weld-on PHPK VR-46-M®, CVI V-1046-41®, or approved equal.

d. When CVI V-1046-41 ® seal-off valve assemblies are used for new construction or pipeline modifications, they shall be retrofitted with Viton® seals.

e. Four (4) seal-off valve operators which mate to the seal-off valve assembly shall be supplied for each assembly.

f. The seal-off valve assembly shall include, a thermocouple manifold tube, a thermocouple manifold tube isolation valve, two thermocouples, and a protective thermocouple/valve housing.

g. The thermocouple manifold tube shall accommodate two 1/8-inch male NPT thermocouple valve gage tubes.

h. The thermocouple manifold tube isolation valve shall be used to isolate the piping annulus from the two thermocouple gage tubes.

i. The valve shall be bellows type.

j. The thermocouples shall be Teledyne Hastings P/H DV6R® or approved equal.

k. The thermocouple/valve protective housing shall provide protection for the thermocouple tubes from the environment.

l. The cover shall be easily removed by means of toggle latches.

m. When and where indicated on plan and elevation, isometric, pipe spool, or other drawings, seal-off valve assemblies are to be installed at a remote location away from the vacuum closure pull-down port connected to the respective seal-off valve assemblies. For these cases, one-inch tubing shall be routed from the vacuum closure pull-down port to the seal-off valve assembly location.

n. The tubing shall also be connected to and routed along the outside of the outer pipe and fittings.

o. Where drawings do not show locations of remotely located seal-off valve assemblies, the pipe spool/segment manufacturer shall determine appropriate seal-off valve assembly locations by consulting the Contracting Officer or his/her representative.

5.2.12 Outer Pipe Standoffs

a. Standoffs retaining the inner pipelines within the outer (vacuum jacket) piping shall conform to requirements of section 5.1.10 of this SSTD.

b. Standoffs shall be designed and fabricated such that heat leakages allowed on Table 1 in section 5.2.2 are not exceeded.

c. The outer (vacuum) jacket shall be permanently marked to show locations and types of standoffs contained inside this piping.

d. The outer piping shall also be marked to show location and types of external pipe supports to be installed by others.

5.2.13 Outer Pipe Welding and Weld Joints

a. Weld end preparations shall be in accordance with ASME B16.25 and SSTD-8070-0017-WELD.

b. All welds shall conform to SSTD-8070-0017-WELD.

c. Inspect all weldments, except for longitudinal weldments on flexible convolute sections (bellows), in accordance with applicable section 5.1.13 requirements and SSTD-8070-0013-WELD, Class 3. Inspect all longitudinal weldments on flexible convolute sections in accordance with applicable requirements of section 5.2.5 of this SSTD.

5.2.14 Outer Pipe Inspections and Tests

5.2.14.1 Outer Pipe Visual Inspections

Perform 100% visual inspection of all weldments in accordance with ASME B31.3. Repair or replace and then reinspect welds found to be defective. These processes shall be repeated at no additional cost to the government until all welds pass inspection.

5.2.14.2 Outer Pipe Radiographic Inspections

Radiographic inspections are not required for any outer (vacuum jacket) piping.

5.2.14.3 Outer Pipe Dye-Penetrant Inspections

All weldments shall be 100% dye-penetrant inspected. Repair or replace and then reinspect welds found to be defective. These processes shall be repeated at no additional cost to the government until all welds pass inspection.

5.2.14.4 Outer Pipe Pressure Tests

a. Pressure tests are not required for any outer (vacuum jacket) piping.

b. Pressure tests to check integrity of the outer piping may be performed at end user's discretion, but it shall be performed only with air, gaseous nitrogen, or gaseous helium.

c. Test pressure shall not exceed 20-psig.

d. Any observed damage or leakage resulting from the pressure test shall be repaired at no additional cost to the government.

5.2.14.5 Outer Pipe Leakage Tests

If the inner pipe leak tests of Section 5.1.12.5 are not performed after installation of the outer pipe and if vacuum jacketed pipe sections and spools are fabricated, inspected, and tested by a commercial manufacturer at a facility outside of NASA/SSC, the vacuum jacket of each fabricated spool and the fabricated pipe shall be mass spectrometer leak tested prior to shipment. This test shall conform to the following requirements:

a. All field weld joints shall be exposed and uninsulated for examination during testing and shall be left unprimed and unpainted prior to and during testing.

b. Bag completed spools in polyethylene sheeting such that both inner and outer lines are soaked with gaseous helium. Gaseous helium should not be directly introduced into the annular space between inner and outer pipe (from past engineering experience, helium introduced into this space has been found to be difficult to remove).

c. Replace the air in the bag with gaseous helium to a positive pressure.

d. Evacuate the annular space of the vacuum jacket to 10 microns or less of mercury and maintained at that level by the mass spectrometer pump.

e. A leak indication less than 3×10^{-9} scc/sec helium with the mass spectrometer calibrated at 1×10^{-10} scc/sec. constitutes a successful test.

f. If the test is not successful and leakage is detected, the leak(s) shall be repaired and the effected pipeline system, section, or spool shall be retested for leakage in accordance with this section.

g. If repairs are required for any welded joints on the inner pipe, all repaired welds shall be re-inspected in accordance with Sections 5.1.12.1, 5.1.12.2, and 5.1.12.3 of this SSTD. If any pressure retaining and sealing welds of the inner need to be repaired, inner pipe pressure and leakage tests shall be redone in accordance with Sections 5.1.12.4 and 5.1.12.5.

h. If repairs are required for any welded joints on the outer pipe, all repaired welds shall be re-inspected and retested in accordance with Section 5.2.14 of this SSTD.

i. A certificate of inspection and testing shall be provided by the organization(s) or entity/entities performing the leakage tests and those witnessing these tests.

5.2.14.6 Outer Pipe Bake-Out/Vacuum-Retention Test

For vacuum jacketed pipe sections and spools fabricated, inspected, and tested by a commercial manufacturer at a facility outside of NASA/SSC, the bake-out/vacuum retention test shall be performed in accordance with the following procedures:

a. Evacuate the vacuum jacket annular space to a pressure not to exceed 5 microns of mercury after the entire spool (inner and outer piping) has been heated to 250 ±25 degrees F. The heating and evacuation periods will not be less than 24 hours each.

b. Insulate the spool section and allow it to return to ambient temperature.

c. Initiate the vacuum hold test after the assembly has returned to ambient temperature. The minimum retention period is 7 days. Record the vacuum pressure level every 24 hours along with the ambient temperature. Take vacuum readings using the thermocouple gage tubes provided with each pump out assembly.

d. The retention test data will be interpreted as follows:

    1. If the spool pressure level is less than 25 microns and there is no rise in the pressure level other than caused by ambient temperature changes, the spool is acceptable.

    2. If there is a rise in vacuum pressure level of less than 2 micron per day for the first several days followed by a stabilized vacuum reading and the final stabilized reading does not exceed 25 microns of mercury, the spool is acceptable.

    3. If the spool vacuum level exceeds 25 microns of mercury or if the rate of rise exceeds 2 microns per day, the affected spool will be subjected to further leak checking, repair and pumping, and the vacuum retention test repeated until successfully completed.

5.2.14.7 Outer Pipe Field Vacuum Retention Test

For vacuum jacketed piping systems, sections, and spools fabricated at NASA/SSC facilities, field vacuum retention tests shall be performed. For the field vacuum retention test, pump out each vacuum annulus or closure to pressure between zero and 200 microns of mercury. Each vacuum annulus must then be isolated from pump(s) and the pump(s) must then be shut off for a period of 24 hours. During this period, the pressure may not increase by more than 100-microns and the final pressure may not exceed 200-microns.

For vacuum jacketed pipe sections and spools fabricated, inspected, and tested by a commercial manufacturer at a facility outside of NASA/SSC, the field joints of the inner pipe shall be tested for leakage in accordance with Section 5.1.12.5 prior to installation or connection of the field-installed vacuum closures. The field-installed vacuum closures shall then be leak tested in accordance with the above paragraph or in accordance with Section 5.2.14.5, Parts b. through i.

5.2.15 Vacuum Annulus/Closure Contaminant Removal

All significant surfaces in vacuum annuluses and spaces shall be certified as commercial clean per RPTSTD-8070-0001 Cleanliness Level 3, with the exception of locations where chemical getter material deposits may be present or where these deposits can accumulate. For purposes of this SSTD, visible contaminants are defined as those larger than 40-microns in any dimension.

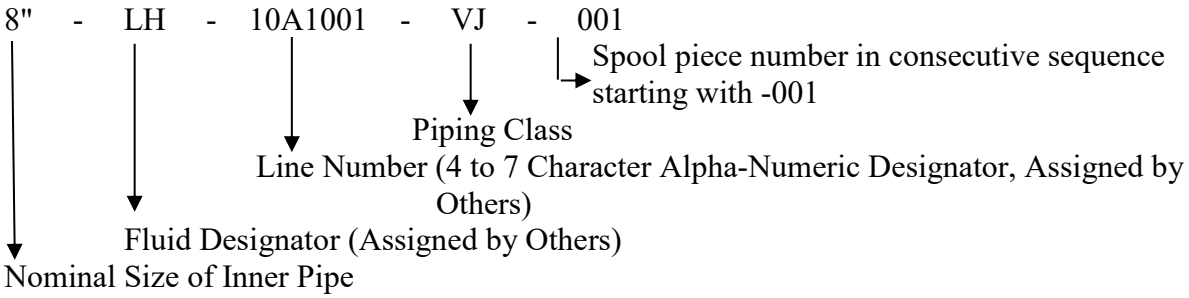
5.2.16 Outer Pipe Marking

a. The outer piping for each section or spool of vacuum jacketed piping between field weld joints or flange connections shall be permanently marked with the following information:

1. Purchase Order or Contract Number
2. Isometric Drawing Number (if applicable)
3. Line Number (if applicable)
4. Spool Number
5. NASA-SSC SSTD 8070-0069-PIPE
6. Pressure Rating of Inner Pipeline (275-psig or 230-psig; Ref. Section 5.1.5)
7. Service Temperature Range of Inner Pipeline Pressure Test of Inner Pipeline (Ref. Section 5.1.12.4 for Test Pressure Requirements)
8. Date of Pressure Test of Inner Pipeline

b. Outer pipelines shall be permanently marked to show the locations and types of external supports to be welded, attached, or in contact with each fabricated pipeline section, segment, or spool. Unless indicated otherwise on drawings, these external supports will be fabricated and installed by others. (Reference sections 5.2.1 and 5.2.12 for additional requirements regarding external supports.)

c. Spool numbering shall be as follows:



d. For pipe sections and spools containing flexible convolute sections with liners on the inner pipeline, the outer pipe shall be conspicuously marked with flow direction arrows at the approximate location(s) of the respective convolute section(s) and near the field weld joints and flange connections.

e. Inner piping shall be marked near these convolute sections as stated in section 5.1.4 of this SSTD.

f. All permanent markings shall be electro-chemical etchings on the outer pipe or stamped or etched 300-series data plates that are tack-welded to the outer pipe.

g. The markings shall not compromise the pressure rating or leak-tightness of the outer piping.

5.3 Submittal Documents

a. Unless stated otherwise in contract specifications or drawings, the contractor/vendor shall furnish the Contracting Officer with information included in Table 2 below and in accordance with requirements shown on this table. Where there is a conflict between requirements of Table 2 and those of contract specifications or drawings, the latter requirements govern.

b. For each pipe spool, section, or segment, the following data and information shall be included in submittal documentation:

1. Purchase Order or Contract Number
2. Isometric Drawing Number (if applicable)
3. Line Number (if applicable)
4. Spool Number
5. NASA-SSC SSTD 8070-0069-PIPE (as the governing SSTD)
6. Pressure Rating of Inner Pipeline (275-psig or 230-psig; reference section 5.1.5)
7. Service Temperature Range of Inner Pipeline
8. Pressure Test Media of Inner Pipeline (water, air, helium, or nitrogen gas)
9. Pressure Test of Inner Pipeline (reference section 5.1.12.4 for Test Pressure Requirements)
10. Date of Pressure Test of Inner Pipeline
11. Leakage Test Pressure of Inner Pipeline
12. Date of Leakage Test of Inner Pipelinews
13. Pipe and Pipe Fitting Materials, including material specification, for Inner Pipeline
14. Date of Mass Spectrometer Test of Outer Pipeline
15. Type of Vacuum Retention Test (Bake-Out/Vacuum Retention Test per section 5.2.14.6 or Field Vacuum Retention Test per section 5.2.14.7)
16. Date of Completion of Vacuum Retention Test

c. The Contracting Officer will review submittals for accuracy, correctness, and conformance with this SSTD.

d. The contractor/vendor is responsible for assuring that all work is completed in accordance with the submitted design and fabrication schedule.

e. The contractor/vendor shall allow for a 10-business day Contracting Officer review of each submittal unless specified otherwise in contract specifications or drawings.

f. All drawing and document changes must be clearly identifiable. Final drawings shall be stamped as "Certified" and submitted to the Contracting Officer as defined in the purchase document or contract.

g. Approval of submittals by the Contracting Officer does not relieve the contractor/vendor of responsibility for accuracy, correctness, and conformance with requirements of this SSTD.

5.4 Preparation for Shipment

a. Adequate overpackaging of pipe segment, sections, spools, and components shall be provided as required, in addition to the packaging hereinafter specified, to protect the pipe segment, sections, spools, components during handling, shipping, and six months outdoor storage. Furthermore, packaging in accordance with section 5.1.13 is required for all precision cleaned hardware.

b. All major items shall be suitably crated and skidded.

c. Skids shall be marked with the applicable order number, project number, item number, and destination.

d. All skids shall be numbered.

e. A copy of the Packing List shall be furnished to the purchaser listing the contents according to these skid numbers.

Submittal	Number of Business Days		
	After Order	Prior to Implementation	Prior to Delivery
Design & Fabrication Schedule including Milestones	7 or less	N/A	N/A
Design & Fabrication Drawings to include: 1.) Spool, segment, and section plan & elevation or isometric layouts with spool numbering per section 5.2.16 and locations of all items listed in 2.) below 2.) Detail drawings of standoffs/internal supports, mechanical and welded closures, convolute/bellows sections, gettering systems, bosses and instrument ports, external pipe support interfaces, evacuation and vacuum measurement systems (vacuum seal-off valve assemblies), radiation shielding	25 or less	5 or more	N/A
Design Analyses and Calculations including: 1.) Stress analyses to include expected maximum loads at all external supports 2.) Convolute/Bellows section calculations for flexibility and number of cycle limits per EJMA specifications 3.) Heat leakage rate calculations	25 or less	5 or more	N/A
Bill of Materials to include description, material, governing material specification for each piece part	35 or less	5 or more	N/A
Weld Procedure Specifications (WPSs) and their supporting Procedure Qualification Records (PQRs)	15 or less	20 or more	N/A
Weld Procedure Qualifications for Persons to Perform Welding	35 or less	10 or more	N/A
Detailed Procedures for Inspections and Tests included in sections 5.1.12 and 5.2.14	10 or less	10 or more	N/A
Precision Cleaning Procedures; ref. section 5.1.13	15 or less	10 or more	N/A
Certified Material Test Reports for all Metallic Parts, including weld filler metal(s)	N/A	N/A	15 or more
Reports of Results from Inspections and Tests included in sections 5.1.12 and 5.2.14 (includes radiographic film prints)	N/A	N/A	**
Precision Cleaning Verification/Sample Analysis Results & Certification for Each Section/Spool; ref. section 5.1.13	N/A	N/A	**
Corrected Design Analyses and Calculations, as Needed	N/A	N/A	10 or more
Final As-built Drawings with Corrected Bill of Materials as Needed	N/A	N/A	10 or more
Certificate of Conformance that all Deliverables Conform to this SSTD	N/A	N/A	With Delivery

Table 2 - Required Submittal Documents

** Note: The submittals for each inspection, test, verification, or analysis or series thereof are to be forwarded to the Contracting Officer within 2 business days after completion of the respective inspection, test, verification, or analysis.

5.5 Shipping

a. All pipe segment, sections, spools, and components shall be packaged as required in section 5.4 of this SSTD. Any damage to this protective packaging will be grounds for rejecting the line portion and will require recleaning at no cost to SSC.

b. All bellows expansion joints in jacket lines and all deflection joints (angular rotation joints) or braided flexible metal hoses shall be shipped with removable constraint devices which span the entire length of each jacket bellows or flex joint.

c. The constraint shall be capable of holding each jacket bellows to its installed length during normal handling.

d. Constraint devices shall be designed to withstand all heat pressures required for the carrier and jacket design parameters.

e. Constraint devices shall not interfere with guides and supports during line installation.

f. The constraints for flex joints shall be installed with each joint in the field assembly position and shall be adequate to withstand normal handling.

g. These constraint devices shall also be designed to be removed without grinding, cutting, etc., on any portion of the vacuum jacketed line following installation.

h. All temporary constraints shall be clearly tagged and labeled as such.

i. Any damage occurring during transit shall be grounds for rejection of the entire spool.

j. Rework, if deemed acceptable, shall be at the option of the Contracting Officer.

k. All joints to be assembled in the field by others shall be shipped out to length and prepared for buttwelding as specified in the contract drawings.

l. Final acceptance of hardware will be upon successful completion of shipping inspection, installation, and operation, including a check of all evacuated portions of the line. Upon receipt of hardware at NASA/SSC, vacuum levels of 25 microns mercury or greater shall be cause for rejection.

6.0 RECORDS AND FORMS

Records and forms required by the procedures of this SSTD shall be maintained in accordance with SPR 1440.1. For quality records refer to the SSC Master Records Index. All forms are assumed to be the latest edition unless otherwise specified and may be obtained from the SSC Electronic Forms repository or from the NASA SSC Forms Management Officer.

7.0 ACRONYMS AND ABBREVIATIONS

ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ASNT	The American Society for Nondestructive Testing
CMTR	Certified Material Test Report
DRD	Data Requirement Deliverable
EJMA	Expansion Joint Manufacturers Association, Inc.
FEA	Finite Element Analysis (Computer Based, 3-dimensional or 2-dimensional with radial symmetry)
"g"	Acceleration due to Gravity at Earth's Surface (9.8 m/sec^2 or 32.174 ft/sec^2)
GOX	Gaseous Oxygen
LO/GO	Liquid Oxygen/Gaseous Oxygen
LOX	Liquid Oxygen
MSFC	Marshall Space Flight Center
MSS	Manufacturers Standardization Society of the Valve and Fitting Industry, Inc.
NASA	National Aeronautics and Space Administration
NDT	nondestructive testing
ppm	parts per million
PQR	Procedure Qualification Record
psig	pounds per square inch gauge
RMS	Root Mean Square (Surface Finish in units of microns)
RPT	Rocket Propulsion Testing
RTJ	Ring Type Joint
SACOM	Synergy Achieving Consolidated Operations and Maintenance
SAE	Society of Automotive Engineers
scc/sec	Standard (Atmospheric; 14.7-psia, 70 F gas) Cubic Centimeters per Second
SPR	John C. Stennis Space Center Procedural Requirement
SSC	John C. Stennis Space Center
SSTD	John C. Stennis Space Center Standard
TFE	Tetrafluoroethylene
VJ	Vacuum Jacketed
WPS	Weld Procedure Specification