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COMPLIANCE IS MANDATORY

JOHN C. STENNIS SPACE CENTER

TUBING SYSTEMS

FOR FACILITY SYSTEMS, SPECIAL TEST

EQUIPMENT, AND AEROSPACE HARDWARE

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NASA SSC Center Operations
Project Management Directorate

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NASA SSC Engineering & Test Directorate

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Document History Log

Revision	Date	Originators/ Phone	Description
Basic	11/06/06	Bill St. Cyr 8-1134 Larry de Quay 8-1956	Initial Release; supersedes SSC STD 47-220. New document number and format per SPR 1400.1, <i>John C. Stennis Space Center Document Preparation, Numbering, and Management Guidelines and Standards</i> . Added/specified sections per SPR 1400.1.
Basic - History (from SSC STD 47-220 to current standard)	06/20/07	Larry de Quay 8-1956	<u>Section 2.0</u> : state allowed tubing, tube fitting types, and end-connections. <u>Section 3.0</u> : Add ASTM and SAE tubing specifications; add SAE specifications for tube and tube fittings and for commonly used parts. <u>Section 4.0</u> : add tables 1A and 1B. <u>Section 4.1</u> : add references to form SSC-716, SSTD-8070-0007-CONFIG, and SOI-8080-0016 for cases where tubing other than S/S tubing per standard MIL, ASTM, and SAE specifications (listed in table 2A) are used. Account for tube wall thickness and O.D. tolerances in MAWPs of tubing which results in 13 to 22% decrease in MAWPs from those in Standard 47-220 . Add ASTM and SAE tubing specifications to list of allowed specifications for purchased or acquired tubing and add selected restrictions regarding the use of tubing made to MIL tubing specifications (which are now “inactive for new design”). Add pressure ratings/limits for flared tube end and NPT connections on table 2A with MAWP of tubing. Add tables separately showing pressure ratings of tube-fitting-to-boss connections with different seal types and for male straight thread ends of differing lengths. Add table to show required thread engagement lengths for NPT connections. Add table to show options and requirements for increased NPT connection pressure ratings where needed. <u>Section 4.2</u> : add/clarify restrictions regarding tube fittings listed in SAE AIR310, where 1) flareless, socket weld, hose end, beam seal, and swivel type fittings are not allowed; 2) titanium fittings are not allowed in oxidizer or oxidizer rated systems; 3) 400 psig pressure limit applies to aluminum fittings in or rated for oxygen service. Addition of drawings in

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			referenced Appendix B to show configuration, part specifications and selected assembly information and requirements of fitting-to-boss connections with seals and seal retainers. State additional restrictions and allowances regarding non-metallic boss connection seal materials used or rated for oxidizer and cryogenic services. State allowed metallic materials for spring energized seals used in boss connections. Add requirements for disassembly and assembly of NPT connectors, including sealing of these connections and removal of sealing material from disassembled connectors. Increase allowed maximum allowed operating pressure of flareless double-ferrule (Swagelok ® or equivalent) type tubing and tube fittings from 1000 to 3000 psig for sizes of one inch and smaller and to 1500 psig for larger sizes, without CCB approval. Expand list of allowable tube fittings with double-ferrule flareless end connections beyond what was listed in Standard 47-220. Add table 5 to show required tube wall thicknesses of flareless tubing. <u>Section 4.3</u> : add tube size and I.D. data for 10, 30, 40, and 60 ksig rated coned-and-threaded tubing. <u>Section 4.4</u> : add reference to Appendix D to show geometric dimensions, tolerances, and requirements for coned-and-threaded type tubing and tube fitting end connections; add statement that 10 and 20 ksig rated tube fittings are not interchangeable with those rated at higher pressures. <u>Section 4.5</u> : new section added to state requirements for welding and weldment inspection, including the required pressure rating reduction when tubing and tube fittings made of “cold worked” or hardened stainless steel are welded.
A	07/16/07	Bill St. Cyr 8-1134 Larry de Quay 8-1956	Added Rev. Basic History to Document History Log to identify changes between cancelled Standard 47-220 and Rev Basic of this standard. Added hyperlinks. <u>Section 2.0</u> : add statement about government’s right to inspect any and all aspects of work and processes used to produce, clean, test, inspect, and package tubing, tube fittings, and associated hardware. <u>Section 3.0</u> : add “and Applicable” to title; add SSC Standard 79-002, SSTD 8070-0089-FLUIDS, SAE AMS 5557, SPR 1440.1, SSC form 517, and SSC form 716. <u>Section 4.0</u> : add cleanliness, packaging, and storage

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			requirements; new section 4.7 referenced (prior sections 4.7 and 4.8 renumbered to 4.8 and 4.9 respectively); add requirement for off-site vendors to provide Certificate of Conformance for all provided products and services. <u>Sections 4.1 and 4.3</u>: add quantified and measurable surface finish requirements for tubing, based on those in previously used MIL tubing specifications for flared type tubing and based on manufacturer specifications for coned-and-threaded tubing. <u>Section 4.7</u>: new section added to mandate requirements to assure removal of gross contamination or blockage in flow passages inside tubing prior to acceptance and precision cleaning processes at SSC; prevent recontamination of stored tubing; define allowed methods to inspect tubing for gross contamination or blockage; and reference SSC Standard 79-002 for test gas purity for leak tests performed after precision cleaning. <u>Section 4.8</u>: section number was 4.7 in Rev. Basic; revise wording to allow replacement of crush washers after proof pressure tests. <u>Section 4.9</u>: section number was 4.8 in Rev. Basic; add requirement for test gas to conform to SSC Standard 79-002 for leak tests of precision cleaned systems, this test gas requirement does not apply to commercially clean (Cleanliness Level 3) systems. <u>Section 5</u>: added section. <u>Appendix A</u>: added OSMA to list.
B	08.12.14	Larry de Quay 8-1956	Five-year revision, references updated. Per Variance SSTD-8070-0126.3, Section 4.8a was revised to read "With the exception of selected vent system segments/ sections and tubing used in Category D fluid service (as defined in ASME B31.3), all proof pressure test procedures for tube system sections, components, and connections shall conform to all applicable (pressurized) leak test requirements of ASME B31.3, prior to placing the system into operational service."
B-1	02.04.15	Larry de Quay 8-1956	Administrative change required, adding the PIPE designator to the document number.
B-2	02.12.16	R. Carol Wolfram 8-1164	Administrative change. Replaced "Test Operations" with "Test Complex" throughout document.

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1.0 PURPOSE

This John C. Stennis Space Center (SSC) standard (SSTD) provides the design requirements and operating limits for tubing and tube fittings at Stennis Space Center for facility and special test equipment (STE). This standard may be used for aerospace hardware tubing systems where deemed appropriate. These provisions are intended to assure system reliability, safety, and cost effective interchangeability between tube system hardware and components.

2.0 APPLICABILITY

This standard covers all facility and STE tubing systems erected/assembled with the following:

- Tubing with 37° flared ends
- Tubing with flareless ends connected to Swagelok® type flareless tube fitting end connections
- Tubing with coned- and left hand-threaded ends
- Tube fittings with 37° flared, Swagelok® type flareless, (American) National (Standard Taper) Pipe Thread (ANSI/ASME B1.20.1) (NPT), and coned- and left hand-threaded end connections
- Fittings with Society of Automotive Engineers (SAE) (formerly AN/MS) straight internal (female) thread patterned boss connections
- Fittings with SAE (formerly AN/MS) straight thread external (male) thread patterned end connections that connect to boss connections as stated in e., above.

Tube fittings that have end connections other than those listed above are not governed by and are not permitted under this standard.

Pressure and temperature ratings are specified for tubes with outside diameters between 0.250" (6.35 mm) and 2.00" (50.8 mm) with wall thicknesses of 0.028" (0.71 mm) and over. Other diameters and wall thicknesses may be used provided they meet the minimum requirements of ANSI/ASME B31.3.

Piping supplied per Nominal Pipe Size (NPS) (e.g., 8" Schedule 5S, 2" Schedule 40, etc.) is not governed by this standard. However, pipe that is threaded and connected to NPT fitting connections may reduce the pressure rating of the connection below those stated in this standard; details are provided in [section 4.2](#).

Freon®, Heating, Ventilating and Air Conditioning (HVAC), and low pressure (less than 150-psig) water tubing systems are not governed by this standard. Facility compressed air systems operating at 150 psig or less and vacuum systems are not governed by this standard. Refer to International Association of Plumbing and Mechanical Officials (IAPMO), Uniform Plumbing

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Code (UPC), American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) standards, and applicable Central Engineering Files (CEF)-issued SSC piping system standards and specifications.

Existing designs are not required to comply with this standard except that any modifications or changes to the existing designs shall meet the minimum requirements of this standard.

The government reserves the right to witness or inspect any aspect of the fabrication, cleaning, inspection, testing, and packaging of the tubing, tube fittings, and other related products and services governed by this standard.

3.0 REFERENCED AND APPLICABLE DOCUMENTS

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

49 CFR 195, *Code of Federal Regulations, Title 49, Part 195, Transportation of Hazardous Liquids by Pipeline*
 AISI 304, *Stainless Steel*
 AISI 316, *Stainless Steel, annealed bar*
 AISI 321, *Stainless Steel, annealed sheet*
 AISI 347, *Stainless Steel, annealed and cold drawn, bar*
 ANSI/AIAA G-095, *Guide to Safety of Hydrogen and Hydrogen Systems*
 ANSI/ASME B1.20.1, *Pipe Threads, General Purpose (Inch)*
 ANSI/ASME B31.3, *Process Piping*
 ANSI/ASME Boiler & Pressure Vessel Code, Sections V and VIII
 ASME B46.1, *Surface Texture (Surface Roughness, Waviness, and Lay)*
 ASTM A213/A213M, *Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes*
 ASTM A269, *Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service*
 ASTM A632, *Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing (Small Diameter) for General Service*
 MIL-T-8504, *Tubing, Steel, Corrosion-Resistant (304), Aerospace Vehicle Hydraulic Systems, Annealed, Seamless and Welded*
 MIL-T-8808, *Tubing, Steel, Corrosion-Resistant (18-8 Stabilized), Aircraft Hydraulic Quality.*
 MS28774, *Retainer, Packing Backup, Single Turn, Polytetrafluoroethylene (Inactive for New Design)*
 MS28777, *Washer, Flat, Aircraft Hydraulic Backup (Inactive for New Design)*
 MS28778, *Tube Fitting Boss Gasket*
 MSS SP-6, *Standard Finishes for Contact Faces of Pipe Flanges and Connecting-End Flanges of Valves and Fittings*

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MSFC-STD-3535, *Sampling Requirements and Maximum Allowable Impurities for SSC Fluids and Fluid Systems*

NASA/MSFC-STD-506, *Standard Materials and Processes Control*

NASA-STD-6001, *Flammability, Offgassing, and Compatibility Requirements and Test Procedures*

SAE AIR310, *Fittings, Catalog of Flared, Flareless, Pipe Threaded, Port, Hose, and Other Type Tube Standard Connectors*

SAE AMS 5556, *Steel, Corrosion and Heat-Resistant, Seamless or Welded Hydraulic Tubing, 18Cr – 11Ni – 0.07 Cb (30347), Solution Heat Treated*

SAE AMS 5557, *Steel, Corrosion and Heat-Resistant, Seamless or Welded Hydraulic Tubing 18.5CR - 10.5NI - 0.40TI (SAE 30321) Solution Heat Treated*

SAE AMS 5566, *Steel, Corrosion Resistant, Seamless or Welded Hydraulic Tubing, 19Cr – 10Ni (304), High Pressure, Cold Drawn*

SAE AMS 5567, *Steel, Corrosion Resistant, Seamless or Welded Hydraulic Tubing, 19Cr – 10Ni (SAE 30304) Solution Heat Treated*

SAE AMS-T-6845, *Tubing, Steel, Corrosion-Resistant (S30400), Aerospace Vehicle Hydraulic System 1/8 Hard Condition*

SAE AS 33583, *Tubing End Double Flare, Standard Dimensions For*

SAE AS 758, *Fittings – Installation in Straight Threaded Boss*

SAE AS 930, *Fitting End, Straight Thread, Boss Connection, Design Standard*

SAE AS 1098, *Fitting End, Flared Tube, for Seal Ring, Standard Dimensions for, Design Standard*

SAE AS 1099, *Fitting End, Bulkhead Flared Tube, for Seal Ring, Standard Dimensions for, Design Standard*

SAE AS 1941, *Fitting End, Straight Thread, High Pressure, Boss Connection, Design Standard*

SAE AS 28778, *Packing, Preformed, Straight Thread Tube Fitting Boss*

SAE AS 33583, *Tubing End Double Flare, Standard Dimensions for*

SAE AS 4320, *Fitting End, Straight Thread, Standard Dimensions for, Design Standard*

SAE AS 4330, *Tubing, Flared, Standard Dimensions for, Design Standard*

SAE AS 4395, *Fitting End, Flared Tube Connection, Design Standard*

SAE AS 4396, *Fitting End, Bulkhead, Flared Tube Connection, Design Standard*

SAE AS 4841, *Fittings, 37° Flared, Fluid Connection*

SAE AS 4842, *Fittings and Bosses, Pipe Threaded, Fluid Connection*

SAE AS 4842/1, *Fittings, 37° Flared to Pipe Threaded, Fluid Connection*

SAE AS 4842/2, *Fittings, Flareless to Pipe Threaded, Fluid Connection*

SAE AS 4875, *Fittings, Straight Threaded Boss or Flanged, Fluid Connection*

SAE AS 4875/1, *Fittings, Straight Thread Boss or Flanged to 37° Flared, Fluid Connection*

SAE AS 5179, *Nut, Fitting, Port*

SAE AS 5201, *Fitting End, External Taper Pipe Thread, Design Standard*

SAE AS 5202, *Port or Fitting End, Internal Straight Thread, Design Standard*

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SAE AS 71051, *Pipe Threads, Taper, Aeronautical National Form, Symbol ANPT – Design and Inspection Standard*
 SAE AS 758, *Fittings – Installation in Straight Threaded Boss*
 SAE AS 8791, *(R) Hydraulic and Pneumatic Retainers (Back-Up Rings), Polytetrafluoroethylene (PTFE) Resin*
 SPR 1440.1, *Records Management Program Requirements*
 SSC form 517, *Variance Request*
 SSC form 716, *Materials Usage Agreement (MUA)*
 SSTD-8070-0013-WELD, *Classes of Welding Inspection*
 SSTD-8070-0091-FLUIDS, *SSC Requirements for Materials Used In LOX/GOX Service*
 SSC Drawing No. 54000-GM30, *Specification for Materials Used In LOX and GOX Service Exempt from Batch Test Requirements*
 SSC SOI-8080-0016, *Material and Process Control for Propulsion Test Facilities and Systems*
 SSTD-8070-0005-CONFIG, *SSC Preparation, Review, Approval and Release of SSC Standards*
 SSTD-8070-0007-CONFIG, *Variance and Alternate Standard Request*
 RPTSTD-8070-0001, *Surface Cleanliness Standard of Fluid Systems for Rocket Engine Test Facilities of the NASA Rocket Propulsion Test Program*
 USAF TO 00-25-223, *Technical Manual: Integrated Pressure Systems and Components (Portable and Installed)*

4.0 REQUIREMENTS

- a. All tubing shall be seamless; tubing with seam welds is not permitted.
- b. All metallic and non-metallic materials, including lubricating oils and greases used to assemble tube systems, shall be compatible with the service media and must conform to material traceability and service media compatibility requirements delineated in other SSC and NASA requirements documents. For example, SSTD-8070-0091, SSC Specification Control Drawing (SCD) 54000-GM30, and NASA-STD-6001 govern non-metal material compatibility requirements for oxygen and other oxidizer fluid (i.e. fluorine) systems. Guidance regarding hydrogen embrittlement resistant materials is provided in NASA/MSFC-STD-506 and ANSI/AIAA G-095-2004.
- c. Requirements for cleanliness, packaging, and storage of tubing, tube fittings, and assembled tubing systems are given in [section 4.7](#).
- d. For all tubing, tube fitting, and other related products and services under the purview of this standard that are provided by vendors not located at SSC, the

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respective vendors shall provide a Certificate of Conformance which states that all provided products and services are in full conformance with this standard.

- e. Installation of fluid tube systems shall conform to tube routing and external system support spacing requirements of USAF TO 00-25-223. Tables 1A and 1B provide recommended maximum span distance between external supports for tubing systems.
- f. Contact between dissimilar metals shall be prevented or provisions to prevent galvanic corrosion shall be used in all tubing system installations.
- g. A neat and orderly routing of tube systems, where multiple criss-crossing of tube runs is avoided, is required.
- h. All connections and components shall be accessible for inspection, disassembly and removal.
- i. Tube system routing shall incorporate expansion loops and offsets such that the yield stress is not exceeded under the combined stresses from internal fluid pressure, thermal expansion or contraction, dead weight loads, external interfaces, and wind loads.
- j. In selected cases, a detailed stress analysis in accordance with ANSI/ASME B31.3 will be required to assure that yield stresses are not exceeded for system pressure retaining materials.

TABLE 1A

Spacing of External Supports for Tubing Systems with Tubing and Fittings Specified by Sections 4.1 and 4.2

Nominal Tube OD (inches)	Maximum Span (feet)		
	Stainless & Carbon Steel	Aluminum & Titanium Alloys	Bronze & Copper Alloys
1/8 to 1/2, excl.	4	4	3
1/2 to 1, excl.	6	5	4
1 to 2	9	7	5

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TABLE 1B

Spacing of External Supports for Tubing Systems with (Coned-and-Threaded) Tubing and Fittings Specified by Sections 4.3 and 4.4

Nominal Tube OD (inches)	Service Fluid Type	Maximum Allowable Working Pressure (psig)	Maximum Spacing of Supports or Anchors (feet)
¼ to 1	Gaseous & Cryogenic	6,000 to 10,000	4
¼ to 1	Gaseous & Cryogenic	Above 10,000	3
¼ to 1, incl.	Hydraulic *	6,000 to 30,000	4
* Note: Liquid Service Fluid with Minimum Service Temperatures above -50°F			

4.1 Tubing for Fluid Pressure Less Than 10,000 psig

- a. All tubing for fluid pressure less than 10,000 psig shall meet the requirements of one of the material specifications and grades listed in Table 2A. Planned use of any other material or specification requires either a Variance Request, form SSC-517, for facility fluid systems, or a Materials Usage Agreement (MUA), form SSC-716, for STE, prepared and approved in accordance with SSTD-8070-0007-CONFIG or SSC SOI-8080-0016, respectively.
- b. Tubing surface roughness shall not exceed an arithmetical average roughness (Ra) of 70 on inside surfaces and Ra of 40 on outside surfaces as defined by ASME B46.1.
- c. The maximum depth of individual surface discontinuities shall not exceed limits specified in Table 2B.
- d. Design of tube pressure systems for fluid pressures less than 10,000 psig shall meet, as a minimum, the requirements of ANSI/ASME B31.3. Hydrostatic and pneumatic pressure test requirements are given in sections [4.8](#) and [4.9](#). In some situations, or to meet specific customer requirements, requirements that are more stringent with higher factors of safety may be required. Table 3A lists the maximum allowable working pressure for various tube sizes based on the minimum wall thicknesses permitted for ASTM A269 tubing and the requirements of ANSI/ASME B31.3. Refer to ANSI/ASME B31.3 for calculation of the maximum allowed pressure or minimum wall thickness required for other diameters and wall thicknesses. These pressure ratings also apply to tube bends provided the minimum wall thickness is maintained after bending.

CAUTION

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Although the tubing may be rated to pressures as described in Table 3A, system pressure ratings may be limited to lower pressures based on tube fittings or other system components. The lowest pressure rating of any system component is the maximum allowed operating pressure for the tubing system.

- e. Table 3B lists boss connection pressure ratings.
- f. Table 3C lists increased pressure ratings for NPT end connections meeting additional requirements.
- g. Table 3D lists required thread engagement length for NPT end connections.
- h. All tubing dimensional tolerances for OD (Outside Diameter) and wall thickness, prior to swaging or flaring, shall conform to those shown in Table 4.
- i. Flared tube ends: Tube ends to be used with flared fittings shall be flared to conform to the geometric requirements of SAE AS4330 or SAE AS33583.

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TABLE 2A

Material Specifications for Austenitic Stainless Steel Tubes

Specification	Diameter Range, in [mm]	Thickness Range, in [mm]	Grade or Type	SMYS (ksi/MPa)	SMTS (ksi/MPa)	B31.3 Allowable Stress*
ASTM A269 (Seamless only)	0.25 I.D. and over [6.35 I.D.]	0.020 and over [0.508]	TP 304, TP 316, TP 321, TP 347	30/207	75/517	20.0 ksi 138 MPa
			TP304L, P316L	25/172	70/483	16.7 ksi 115 MPa
ASME SA213 ASTM A213	0.125 ID to 5.00 O.D. [3.175 to 127]	0.015 to 0.50 [0.381 to 12.7]	TP 304, TP 316, TP 321, TP 347	30/207	75/517	20.0 ksi 138 MPa
			TP304L, P316L	25/172	70/483	16.7 ksi 115 MPa
ASTM A632 (Seamless only)	0.050 to < 0.5 O.D. [1.27 to <12.7]	0.005 to <0.065 [0.127 to <1.651]	TP 304, TP 316, TP 321, TP 347	30/207	75/517	20.0 ksi 138 MPa
			TP304L, P316L	25/172	70/483	16.7 ksi 115 MPa
AMS 5556** (Type 1 only)	All diameters and wall thickness		347	30/207	75/517 Max. spec	20.0 kPi 138 MPa
AMS 5557** (Type 1 only)	All diameters and wall thickness		321	30/207	75/517 Max. spec	20.0 ksi 138 MPa
AMS 5566** (Type 1 only)	All diameters and wall thickness		304	75/517	105/724 Max. spec	40.0 ksi 276 MPa
AMS 5567** (Type 1 only)	All diameters and wall thickness		304	30/207	100/689 Max. spec	20.0 ksi 138 MPa
AMS-T-6845 (Type 1 only)	0.25 O.D. and over [6.35 O.D.]	All	304	75-110/ 517-759	105-140/ 724-965	35.0-46.7 ksi 241-322 MPa
MIL-T-8504 # (Type 1 only)	All diameters and wall thickness		304	30/207	75/517 Max. spec	20.0 ksi 138 MPa
MIL-T-8808 # (Type 1 only)	All diameters and wall thickness		321, 347	30/207	75/517 Max. spec	20.0 ksi 138 MPa
Notes: * to 150°F per ANSI/ASME B31.3, based on lesser of 1/3 SMTS and 2/3 SMYS. (Only ASTM A269 is listed in ASME B31.3.) ** Hydraulic Tubing # Specification is now inactive for new design, except for replacement purposes, but tubing previously manufactured under this specification can be used for existing and new systems when available.						

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TABLE 2B

Allowed Depth of Tubing Surface Discontinuities

Nominal Wall Thickness (inches)	Maximum Permissible Depth of Discontinuities (inches)
0.020 and Under	10 % of nominal wall thickness
0.021 through 0.030	0.0020
0.031 through 0.040	0.0025
0.041 through 0.050	0.0030
0.051 through 0.066	0.0040
0.067 through 0.085	0.0060
0.086 and Over	7.0 % of nominal wall thickness

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TABLE 3A

Maximum Allowable Working Pressures, Stainless Steel Tubing and Tube Fittings with Flared and NPT End Connections; Tubing is in accordance with ANSI/ASME B31.3 (AISI Types 304, 316, 321 and 347).

Nominal Tube Wall Thickness	NOMINAL TUBE OUTSIDE DIAMETER (OD)								
	0.250	0.375	0.500	0.750	1.000	1.250	1.500	1.750	2.000
0.025	3571	2342	1848	1221	911	727	603	517	452
0.028	4035	2637	2079	1372	1022	816	677	579	507
0.032	4665	3037	2390	1574	1172	934	775	663	580
0.035	5147	3341	2626	1727	1285	1024	849	726	635
0.042	6306	4063	3185	2086	1550	1234	1022	874	764
0.049	7515	4806	3755	2451	1817	1445	1196	1023	893
0.058	<i>9361</i>	5790	4507	2927	2165	1720	1422	1215	1061
0.062	<i>10000</i>	6240	4848	3142	2322	1843	1523	1301	1136
0.065		6581	5107	3304	2440	1935	1599	1366	1192
0.072		7395	5720	3686	2717	2153	1778	1517	1324
0.083		<i>8951</i>	6711	4298	3158	2498	2060	1757	1532
0.094		<i>10000</i>	<i>7736</i>	4923	3606	2848	2346	2000	1742
0.095			7827	4981	3648	2880	2372	2022	1761
0.102			<i>8209</i>	5388	3938	3105	2556	2177	1896
0.109			<i>8834</i>	5800	4231	3332	2741	2334	2032
0.120			9823	6461	4698	3694	3035	2581	2246
0.125			<i>10000</i>	6767	4913	3859	3169	2695	2344
0.152				<i>8179</i>	6103	4773	3907	3315	2879
0.188					<i>7770</i>	6039	4923	4166	3610
0.190					<i>7862</i>	6112	4981	4214	3652
0.250						<i>8333</i>	6767	5696	4918
End Connection Type									
37° Flared Tube	9600	9600	7400	7150	5300	5200	4600	4600	4600
NPT (Non-H ₂ Service) *	6200	4900	5600	5000	4000	3600	3600	3200	3200
NPT (H ₂ Service)	3000	3000	3000	3000	3000	3000	3000	3000	3000

Notes: All dimensions are in inches, all pressures in psig, temperatures not exceeding 150°F. For “L” grades of stainless steel, the Maximum Allowable Working Pressure (MAWP) shall be multiplied by a factor of 0.833 based on equation (3c) of B31.3 and tube minimum wall thickness.

Tubing with pressure ratings shown in **BOLD** are usually stocked in the warehouse.

Entries shown in *italics* represent tubing with $t \geq D/6$. See ANSI/ASME B31.3, para.304.1.2 (b).

See section 4.2 for other restrictions on maximum working pressures on 37° flared tube fittings.

- * If threaded pipe is connected to FNPT end connections, the listed pressure ratings above are valid only if pipe is Schedule 80S or heavier and if pipe material has allowable stress of 20,000 psi or higher per ASME B31.3. To attain higher pressure ratings for non-H₂ service with 20,000 psi allowed material stress, refer to Table 3C.

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TABLE 3B

Boss Connection Pressure Ratings

Nom. Size (in.)	Maximum Allowable Working Pressure (psig)					
	SAE AS930 to SAE AS5202 w/ Harrison K- Seal ® or Equiv. #	SAE AS930 to SAE AS5202 w/ SAE AS28778 O- Ring *	SAE AS1941 or AS4320 to SAE AS5202 w/ Harrison K- Seal ® or Equiv. #	SAE AS1941 or AS4320 to SAE AS5202 w/ SAE AS28778 O- Ring *	SAE AS1098 or AS4395 to SAE AS5202 w/ Harrison K- Seal ® or Equiv. #	SAE AS1098 or AS4395 to SAE AS5202 w/ SAE AS28778 O- Ring *
0.25	5200	7150	4850	6800	6050	8000
0.375	4200	5950	4750	6500	5300	7000
0.50	4050	5500	5950	7350	5450	6900
0.75	2650	3700	4950	5950	6250	7300
1.00	2250	3200	5050	6050	4400	5350
1.25	1950	2750	4400	5200	5150	5950
1.50	1750	2450	4400	5050	5900	6650
1.75	1500	2150	3750	4450	5650	6250
2.00	1350	1950	3400	4050	6200	6600
Notes: * See section 4.2 for SAE AS28778 O-Ring requirements and allowances, recommendations, and requirements that govern substitution of other type seals for these O-Rings. # See section 4.2 for K-Seal ® requirements.						

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TABLE 3C

Increased Pressure Ratings (above those listed in Table 3A) for NPT End Connections with Associated Requirements; Non-H₂ Service Only

Nominal Size (in.)	Pressure Rating (psig)	Minimum OD or Distance Between Flats on FNPT Part (in.) *	Minimum Schedule of Connected Pipe, if used	Maximum Allowed Bore of MNPT Part (in.) **
1/4	7700	0.794	80S	0.332
3/8	6500	0.931	80S	0.455
1/2	6000	1.127	80S	0.583
1/2	8050	1.264	160	0.511
1/2	10550	1.484	XXS	0.326
3/4	7650	1.546	160	0.667
3/4	9050	1.714	XXS	0.511
1	4700	1.648	80S	1.002
1	6800	1.850	160	0.878
1	8800	2.162	XXS	0.689
1-1/4	4000	2.010	80S	1.326
1-1/4	5350	2.163	160	1.223
1-1/4	8150	2.529	XXS	0.992
1-1/2	3650	2.265	80S	1.550
1-1/2	5300	2.472	160	1.408
1-1/2	7550	2.791	XXS	1.200
2	5250	3.086	160	1.775
2	6600	3.323	XXS	1.612

Notes: * Increase Dimension by Distance Between Axial Centerline of Part, at its FNPT End Connection as defined by OD or Midpoints between Parallel External Flats, and Axial Centerline of FNPT Thread Pattern; if this distance is greater than 0.001-inches (Concentricity of thread and part OD outside 0.001-inch allowed tolerance).
** Decrease Dimension by Distance Between Axial Centerline of Bore (or ID), at the MNPT End Connection, and Axial Centerline of the MNPT Thread Pattern; if this distance is greater than 0.001-inches (Concentricity of thread and bore / ID outside 0.001-inch allowed tolerance).
- Material used for fittings and pipe must have allowable stress of 20,000 psi or higher per ASME B31.3 for above pressure ratings.

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TABLE 3D

Required Thread Engagement Length for NPT End Connections

Nominal Size (inches)	Minimum Allowed Thread Engagement Length (inches)
1/16	0.160
1/8	0.162
1/4	0.235
3/8	0.241
1/2	0.320
3/4	0.339
1	0.422
1-1/4	0.446
1-1/2	0.463
2	0.496
Note: Above values reflect minimum allowed thread engagement for all cases. However, longer thread engagements shall be attained as needed to provide snug, wrench-tight, or interference fit in order to prevent loosening of connection under cyclic loads and vibration conditions.	

TABLE 4

Permissible Variation in Diameter and Wall Thickness

Tube Size Outside Diameter, in.	Permissible Variation in Outside Diameter, in. (mm)	Permissible Variation in Wall Thickness *
Up to 0.50	± 0.005 (0.13)	± 15%
0.50 to 1.00, excl	± 0.005 (0.13)	± 10%
1.00 to 1.50, excl	± 0.006 (0.15)	± 10%
1.50 to 2.00	± 0.010 (0.25)	± 10%
* Note: When tubes have an inside diameter of 60% or less of the outside diameter, the permissible variation in wall thickness is ± 12.5 %.		

4.2 Fittings for Fluid Pressures Less Than 10,000 psig

Forged, wrought or cold worked metallic fitting materials shall be used. Castings are not permitted.

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4.2.1 Flared Tube Fittings

- a. 37° flared tube fittings made of type 304, 316, 321, or 347 austenitic stainless steel may be used in pressure systems for pressures up to those shown in Table 3A for various tubing sizes provided the manufacturer's pressure or temperature rating for any component is not exceeded. Maximum allowable working pressure for tube fittings connected to female (internal) thread boss connections are limited to those specified in Table 3B. [Appendix B](#) provides diagrams of flared tube and boss connections listed in Tables 3A and 3B.

- b. For tube fittings made of materials other than type 304, 316, 321, or 347 austenitic stainless steel, the maximum allowable working pressure shall be determined as follows:

$$P = P_{T2} \times (S_A/20,000)$$

Where: P = Maximum Allowable Working Pressure (in psig)

P_{T2} = Maximum Allowable Working Pressure from Table 3A or 3B above (in psig)

S_A = Allowed Stress of New Material per ASME B31.3 (in psi)

- c. Prior to assembly of tube to flared tube fittings, the tube end shall be flared to conform to the geometric requirements of SAE AS4330 or SAE AS33583.
- d. For flared tube fittings (such as adaptor fittings) with multiple types or sizes of end connections, the pressure rating of the fitting shall be no greater than that of the end connection having the lowest pressure rating.
- e. SAE AIR310 is an aid for locating and identifying various fitting designs and configurations. Tubing and tube fittings listed in SAE AIR310 that have flareless, beam seal, socket weld, swivel, and hose type end connections are not permitted. Tube and fittings made of titanium shall not be used in oxidizer systems nor in systems rated for oxidizer service; i.e., oxidizer media can contact internal surfaces. Aluminum fittings are limited to 400-psia in systems rated for oxygen services.
- f. Other tube fittings not listed in SAE AIR310 with straight thread end connections conforming to SAE AS930, AS1098, AS1099, AS1941, AS4320, AS4395, AS4396, and AS5202 and with NPT end connections conforming to ANSI/ASME B1.20.1, SAE AS5201, and SAE AS71051 are

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permitted provided that minimum wall thicknesses (of pressure boundaries) are equal to or greater than those specified for similar fittings listed in SAE AIR310.

4.2.2 Seals Used for Boss Connections

- a. OmniSeal®, OmniSeal RACO™, Raco® or equivalent spring energized seals should be substituted for SAE AS28778 O-Rings in cryogenic, hydrogen, helium, and high pressure gas services to provide leaktight sealing; i.e. assure conformance to leak test requirements in section [4.9](#). With the exception of K-Seal®, seals that are used as substitutes for SAE AS28778, O-Rings shall fit within same seal containment cavity and be totally encapsulated as shown in Figures [B-3](#) and [B-5](#).
- b. For positionable boss connections, as shown in Figure [B-5](#), install in accordance with SAE AS758, except that hydraulic fluid lubricant shall not be used for systems rated for oxygen, oxidizer, or cryogenic services nor for any other systems that interface with oxygen, oxidizer, or cryogenic systems; e.g., where the possibility of lubricant migration into an oxidizer or cryogenic system exists.
- c. If used, lubricants for oxidizer and cryogenic fluid systems shall conform to requirements stated in section [4.0](#).
- d. K-Seal®, illustrated in Figure [B-4](#), shall be Stanley-Harrison series 12120 or equivalent with spacer thickness not to exceed 0.063-inch.
- e. O-Rings used in cryogenic and oxidizer services shall be Virgin PTFE, except that Viton® is also permitted for non-cryogenic oxygen service.
- f. O-Rings used for oxygen services shall be PTFE or Viton® conforming to SSC Drawing 54000-GM30.
- g. O-Rings used for other services shall be Polytetrafluoroethylene (PTFE), Viton®, or Buna-N.
- h. Spring energized seals, including OmniSeal®, OmniSeal RACO™, Raco®, K-Seal® type seals or equivalents, shall be PTFE, metallic with PTFE coating, or uncoated metallic.