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JOHN C. STENNIS SPACE CENTER

TUBING SYSTEMS

FOR FACILITY SYSTEMS, SPECIAL TEST

EQUIPMENT, AND AEROSPACE HARDWARE

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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)

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			<p>400 psig pressure limit applies to aluminum fittings in or rated for oxygen service. Addition of drawings in 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.</p>
A	07/16/07	<p>Bill St. Cyr 8-1134</p> <p>Larry de Quay 8-1956</p>	<p>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.</p>

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		<p><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.</p> <p><u>Section 4.0</u>: add cleanliness, packaging, and storage 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.</p> <p><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.</p> <p><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.</p> <p><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.</p> <p><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.</p> <p><u>Section 5</u>: added section.</p> <p><u>Appendix A</u>: added OSMA to list.</p>

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1.0 PURPOSE

This standard provides the design requirements and operating limits for tubing and tube fittings at Stennis Space Center (SSC) 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:

- a. tubing with 37° flared ends;
- b. tubing with flareless ends connected to Swagelok® type flareless tube fitting end connections;
- c. tubing with coned-and- (left hand) threaded ends;
- d. tube fittings with 37° flared, Swagelok® type flareless, NPT, and coned-and- (left hand) threaded end connections;
- e. fittings with SAE (formerly AN/MS) straight internal (female) thread patterned boss connections; and,
- f. fittings with SAE (formerly AN/MS) straight thread external (male) thread patterned end connections that connect to boss connections 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

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International Association of Plumbing and Mechanical Officials (IAPMO), Uniform Plumbing Code (UPC), American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) standards, and applicable 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

49 CFR 195, *Code of Federal Regulations, Title 49, Part 195, Transportation of Hazardous Liquids by Pipeline*

ANSI/AIAA G-095-2004, *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*

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MS28777, *Washer, Flat, Aircraft Hydraulic Backup* (Inactive for New Design)

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

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

NASA-STD-6001, *Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments That Support Combustion*

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 (SAE 30347), Solution Heat Treated (UNS S34700)*

SAE AMS 5557, *Steel, Corrosion and Heat-Resistant, Seamless or Welded Hydraulic Tubing 18.5CR - 10.5NI - 0.40TI (SAE 30321) Solution Heat Treated - UNS S32100*

SAE AMS 5566, *Steel, Corrosion Resistant, Seamless or Welded Hydraulic Tubing, 19Cr – 10Ni (SAE 30304), High Pressure, Cold Drawn (UNS S30400)*

SAE AMS 5567, *Steel, Corrosion Resistant, Seamless or Welded Hydraulic Tubing, 19Cr – 10Ni (SAE 30304) Solution Heat Treated (UNS S30400)*

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

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 (Formerly KC105)*

SAE AS 1099, *Fitting End, Bulkhead Flared Tube, for Seal Ring, Standard Dimensions for, Design Standard (Formerly KC104)*

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

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

SAE AS 4330, *Tubing, Flared, Standard Dimensions for, Design Standard- FSC 4730* (Formerly MS33584)

SAE AS 4395, *Fitting End, Flared Tube Connection, Design Standard* (Formerly MS24385 and MS33656)

SAE AS 4396, *Fitting End, Bulkhead, Flared Tube Connection, Design Standard* (Formerly MS24386 and MS33657)

SAE AS 4841, *Fittings, 37° Flared, Fluid Connection* (Formerly MIL-F-5509 in part)

SAE AS 4842, *Fittings and Bosses, Pipe Threaded, Fluid Connection* (Formerly MIL-F-5509 in part)

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* (Formerly MIL-F-5509 in part)

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

SAE AS 5179, *Nut, Fitting, Port* (Formerly AN6289)

SAE AS 5201, *Fitting End, External Taper Pipe Thread, Design Standard* (Formerly AND100775 and MS33677)

SAE AS 5202, *Port or Fitting End, Internal Straight Thread, Design Standard* (Formerly MS33649C and SAE AS33649)

SAE AS 8791, *(R) Hydraulic and Pneumatic Retainers (Back-Up Rings), Polytetrafluoroethylene (PTFE) Resin* (Replaces MS28774)

SAE AS 28778, *Packing, Preformed, Straight Thread Tube Fitting Boss - FSC 5331* (Replaced MS28778)

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SAE AS 33583, *Tubing End Double Flare, Standard Dimensions for - FSC 4730* (Formerly MS33583)

SAE AS 71051, *Pipe Threads, Taper, Aeronautical National Form, Symbol ANPT – Design and Inspection Standard*

[SPR 1440.1, Records Management Program Requirements](#)

[SSC form 517, Variance Request](#)

[SSC form 716, Materials Usage Agreement \(MUA\)](#)

[SSC Standard 34-004, Classes of Welding Inspection](#)

SSC Standard 47-000, *Index of Facility Piping System*

[SSC Standard 79-002, Sampling Requirements and Maximum Allowable Impurities for SSC Fluids and Fluid Systems](#)

[SSC Standard 79-010, 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-8070-0007-CONFIG, Variance and Alternate Standard Request](#)

[SSTD-8070-0089-FLUIDS, John C. Stennis Space Center Surface Cleanliness Requirements for SSC Fluid Systems](#)

USAF TO 00-25-223, *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

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and NASA requirements documents. For example, SSC Standard 79-010, 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 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.

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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

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)
1/4 to 1	Gaseous & Cryogenic	6,000 to 10,000	4
1/4 to 1	Gaseous & Cryogenic	Above 10,000	3
1/4 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

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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

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
<p>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.)</p> <p>** Hydraulic Tubing</p> <p># 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.</p>						

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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			8209	5388	3938	3105	2556	2177	1896
0.109			8834	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				8179	6103	4773	3907	3315	2879
0.188					7770	6039	4923	4166	3610
0.190					7862	6112	4981	4214	3652
0.250						8333	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 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 %.

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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.

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-psi 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

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AS5202 and with NPT end connections conforming to ANSI/ASME B1.20.1, SAE AS5201, and SAE AS71051 are 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-Seals®, 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-Seals®, 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 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.

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CAUTION

Uncoated metallic seals are highly prone to leakage if 16 RMS or smoother microfinish is not maintained on all seal contact surfaces. Uncoated metallic seals should be used only where necessary, such as cases where service temperatures or service fluid compatibility issues preclude the use of PTFE or PTFE coated seals. User is cautioned to use great care during assembly and disassembly of boss connections with uncoated metallic seals to assure that finishes on sealing surfaces are not scratched or damaged.

- i. Metallic materials used for spring energized seals are restricted to type 304, 304L, 316, 316L, A286, 17-4, and 17-7 stainless steels, Inconel 718, Inconel X-750, and Elgiloy® alloys unless an alternate material is approved under a Variance Request (form SSC-517) or MUA (form SSC-716). Type 17-4PH and 17-7PH stainless steels are not permitted for hydrogen service.

4.2.3 NPT Connections on Tube Fittings

- a. NPT connections on tube fittings may be used at pressure ratings specified on Table 3A or Table 3C. If higher pressure ratings of Table 3C are used, then dimensions, schedule of connected pipe, if applicable, and material properties must conform to those listed/stated on that table. In all cases, the length of thread engagement shall be equal to or greater than values shown on Table 3D.
- b. Virgin PTFE tape shall be used for sealing NPT thread connections.
- c. For oxygen service, the virgin PTFE tape shall conform to the latest revision of NASA/SSC Drawing 54000-GM30.
- d. The PTFE tape shall be wrapped around the external (male) thread in the direction used for loosening the thread connection, stretching over threads so that it conforms to the shape of the thread.
- e. There shall be no overlapping PTFE tape on the engaging thread. Overlap the starting turn (wrap or layer) by approximately ½-inch and break the tape. For one-inch and larger NPT thread connections use two identical wrappings side by side. Assembly of thread connection can then be made.

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CAUTION

NPT connectors used in hydrogen and helium services can be highly prone to leakage, especially at operating pressures exceeding 3000-psig, cryogenic service temperatures, or moderate to high frequency cyclic loading and stress conditions.

- f. The use of additional turns (wraps or layers) of PTFE tape on the male thread may be used to acquire leak-tight NPT connections provided that minimum thread engagement length specified in Table 3D is attained. When additional turns of PTFE tape are used, the final turn shall overlap the start of the initial turn by approximately ½-inch. Break off remaining tape prior to assembling the connection.
- g. When disassembling NPT connections, remove all old tape from the internal and external threads and use new PTFE tape as described above prior to reuse.

4.2.4 SWAGELOK[®] Flareless Type Tube Fittings

- a. The use of Swagelok[®] type tube fittings is normally restricted to systems in which the maximum operating pressure does not exceed 3000 psig for fittings up to 1-inch tube size and 1500 psig for fittings over 1 inch through 2 inches tube sizes and the temperature does not exceed 150°F. The listing of approved Swagelok[®] flareless type tube fittings allowed for use at SSC is provided in [Appendix C](#).
- b. When operating conditions of the system do not allow for use of 37° flared tube fittings or coned and threaded type tube fittings, Swagelok[®] type tube fittings may be used at pressures higher than those listed above. Such use shall be covered by an approved Variance Request (form SSC-517) or MUA (form SSC-716).
- c. All Swagelok[®] type flareless type tube fittings shall be manufactured from AISI 316 stainless steel unless operating pressures, temperatures, and hazards associated with service media preclude the use of this material.
- d. Use of materials other than AISI 316 stainless steel shall be covered by an approved Variance Request or MUA.
- e. The system design pressure shall not exceed the manufacturer's pressure rating for the fitting. Swagelok[®] type tube fittings are generally rated to the maximum working pressure of the tubing. However, some fittings with type AN, O-Seal, SAE/MS or pipe ends may have lower ratings.

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- f. To minimize the possibility of leaks in any gas system due to tube surface defects such as scratches, Swagelok® recommends the minimum wall thickness shown in Table 5 be used. Assembly of Swagelok® type fittings shall be in accordance with manufacturers' recommended procedures.

Table 5

Minimum Recommended Tube Wall Thicknesses

For Swagelok® Fittings in Gas Service (from manufacturer's catalog)

Tube OD, in.	Nominal Minimum Wall Thickness, in.	Tube OD, in.	Nominal Minimum Wall Thickness, in.
0.25	0.028	0.875	0.083
0.375	0.035	1.00	0.083
0.50	0.049	1.25	0.109
0.625	0.065	1.50	0.134
0.75	0.065	2.00	0.180

4.3 Tubing for Fluid Pressure of 10,000 psig and Higher

- a. Coned and (Left Hand) Threaded Tubing (also known as Superpressure® Tubing) may be used for medium and high pressure service when the required operating pressure exceeds the capability of flared or swaged tubing and tube fitting systems. Typical pressure ratings for seamless cold worked (cold drawn) AISI type 304/316 stainless steel coned and threaded tubing at a maximum service temperature of 100°F are shown in Table 6.
- b. Maximum operating pressure for higher temperatures shall be in accordance with manufacturer's published recommendations.
- c. Hydrostatic and pneumatic pressure test requirements shall conform to sections [4.8](#) and [4.9](#). Consult manufacturer's catalogs for other diameters and pressures.

CAUTION

Although the tubing may be rated to pressures as described in Table 6, 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.

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- d. Surface finishes for inside diameter (inner bore) surfaces of Coned and Threaded Tubing shall be 100 RMS or smoother.
- e. Outside diameter surfaces of Coned and Threaded Tubing shall have a bright surface finish, nominally 250 RMS or smoother.
- f. The depth of surface discontinuities or defects shall be no greater than 0.004-inches for inside diameter surfaces and no greater than 0.005-inches for outside diameter surfaces.

TABLE 6
Maximum Allowable Working Pressures
Coned and LH Threaded Medium and High Pressure Tubing
Maximum Service Temperature 100° F

Nominal Tube Size, in.	Tube ID, in.	Pressure Rating, psig (to Temp. 100°F)	Flow Area, in. ²	Producers (see Appendix E)
0.5625	0.359	10,000	0.101	AE
0.75	0.516	10,000	0.209	AE, HiP
1.00	0.688	10,000	0.371	AE, HiP
0.25	0.109	20,000	0.009	AE, BuT, HiP
0.375	0.203	20,000	0.032	AE, BuT, HiP
0.5625	0.312	20,000	0.076	AE, BuT, HiP, NSI
0.75	0.438	20,000	0.151	AE, BuT, HiP
1.00	0.562	20,000	0.248	AE, BuT, HiP
1.00	0.438	30,000	0.151	AE, HiP
0.5625	0.250	40,000	0.048	AE
0.25	0.083	60,000	0.005	AE, BuT, HiP, NSI
0.375	0.125	60,000	0.012	AE, BuT, HiP, NSI
0.5625	0.187	60,000	0.028	AE, BuT, HiP, NSI

Note: Above pressure ratings correspond to tube and fittings made of cold worked AISI Type 304/316 stainless steel with SMYS of 60,000 psi and SMTS of 110,000 psi (1/8 hard condition). If tube and fittings are made of another material, new pressure ratings are determined as follows:

$$P_{\text{new}} = P_{T4} \times (S_A/40,000)$$

where: P_{new} = New Pressure Rating (in psig)
 P_{T4} = Pressure Rating from Table 5 (in psig)

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

For cold worked stainless steel parts that are welded, see Section 4.5 for pressure rating reductions.

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4.4 Coned and (Left Hand) Threaded Tube Fittings

- a. Coned and threaded tube fittings are those that utilize end connection geometries illustrated in [Appendix D](#).
- b. Medium pressure coned and threaded tubing fittings (10,000 psig to 20,000 psig) are not interchangeable with high pressure coned and threaded tube fittings (30,000 psig and over).
- c. Coned and threaded tube fittings that also have other types of end connections allowed by this standard (such as MS/AN to Autoclave and other adaptor fittings) may be used, but the pressure rating of the fitting shall be down-rated to that of the fitting connection having the lowest pressure rating.
- d. Tube ends shall be prepared as shown in [Appendix D](#) prior to connecting the respective tube fitting connection. It is critical that all burrs, shavings, slivers, and contaminant particles be removed from the conical taper end and tip of each tube end prior to connecting a tube to a fitting.
- e. To achieve improved leak-tight integrity of the coned and threaded type tubing connection it may be necessary to hone or wipe the conical surfaces to an 8 RMS or smoother microfinish and to assure that the rim of the conical tip on the tube or male connection is coplaner in a plane that is perpendicular to the tube or fitting bore axial centerline within $\pm 1/4$ degree.

4.5 Welded Tube Connections

- a. Full penetration welded tube connections are permitted. Socket or other type weld connections that have surfaces not accessible to visual inspection and removal of contaminants by cleaning agents are not permitted.
- b. Welding shall meet the requirements of ANSI/ASME B31.3.
- c. To obtain the maximum pressure rating for the system, 100% of the welds shall be non-destructively examined and pass a Class 1 weld inspection in accordance with SSC Standard 34-004.
- d. If 100% NDE is not performed, the system pressure rating shall be reduced in accordance with the requirements of ANSI/ASME B31.3.

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- e. When coned and threaded tubing and tube fittings made of cold worked or hardened (1/8 hard condition) stainless steel are welded, the pressure rating of each welded tube or fitting shall be reduced to 50% of the corresponding value listed in Table 6.

4.6 Pipe Runs

Butt-welded pipe and pipe fittings are approved alternates to the use of pressure tubing. Refer to applicable CEF-issued SSC piping system standards and specifications for pipe, pipe fitting, and pipe system requirements.

4.7 Cleanliness, Packaging, and Storage Requirements

- a. All cleaning, packaging, and storage of tubing shall conform to all applicable requirements of the applicable tubing specification listed in Table 2A.
- b. All tubing and tube fittings received from off-site vendors and in storage shall be visually free of drawing compounds, carbon, dirt, dust, visible surface oxides, grit, metallic flakes, scale, surface films, loose or adherent particles, foreign matter, or other detrimental materials.
- c. Prior to acceptance at NASA/SSC and precision cleaning processes, all tubing shall be 100% inspected for cleanliness and freedom from contaminants, such as drawing compounds, carbon, dirt, and dust, by one of the following methods:
1. passing or forcing a solvent-soaked swatch of lint-free yarn or cloth, or a felt plug through the tube. Isopropyl alcohol, methanol, ethanol, denatured alcohol, or acetone followed by alcohol are acceptable solvents. Because acetone leaves a residual film, cleaning with acetone alone is not acceptable. While a heavy discoloration of the swatch is unacceptable, a light discoloration is acceptable unless particles of grit or metallic flakes are visually detectable without the use of magnification (nominally larger than 40 microns in any dimension);
 2. pushing or forcing a rod or smaller diameter tube through the entire length of each inspected tube to verify no obstructions are contained or trapped inside the same; or,
 3. an alternate method that is documented, submitted to, and approved in writing by the NASA/SSC OSMA.
- d. The method used to inspect tubing for cleanliness and freedom from contaminants shall not result in the generation of additional or residual internal gross contamination.

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- e. All tubing and tube fittings that are not installed or used in systems shall be packaged and stored to maintain cleanliness of threaded and internal, service media wetted, surfaces.
- f. Tubing shall be capped or sealed at both ends to prevent contaminant entry when not in use or when placed in storage for later use.
- g. For all tubing stored in outdoor environments, all caps, plugs, and other packaging exposed to the environment shall be made of materials that do not degrade in 100% humidity environments and exposure to sunlight.
- h. Prior to final installation or assembly into tubing systems, all tubing and tube fittings shall be precision cleaned and certified to meet clean level requirements of the respective systems in accordance with SSTD-8070-0089-FLUIDS.
- i. All precision cleaning and clean level certifications of tubing, tube fittings, and tubing systems per SSTD-8070-0089-FLUIDS shall be performed prior to the system leak tests required under section [4.9](#).

4.8 Proof Pressure Test Requirements

- a. With the exception of selected vent system segments/sections, all tube system sections, components, and connections shall be hydrostatically tested at 1.5 times the maximum allowable working pressure (MAWP) of the tubing, as specified by this standard, prior to placing the system into operational service.
- b. In tubing systems where one or more system components are rated at a lower MAWP than that of the tubing, the system shall be hydrostatically tested at 1.5 times the design pressure of the system prior to placing the system into operational service.
- c. Vent system segments and sections exempted from proof pressure tests are limited to those where the total axial centerline length is no greater than 10 feet and where the system section/segment exits directly to ambient atmosphere. Furthermore, there shall be only one mechanical, non-welded, joint in each of the respective sections/segments, which is to be located at the upstream end of this section/segment.
- d. On a case-by-case basis and with approval of the NASA Safety representative, pneumatic pressure tests at 1.25 times maximum system operating pressure or at 1.25 times system design pressure are permitted in lieu of hydrostatic pressure testing. Appropriate measures to reduce or eliminate rapid explosion or gas decompression hazards to personnel and hardware

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to acceptable risk and hazard abatement levels shall be incorporated when pneumatic proof pressure tests are performed.

- e. All proof pressure tests shall be in full compliance with all applicable requirements of 49 CFR 195.
- f. All proof pressure test procedures shall conform to all applicable (pressurized) leak test requirements of ASME B31.3.
- g. Hydrostatic proof pressure tests may be performed on separate tubing system sections, fittings, tubing runs, and components prior to precision cleaning and final assembly of the same. Systems and system sections may be disassembled after hydrostatic proof pressure tests to enable or facilitate precision cleaning of system hardware. However, with the exception of crush washers and (microscopically thin) oxide layers produced on material surfaces during passivation processes, the configuration, material properties, and material boundary wall thicknesses of tested parts, fittings, and tubing may not be altered after completion of the hydrostatic proof pressure tests. Additionally, proof pressure tests shall be performed after completion and acceptance of all tubing system weld joints/connections.

4.9 System Leak Test Requirements

- a. With the exception of selected vent system segments/sections, pneumatic leak tests are required for all fluid tube systems, after final assembly of the system. For tubing systems that are certified as precision clean per one of the cleanliness levels, except Level 3 (Commercial Clean), under SSTD-8070-0089-FLUIDS, all test gases shall conform to SSC Standard 79-002.
- b. Vent system segments and sections exempted from leak tests are limited to those where the total axial centerline length is no greater than 10 feet and where the system section/segment exits directly to ambient atmosphere. There shall be no cross-sectional flow area changes in each of the respective sections/segments and only one mechanical, non-welded, joint which is to be located at the upstream end of each of these sections/segments.
- c. Leak tests that are not performed by NASA test operations personnel shall be performed with test gas at maximum system operating pressure or at system design pressure.
- d. For hydrogen and helium tubing systems, leak test gas shall be helium or a nitrogen-and-helium gas mixture with a minimum of 10% volume (mole) fraction of helium. Nitrogen, air, helium, or a mixture of these gases may be used for leak testing of systems that are not rated or used in hydrogen or helium service.

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- e. When leak tests are not performed with test gas at maximum system operating pressure nor at system design pressure, they shall be performed at pressures between 40 and 150 psig.
- f. Systems with flammable, highly reactive, and hazardous service fluids, such as hydrogen and oxygen, shall be equipped with fully operable and remote leak detection equipment prior to and during system pressurization.
- g. Leakage through all system mechanical and welded joints shall be measured by “soap solution,” “Leak-Tec[®],” or equivalent bubble test or mass spectrometer with sensitivity set to 10^{-4} sccm or lower. Zero visible or “bubble tight” external system leakage is required for bubble tests. A maximum of 10^{-4} sccm external system leakage is allowed for mass spectrometer tests unless a higher leakage rate is deemed acceptable by the NASA Mechanical Test Operations Engineer, Engineer responsible for the tested tubing system(s), or governing CCB.
- h. All system leakage test procedures shall conform to all applicable ANSI/ASME B31.3 requirements.
- i. All system leakage tests shall conform to applicable requirements of 49 CFR 195.

5.0 RECORDS AND FORMS

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

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Appendix A - Acronyms, Abbreviations, and Definitions

AIAA	American Institute of Aeronautics and Astronautics
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
AMS	Aerospace Material Specification (from SAE)
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CCB	Configuration Control Board
CEF	(NASA SSC) Central Engineering Files
DR	Deviation Request
FNPT	Female (Internal Thread) NPT
H ₂	Hydrogen
IAPMO	International Association of Plumbing and Mechanical Officials
HVAC	Heating, Ventilating and Air Conditioning
LH	Left Hand(ed)
MAWP	Maximum Allowable Working Pressure
MNPT	Male (External Thread) NPT
MPa	Mega-Pascal
MSFC	Marshall Space Flight Center
MUA	Materials Usage Agreement (form SSC-716)
NASA	National Aeronautics and Space Administration
NPS	Nominal Pipe Size
NPSM	National Pipe Straight Mechanical (ANSI/ASME B1.20.1)
NPT	(American) National (Standard Taper) Pipe Thread (ANSI ASME B1.20.1)
OD	Outside Diameter
OSMA	Office of Safety & Mission Assurance
psi	Pounds Force per Square Inch
psig	Pounds Force per Square Inch (Gauge)
PTFE	Polytetrafluoroethylene
Ra	Roughness Average (in micro-inches, ASME B46.1)
RMS	Root Mean Square (Roughness, in micro-inches, ASME B46.1)
SAE	Society of Automotive Engineers
sccm	standard cubic centimeter per minute
SCD	Specification Control Drawing
SOI	Standard Operating Instructions
SMYS	Specified Minimum Yield Strength
SMTS	Specified Minimum Tensile Strength
SSC	Stennis Space Center

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SSTD	Stennis Space Center Standard
STE	Special Test Equipment (provided by SSC)
USAF	United States Air Force
UPC	Uniform Plumbing Code
XXHY	Double Extra Heavy (Pipe Schedule)
XXS	Double Extra Strong (Pipe Schedule)

Tube For the purposes of this standard, tube is defined as a pressure-tight cylinder used to convey a fluid or to transmit a fluid pressure, with its dimensions specified by its outside diameter (OD) and wall thickness in decimal (preferred) or fraction of an inch. Tube sizes covered by this standard range from 0.05” to 2” OD, with wall thickness ranging from 0.005” to 0.250”.

Pipe For reference purposes, a pipe is defined as a pressure-tight cylinder used to convey a fluid or to transmit a fluid pressure, with its dimensions specified by its nominal pipe size (NPS) and schedule. For example, stainless steel pipe sizes range from 1/8” NPS to 72” diameter and above. Pipe schedules, which refer to wall thickness, range from 5 (or 5S for stainless steel pipe) to XXS (or XXHY) and above.

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Appendix B - Flared Tube and Straight Thread Boss Connections

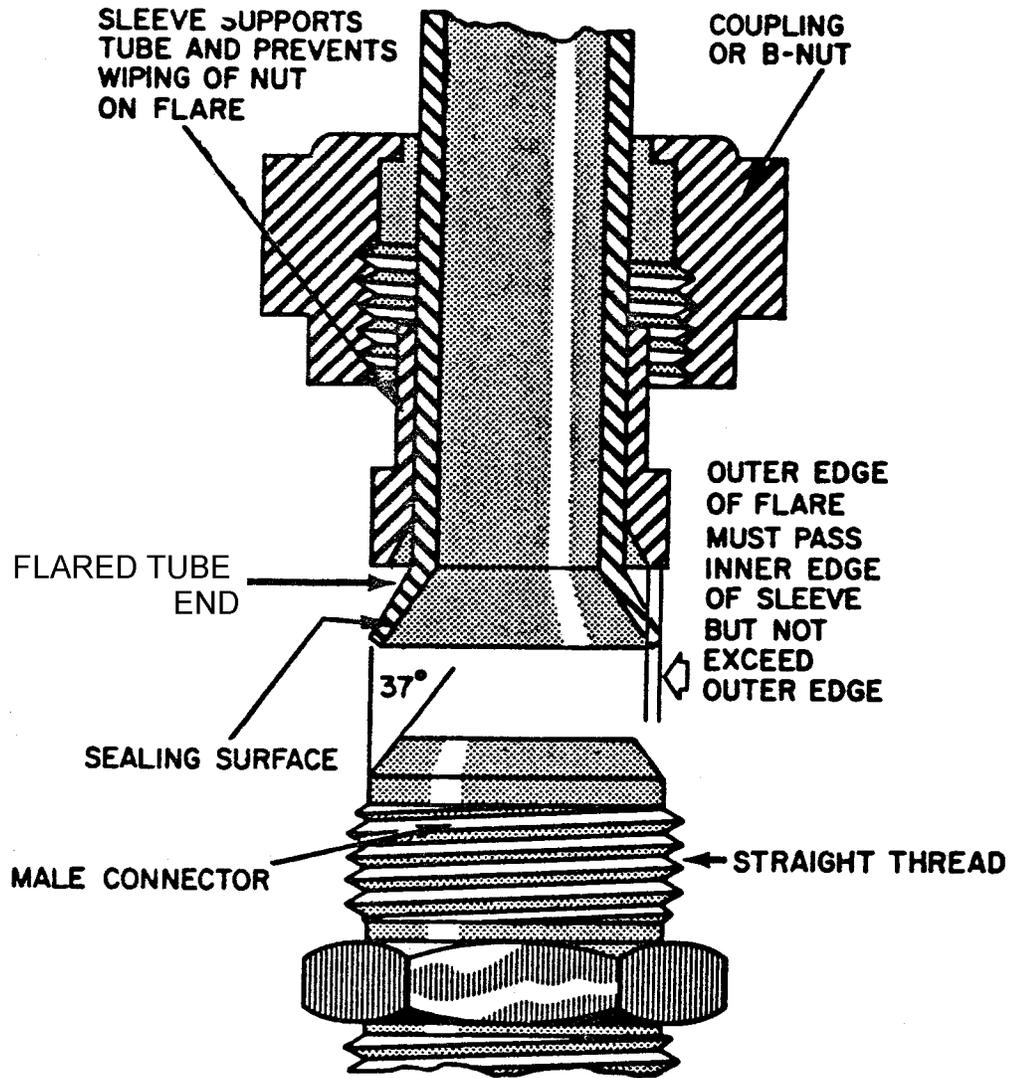


Figure B-1. Three-Piece 37° Flared Tube Fitting Connection, Disassembled

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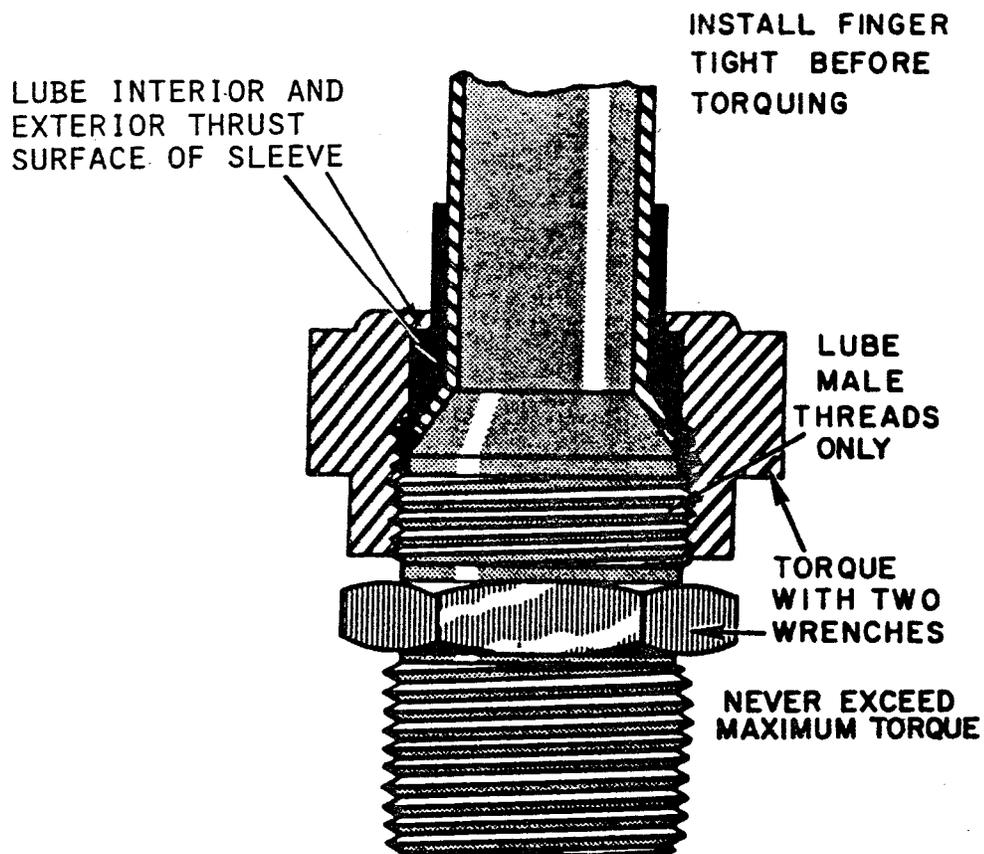
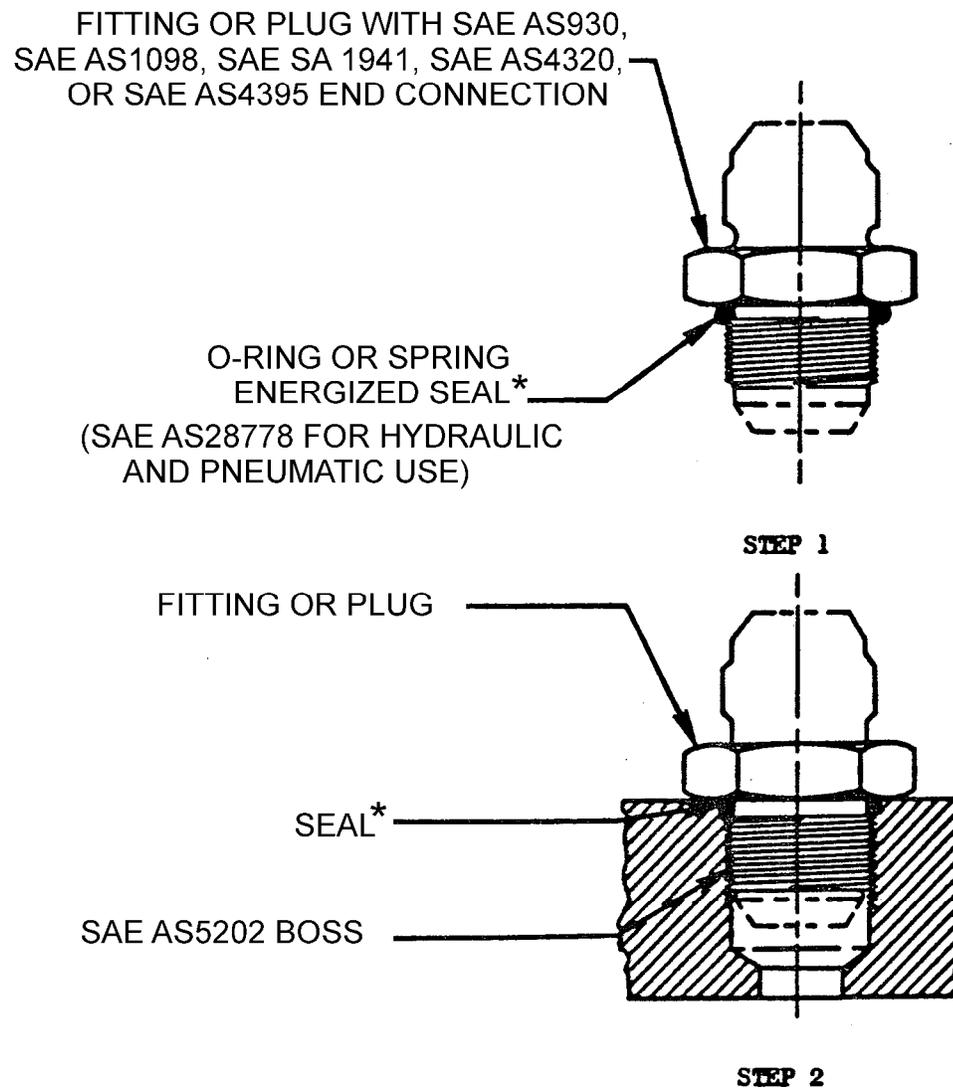


Figure B-2. Three-Piece 37° Flared Tube Fitting Connection, Assembled

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* Reference [Section 4.2](#), "Seals Used for Boss Connections" subsection, for detailed seal requirements

Figure B-3. SAE AS930, AS1098, AS1941, AS4320, or AS4395 to SAE AS5202 Boss Connection with O-Ring or Spring Energized Seal

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Port Seal Application

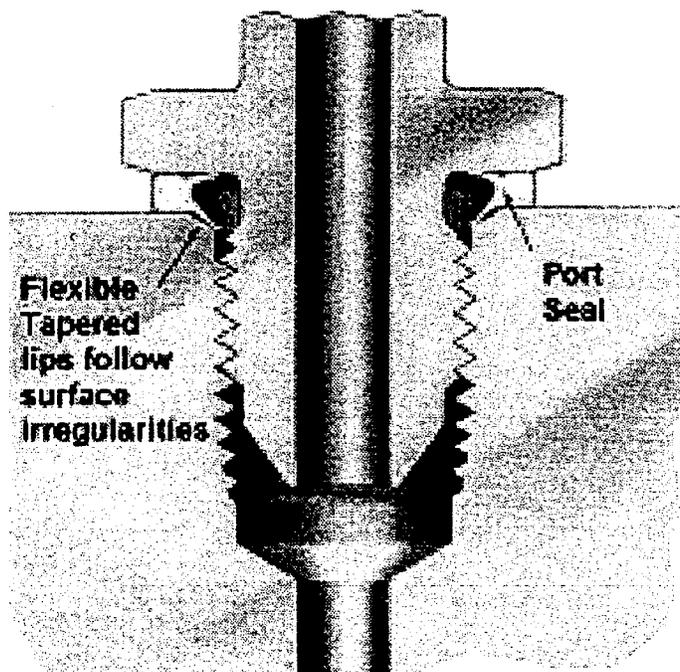
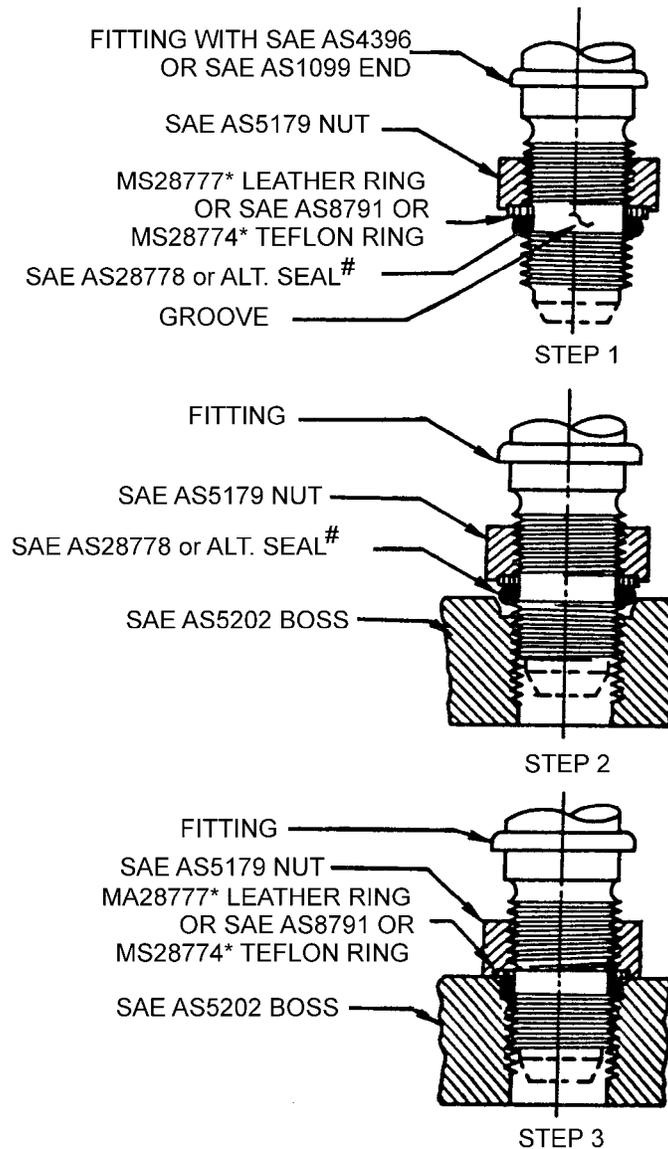


Figure B-4. SAE AS930, AS1098, AS1941, AS4320, or AS4395 to SAE AS5202 Boss Connection with K-Seal® or Equivalent Type Seal

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* MS28774 and MS28777 rings are used for existing designs and replacement purposes only, not to be used for new designs and systems

Refer to "Seals Used for Boss Connections" subsection in Section 4.2 for detailed requirements for Alternate and SAE AS28778 Seals

Figure B-5. Positionable Fitting End into SAE AS5202 Boss

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Appendix C - Approved Double Ferrule Flareless Type (Swagelok®) Tube Fittings

Swagelok® to Male NPT Adapter		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
1/16	1/16	-100-1-1
1/16	1/8	-100-1-2
1/16	1/4	-100-1-4
1/8	1/16	-200-1-1
1/8	1/8	-200-1-2
1/8	1/4	-200-1-4
1/8	3/8	-200-1-6
1/8	1/2	-200-1-8
3/16	1/8	-300-1-2
3/16	1/4	-300-1-4
1/4	1/16	-400-1-1
1/4	1/8	-400-1-2
1/4	1/4	-400-1-4
1/4	3/8	-400-1-6
1/4	1/2	-400-1-8
1/4	3/4	-400-1-12
5/16	1/8	-500-1-2
5/16	1/4	-500-1-4
5/16	3/8	-500-1-6
3/8	1/8	-600-1-2
3/8	1/4	-600-1-4
3/8	3/8	-600-1-6
3/8	1/2	-600-1-8
3/8	3/4	-600-1-12
1/2	1/8	-810-1-2
1/2	1/4	-810-1-4
1/2	3/8	-810-1-6
1/2	1/2	-810-1-8
1/2	3/4	-810-1-12
1/2	1	-810-1-16
5/8	3/8	-1010-1-6
5/8	1/2	-1010-1-8
5/8	3/4	-1010-1-12
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® to Male NPT Adapter (Continued)		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
3/4	1/2	-1210-1-8
3/4	3/4	-1210-1-12
3/4	1	-1210-1-16
7/8	3/4	-1410-1-12
7/8	1	-1410-1-16
1	1/2	-1610-1-8
1	3/4	-1610-1-12
1	1	-1610-1-16
1 1/4	1	-2000-1-16
1 1/4	1 1/4	-2000-1-20
1 1/2	1 1/2	-2400-1-24
2	2	-3200-1-32
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

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Metric Swagelok® to Male NPT Adapter		
Tube OD (mm)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
2	1/8	-2MO-1-2
3	1/8	-3MO-1-2
3	1/4	-3MO-1-4
4	1/8	-4MO-1-2
4	1/4	-4MO-1-4
6	1/8	-6MO-1-2
6	1/4	-6MO-1-4
6	3/8	-6MO-1-6
6	1/2	-6MO-1-8
8	1/8	-8MO-1-2
8	1/4	-8MO-1-4
8	3/8	-8MO-1-6
8	1/2	-8MO-1-8
10	1/8	-10MO-1-2
10	1/4	-10MO-1-4
10	3/8	-10MO-1-6
10	1/2	-10MO-1-8
10	3/4	-10MO-1-12
12	1/8	-12MO-1-2
12	1/4	-12MO-1-4
12	3/8	-12MO-1-6
12	1/2	-12MO-1-8
12	3/4	-12MO-1-12
14	1/4	-14MO-1-4
14	3/8	-14MO-1-6
14	1/2	-14MO-1-8
15	1/2	-15MO-1-8
16	3/8	-16MO-1-6
16	1/2	-16MO-1-8
16	3/4	-16MO-1-12
18	1/2	-18MO-1-8
18	3/4	-18MO-1-12
20	1/2	-20MO-1-8
20	3/4	-20MO-1-12
22	3/4	-22MO-1-12
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Metric Swagelok® to Male NPT Adapter (Continued)		
Tube OD (mm)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
22	1	-22MO-1-16
25	1/2	-25MO-1-8
25	3/4	-25MO-1-12
25	1	-25MO-1-16
28	1	-28MO-1-16
28	1 1/4	-28MO-1-20
32	1 1/4	-32MO-1-20
38	1 1/2	-38MO-1-24
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® to Male NPT Bulkhead Adapter		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
1/8	1/8	-200-11-2
1/4	1/8	-400-11-2
1/4	1/4	-400-11-4
3/8	1/4	-600-11-4
3/8	3/8	-600-11-6
3/8	1/2	-600-11-8
1/2	3/8	-810-11-6
1/2	1/2	-810-11-8
3/4	3/4	-1210-11-12
1	1	-1610-11-16
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Metric Swagelok® to Male NPT Bulkhead Adapter		
Tube OD (mm)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
6	1/4	-6MO-11-4
12	1/2	-12MO-11-8
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

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Swagelok® to Male SAE/MS Straight Thread Adapter		
Tube OD (in.)	SAE/MS Thread Size (in.)	Swagelok® Basic Part Number *
1/8	5/16-24	-200-1-2ST
1/8	7/16-20	-200-1-4ST
1/8	9/16-18	-200-1-6ST
1/4	7/16-20	-400-1-4ST
1/4	9/16-18	-400-1-6ST
1/4	3/4-16	-400-1-8ST
1/4	7/8-14	-400-1-10ST
5/16	1/2-20	-500-1-5ST
3/8	7/16-20	-600-1-4ST
3/8	9/16-18	-600-1-6ST
3/8	3/4-16	-600-1-8ST
3/8	7/8-14	-600-1-10ST
1/2	9/16-18	-810-1-6ST
1/2	3/4-16	-810-1-8ST
1/2	7/8-14	-810-1-10ST
1/2	1 1/16-12	-810-1-12ST
5/8	3/4-16	-1010-1-8ST
5/8	7/8-14	-1010-1-10ST
3/4	3/4-16	-1210-1-8ST
3/4	1 1/16-12	-1210-1-12ST
7/8	1 3/16-12	-1410-1-14ST
1	1 1/16-12	-1610-1-12ST
1	1 5/16-12	-1610-1-16ST
1 1/4	1 5/8-12	-2000-1-20ST
1 1/2	1 7/8-12	-2400-1-24ST
2	2 1/2-12	-3200-1-32ST
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® to Male SAE/MS Straight Thread, Long Adapter		
Tube OD (in.)	SAE/MS Thread Size (in.)	Swagelok® Basic Part Number *
1/4	7/16-20	-400-1L-4ST
5/16	½-20	-500-1L-5ST
3/8	9/16-18	-600-1L-6ST
1/2	3/4-16	-810-1L-8ST
5/8	7/8-14	-1010-1L-10ST
3/4	1 1/16-12	-1210-1L-12ST
7/8	1 3/16-12	-1410-1L-14ST
1	1 5/16-12	-1610-1L-16ST
1 1/4	1 5/8-12	-2000-1L-20ST
1 1/2	1 7/8-12	-2400-1L-24ST
2	2 1/2-12	-3200-1L-32ST
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

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Swagelok® to Male NPT Elbow, 90°		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
1/16	1/16	-100-2-1
1/16	1/8	-100-2-2
1/8	1/16	-200-2-1
1/8	1/8	-200-2-2
1/8	1/4	-200-2-4
3/16	1/8	-300-2-2
3/16	1/4	-300-2-4
1/4	1/16	-400-2-1
1/4	1/8	-400-2-2
1/4	1/4	-400-2-4
1/4	3/8	-400-2-6
1/4	1/2	-400-2-8
5/16	1/8	-500-2-2
5/16	1/4	-500-2-4
5/16	3/8	-500-2-6
3/8	1/8	-600-2-2
3/8	1/4	-600-2-4
3/8	3/8	-600-2-6
3/8	1/2	-600-2-8
3/8	3/4	-600-2-12
1/2	1/4	-810-2-4
1/2	3/8	-810-2-6
1/2	1/2	-810-2-8
1/2	3/4	-810-2-12
5/8	3/8	-1010-2-6
5/8	1/2	-1010-2-8
5/8	3/4	-1010-2-12
3/4	1/2	-1210-2-8
3/4	3/4	-1210-2-12
7/8	3/4	-1410-2-12
1	3/4	-1610-2-12
1	1	-1610-2-16
1 1/4	1 1/4	-2000-2-20
1 1/2	1 1/2	-2400-2-24
2	2	-3200-2-32
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Metric Swagelok® to Male NPT Elbow, 90°		
Tube OD (mm)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
3	1/8	-3MO-2-2
3	1/4	-3MO-2-4
4	1/8	-4MO-2-2
4	1/4	-4MO-2-4
6	1/8	-6MO-2-2
6	1/4	-6MO-2-4
6	3/8	-6MO-2-6
6	1/2	-6MO-2-8
8	1/8	-8MO-2-2
8	1/4	-8MO-2-4
8	3/8	-8MO-2-6
8	1/2	-8MO-2-8
10	1/8	-10MO-2-2
10	1/4	-10MO-2-4
10	3/8	-10MO-2-6
10	1/2	-10MO-2-8
12	1/4	-12MO-2-4
12	3/8	-12MO-2-6
12	1/2	-12MO-2-8
12	3/4	-12MO-2-12
15	1/2	-15MO-2-8
16	3/8	-16MO-2-6
16	1/2	-16MO-2-8
16	3/4	-16MO-2-12
18	1/2	-18MO-2-8
18	3/4	-18MO-2-12
20	1/2	-20MO-2-8
20	3/4	-20MO-2-12
22	3/4	-22MO-2-12
22	1	-22MO-2-16
25	3/4	-25MO-2-12
25	1	-25MO-2-16
32	1 1/4	-32MO-2-20
38	1 1/2	-38MO-2-24
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

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Swagelok® to Male NPT Elbow, 45°		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
1/4	1/8	-400-5-2
1/4	1/4	-400-5-4
3/8	1/8	-600-5-2
3/8	1/4	-600-5-4
3/8	3/8	-600-5-6
1/2	3/8	-810-5-6
1/2	1/2	-810-5-8
3/4	3/4	-1210-5-12
1	1	-1610-5-16
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® to Male SAE/MS Straight Thread Positionable Elbow, 90° (Continued)		
Tube OD (in.)	SAE/MS Thread Size (in.)	Swagelok® Basic Part Number *
3/8	3/4-16	-600-2-8ST
1/2	3/4-16	-810-2-8ST
5/8	7/8-14	-1010-2-10ST
3/4	1 1/16-12	-1210-2-12ST
7/8	1 3/16-12	-1410-2-14ST
1	1 5/16-12	-1610-2-16ST
1 1/4	1 5/8-12	-2000-2-20ST
1 1/2	1 7/8-12	-2400-2-24ST
2	2 1/2-12	-3200-2-32ST
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® to Male SAE/MS Straight Thread Positionable Elbow, 45°		
Tube OD (in.)	SAE/MS Thread Size (in.)	Swagelok® Basic Part Number *
1/4	7/16-20	-400-5-4ST
3/8	9/16-18	-600-5-6ST
1/2	3/4-16	-810-5-8ST
3/4	1 1/16-12	-1210-5-12ST
1	1 5/16-12	-1610-5-16ST
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® to Male NPT on Branch Tee		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
1/8	1/8	-200-3TTM
1/8	1/4	-200-3-4TTM
3/16	1/8	-300-3TTM
1/4	1/8	-400-3TTM
1/4	1/4	-400-3-4TTM
5/16	1/8	-500-3TTM
3/8	1/4	-600-3TTM
3/8	3/8	-600-3-6TTM
1/2	3/8	-810-3TTM
1/2	1/2	-810-3-8TTM
5/8	1/2	-1010-3TTM
3/4	3/4	-1210-3TTM
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® to Male SAE/MS Straight Thread Positionable Elbow, 90°		
Tube OD (in.)	SAE/MS Thread Size (in.)	Swagelok® Basic Part Number *
1/4	7/16-20	-400-2-4ST
1/4	9/16-18	-400-2-6ST
5/16	1/2-20	-500-2-5ST
3/8	9/16-18	-600-2-6ST
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

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Metric Swagelok® to Male NPT on Branch Tee		
Tube OD (mm)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
6	1/8	-6MO-3TTM
8	1/8	-8MO-3TTM
10	1/4	-10MO-3TTM
12	3/8	-12MO-3TTM
16	1/2	-16MO-3TTM
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Metric Swagelok® to Male NPT on Run Tee		
Tube OD (mm)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
6	1/8	-6MO-3TMT
6	1/4	-6MO-3-4TMT
8	1/4	-8MO-3-4TMT
12	1/4	-12MO-3-4TMT
12	1/2	-12MO-3-8TMT
16	1/2	-16MO-3TMT
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® to Male NPT on Run Tee		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
1/8	1/8	-200-3TMT
1/8	1/4	-200-3-4TMT
3/16	1/8	-300-3TMT
1/4	1/8	-400-3TMT
1/4	1/4	-400-3-4TMT
5/16	1/8	-500-3TMT
3/8	1/4	-600-3TMT
3/8	3/8	-600-3-6TMT
1/2	3/8	-810-3TMT
1/2	1/2	-810-3-8TMT
5/8	1/2	-1010-3TMT
3/4	3/4	-1210-3TMT
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® to SAE/MS Straight Thread on Run Tee, Positionable		
Tube OD (in.)	SAE/MS Thread Size (in.)	Swagelok® Basic Part Number *
1/4	7/16-20	-400-3TST
3/8	9/16-18	-600-3TST
1/2	3/4-16	-810-3TST
3/4	1 1/16-12	-1210-3TST
1	1 5/16-12	-1610-3TST
1 1/4	1 5/8-12	-2000-3TST
1 1/2	1 7/8-12	-2400-3TST
2	2 1/2-12	-3200-3TST
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

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Swagelok® to Male SAE/MS Straight Thread on Branch Tee, Positionable		
Tube OD (in.)	SAE/MS Thread Size (in.)	Swagelok® Basic Part Number *
1/4	7/16-20	-400-3TTS
3/8	9/16-18	-600-3TTS
1/2	3/4-16	-810-3TTS
3/4	1 1/16-12	-1210-3TTS
1	1 5/16-12	-1610-3TTS
1 1/4	1 5/8-12	-2000-3TTS
1 1/2	1 7/8-12	-2400-3TTS
2	2 1/2-12	-3200-3TTS
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® to Female NPT Adapter		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
1/16	1/16	-100-7-1
1/16	1/8	-100-7-2
1/8	1/8	-200-7-2
1/8	1/4	-200-7-4
3/16	1/8	-300-7-2
1/4	1/8	-400-7-2
1/4	1/4	-400-7-4
1/4	3/8	-400-7-6
1/4	1/2	-400-7-8
5/16	1/8	-500-7-2
5/16	1/4	-500-7-4
3/8	1/8	-600-7-2
3/8	1/4	-600-7-4
3/8	3/8	-600-7-6
3/8	1/2	-600-7-8
3/8	3/4	-600-7-12
1/2	1/4	-810-7-4
1/2	3/8	-810-7-6
1/2	1/2	-810-7-8
1/2	3/4	-810-7-12
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® to Female NPT Adapter (Continued)		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
5/8	3/8	-1010-7-6
5/8	1/2	-1010-7-8
5/8	3/4	-1010-7-12
3/4	1/2	-1210-7-8
3/4	3/4	-1210-7-12
7/8	3/4	-1410-7-12
1	3/4	-1610-7-12
1	1	-1610-7-16
1 1/4	1 1/4	-2000-7-20
1 1/2	1 1/2	-2400-7-24
2	2	-3200-7-32
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® to Female NPT Bulkhead Adapter		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
1/8	1/8	-200-71-2
1/4	1/8	-400-71-2
1/4	1/4	-400-71-4
3/8	1/4	-600-71-4
1/2	3/8	-810-71-6
1/2	1/2	-810-71-8
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Metric Swagelok® to Female NPT Bulkhead Adapter		
Tube OD (mm)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
6	1/4	-6MO-71-4
12	1/2	-12MO-71-8
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

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Swagelok® to Female NPT Elbow, 90°		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
1/8	1/8	-200-8-2
1/8	1/4	-200-8-4
3/16	1/8	-300-8-2
1/4	1/8	-400-8-2
1/4	1/4	-400-8-4
1/4	3/8	-400-8-6
1/4	1/2	-400-8-8
5/16	1/8	-500-8-2
5/16	1/4	-500-8-4
3/8	1/8	-600-8-2
3/8	1/4	-600-8-4
3/8	3/8	-600-8-6
3/8	1/2	-600-8-8
1/2	1/4	-810-8-4
1/2	3/8	-810-8-6
1/2	1/2	-810-8-8
5/8	3/8	-1010-8-6
5/8	1/2	-1010-8-8
3/4	1/2	-1210-8-8
3/4	3/4	-1210-8-12
7/8	3/4	-1410-8-12
1	3/4	-1610-8-12
1	1	-1610-8-16
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Metric Swagelok® to Female NPT Elbow, 90° (Continued)		
Tube OD (mm)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
10	1/4	-10MO-8-4
12	1/4	-12MO-8-4
12	1/2	-12MO-8-8
16	1/2	-16MO-8-8
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® to Female NPT on Run Tee		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
1/8	1/8	-200-3TFT
1/4	1/8	-400-3TFT
1/4	1/4	-400-3-4TFT
3/8	1/4	-600-3TFT
1/2	3/8	-810-3TFT
1/2	1/2	-810-3-8TFT
3/4	3/4	-1210-3TFT
1	3/4	-1610-3-12TFT
1	1	-1610-3TFT
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Metric Swagelok® to Female NPT Elbow, 90°		
Tube OD (mm)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
6	1/8	-6MO-8-2
6	1/4	-6MO-8-4
6	1/2	-6MO-8-8
8	1/4	-8MO-8-4
10	1/8	-10MO-8-2
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

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Metric Swagelok® to Female NPT on Run Tee		
Tube OD (mm)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
6	1/8	-6MO-3TFT
6	1/4	-6MO-3-4TFT
8	1/8	-8MO-3TFT
8	1/4	-8MO-3-4TFT
10	1/4	-10MO-3TFT
12	3/8	-12MO-3TFT
12	1/4	-12MO-3-4TFT
16	1/2	-16MO-3TFT
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Metric Swagelok® to Female NPT on Branch Tee		
Tube OD (mm)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
6	1/8	-6MO-3TTF
6	1/4	-6MO-3-4TTF
8	1/8	-8MO-3TTF
8	1/4	-8MO-3-4TTF
10	1/4	-10MO-3TTF
12	3/8	-12MO-3TTF
12	1/4	-12MO-3-4TTF
16	1/2	-16MO-3TTF
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® to Female NPT on Branch Tee		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
1/8	1/8	-200-3TTF
1/4	1/8	-400-3TTF
1/4	1/4	-400-3-4TTF
3/8	1/4	-600-3TTF
3/8	3/8	-600-3-6TTF
3/8	1/2	-600-3-8TTF
1/2	1/4	-810-3-4TTF
1/2	3/8	-810-3TTF
1/2	1/2	-810-3-8TTF
5/8	1/2	-1010-3TTF
3/4	3/4	-1210-3TTF
1	3/4	-1610-3-12TTF
1	1	-1610-3TTF
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® Union	
Tube OD (in.)	Swagelok® Basic Part Number *
1/16	-100-6
1/8	-200-6
3/16	-300-6
1/4	-400-6
5/16	-500-6
3/8	-600-6
1/2	-810-6
5/8	-1010-6
3/4	-1210-6
7/8	-1410-6
1	-1610-6
1 1/4	-2000-6
1 1/2	-2400-6
2	-3200-6
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

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Metric Swagelok® to Swagelok® Union		
Metric Tube OD (mm)	Fractional Tube OD (in.)	Swagelok® Basic Part Number *
2	1/8	-2MO-6-2
2	1/4	-2MO-6-4
3	1/8	-3MO-6-2
4	1/8	-4MO-6-2
4	1/4	-4MO-6-4
6	1/8	-6MO-6-2
6	1/4	-6MO-6-4
6	5/16	-6MO-6-5
8	1/4	-8MO-6-4
8	3/8	-8MO-6-6
10	1/8	-10MO-6-2
10	1/4	-10MO-6-4
10	5/16	-10MO-6-5
10	3/8	-10MO-6-6
12	5/16	-12MO-6-5
12	3/8	-12MO-6-6
12	1/2	-12MO-6-8
15	1/2	-15MO-6-8
16	5/8	-16MO-6-10
18	3/4	-18MO-6-12
20	1/2	-20MO-6-8
20	1	-20MO-6-16
25	1	-25MO-6-16
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Metric Swagelok® Union	
Tube OD (mm)	Swagelok® Basic Part Number *
2	-2MO-6
3	-3MO-6
4	-4MO-6
6	-6MO-6
8	-8MO-6
10	-10MO-6
12	-12MO-6
14	-14MO-6
15	-15MO-6
16	-16MO-6
18	-18MO-6
20	-20MO-6
22	-22MO-6
25	-25MO-6
28	-28MO-6
32	-32MO-6
38	-38MO-6
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

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Swagelok® Reducing Union		
Tube OD (in.)	Reduced Tube OD (in.)	Swagelok® Basic Part Number *
1/8	1/16	-200-6-1
3/16	1/16	-300-6-1
3/16	1/8	-300-6-2
1/4	1/16	-400-6-1
1/4	1/8	-400-6-2
1/4	3/16	-400-6-3
5/16	1/8	-500-6-2
5/16	1/4	-500-6-4
3/8	1/16	-600-6-1
3/8	1/8	-600-6-2
3/8	1/4	-600-6-4
3/8	5/16	-600-6-5
1/2	1/8	-810-6-2
1/2	1/4	-810-6-4
1/2	3/8	-810-6-6
5/8	3/8	-1010-6-6
5/8	1/2	-1010-6-8
3/4	1/4	-1210-6-4
3/4	3/8	-1210-6-6
3/4	1/2	-1210-6-8
3/4	5/8	-1210-6-10
1	1/2	-1610-6-8
1	3/4	-1610-6-12
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Metric Swagelok® Reducing Union		
Tube OD (mm)	Reduced Tube OD (mm)	Swagelok® Basic Part Number *
3	2	-3MO-6-2M
6	2	-6MO-6-2M
6	3	-6MO-6-3M
6	4	-6MO-6-4M
8	6	-8MO-6-6M
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Metric Swagelok® Reducing Union (Continued)		
Tube OD (mm)	Reduced Tube OD (mm)	Swagelok® Basic Part Number *
10	6	-110MO-6-6M
10	8	-10MO-6-8M
12	6	-12MO-6-6M
12	8	-12MO-6-8M
12	10	-12MO-6-10M
16	10	-16MO-6-10M
16	12	-16MO-6-12M
18	12	-18MO-6-12M
25	18	-25MO-6-18M
25	20	-25MO-6-20M
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® Bulkhead Union	
Tube OD (in.)	Swagelok® Basic Part Number *
1/16	-100-61
1/8	-200-61
3/16	-300-61
1/4	-400-61
5/16	-500-61
3/8	-600-61
1/2	-810-61
5/8	-1010-61
3/4	-1210-61
1	-1610-61
1 1/4	-2000-61
1 1/2	-2400-61
2	-3200-61
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

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Metric Swagelok® Bulkhead Union	
Tube OD (mm)	Swagelok® Basic Part Number *
3	-3MO-61
4	-4MO-61
6	-6MO-61
8	-8MO-61
10	-10MO-61
12	-12MO-61
14	-14MO-61
15	-15MO-61
16	-16MO-61
18	-18MO-61
20	-20MO-61
32	-32MO-61
38	-38MO-61
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

Swagelok® Bulkhead Reducing Union		
Tube OD (in.)	Reduced Tube OD (in.)	Swagelok® Basic Part Number *
1/4	1/8	-400-61-2
3/8	1/4	-600-61-4
1/2	1/4	-810-61-4
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® Union Elbow, 90°	
Tube OD (in.)	Swagelok® Basic Part Number *
1/16	-100-9
1/8	-200-9
3/16	-300-9
1/4	-400-9
5/16	-500-9
3/8	-600-9
1/2	-810-9
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

Swagelok® Union Elbow, 90° (Continued)	
Tube OD (in.)	Swagelok® Basic Part Number *
5/8	-1010-9
3/4	-1210-9
7/8	-1410-9
1	-1610-9
1 1/4	-2000-9
1 1/2	-2400-9
2	-3200-9
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

Metric Swagelok® Union Elbow, 90°	
Tube OD (mm)	Swagelok® Basic Part Number *
3	-3MO-9
4	-4MO-9
6	-6MO-9
8	-8MO-9
10	-10MO-9
12	-12MO-9
14	-14MO-9
15	-15MO-9
16	-16MO-9
18	-18MO-9
20	-20MO-9
22	-22MO-9
25	-25MO-9
28	-28MO-9
32	-32MO-9
38	-38MO-9
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

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Swagelok® Union Tee	
Tube OD (in.)	Swagelok® Basic Part Number *
1/16	-100-3
1/8	-200-3
3/16	-300-3
1/4	-400-3
5/16	-500-3
3/8	-600-3
1/2	-810-3
5/8	-1010-3
3/4	-1210-3
7/8	-1410-3
1	-1610-3
1 1/4	-2000-3
1 1/2	-2400-3
2	-3200-3
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

Metric Swagelok® Union Tee	
Tube OD (mm)	Swagelok® Basic Part Number *
2	-2MO-3
3	-3MO-3
4	-4MO-3
6	-6MO-3
8	-8MO-3
10	-10MO-3
12	-12MO-3
14	-14MO-3
15	-15MO-3
16	-16MO-3
18	-18MO-3
20	-20MO-3
22	-22MO-3
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

Metric Swagelok® Union Tee (Continued)	
Tube OD (mm)	Swagelok® Basic Part Number *
25	-25MO-3
28	-28MO-3
32	-32MO-3
38	-38MO-3
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

Swagelok® Reducing on Branch Union Tee		
Tube OD (in.)	Reduced Tube OD (in.)	Swagelok® Basic Part Number *
3/8	1/4	-600-3-6-4
1/2	1/4	-810-3-8-4
1/2	3/8	-810-3-8-6
5/8	3/8	-1010-3-10-6
3/4	3/8	-1210-3-12-6
3/4	1/2	-1210-3-12-8
1	3/8	-1610-3-16-6
1	1/2	-1610-3-16-8
1	3/4	-1610-3-16-12
1 1/4	1	-2000-3-20-16
1 1/2	1	-2400-3-24-16
2	1	-3200-3-32-16
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® Reducing on Run Union Tees		
Tube OD (in.)	Reduced Tube OD (in.)	Swagelok® Basic Part Number *
3/8	1/4	-600-3-4-6
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

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Swagelok® Reducing on Run and Branch Union Tee		
Tube OD (in.)	Reduced Run & Branch Tube OD (in.)	Swagelok® Basic Part Number *
1/2	3/8	-810-3-6-6
5/8	3/8	-1010-3-6-6
3/4	3/8	-1210-3-6-6
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Metric Swagelok® Union Cross	
Tube OD (mm)	Swagelok® Basic Part Number *
3	-3MO-4
6	-6MO-4
8	-8MO-4
10	-10MO-4
12	-12MO-4
16	-16MO-4
18	-18MO-4
20	-20MO-4
25	-25MO-4
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

Swagelok® Reducing on Run and Branch Union Tee			
Tube OD (in.)	Reduced Run Tube OD (in.)	Reduced Branch Tube OD (in.)	Swagelok® Basic Part Number *
5/8	1/2	3/8	-1010-3-8-6
3/4	1/2	3/8	-1210-3-8-6
1	3/4	3/8	-1610-3-12-6
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel			

Swagelok® to Male SAE/MS Flared End Union		
Tube OD (in.)	Flared Tube Nom. Size (in.)	Swagelok® Basic Part Number *
1/16	1/8	-100-6-2AN
1/8	1/8	-200-6-2AN
1/8	1/4	-200-6-4AN
1/4	1/4	-400-6-4AN
5/16	5/16	-500-6-5AN
3/8	1/4	-600-6-4AN
3/8	3/8	-600-6-6AN
1/2	1/2	-810-6-8AN
3/4	3/4	-1210-6-12AN
1	1	-1610-6-16AN
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® Union Cross	
Tube OD (in.)	Swagelok® Basic Part Number *
1/8	-200-4
1/4	-400-4
5/16	-500-4
3/8	-600-4
1/2	-810-4
3/4	-1210-4
1	-1610-4
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

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Swagelok® to Male SAE/MS Flared End Bulkhead Union		
Tube OD (in.)	Flared Tube Nom. Size (in.)	Swagelok® Basic Part Number *
1/4	1/4	-400-61-4AN
3/8	3/8	-600-61-6AN
1/2	1/2	-810-61-8AN
3/4	3/4	-1210-61-12AN
1	1	-1610-61-16AN
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® to Swagelok® Tube End Reducer		
Tube OD (in.)	Swaged Tube End OD (in.)	Swagelok® Basic Part Number *
1/16	1/8	-100-R-2
1/16	1/4	-100-R-4
1/8	1/16	-200-R-1
1/8	1/8	-200-R-2
1/8	3/16	-200-R-3
1/8	1/4	-200-R-4
1/8	3/8	-200-R-6
1/8	1/2	-200-R-8
3/16	1/8	-300-R-2
3/16	1/4	-300-R-4
1/4	1/8	-400-R-2
1/4	3/16	-400-R-3
1/4	1/4	-400-R-4
1/4	5/16	-400-R-5
1/4	3/8	-400-R-6
1/4	1/2	-400-R-8
1/4	5/8	-400-R-10
1/4	3/4	-400-R-12
5/16	3/8	-500-R-6
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		
# Ordered part comes with pre-swaged nuts and ferrules on the tube end		

Swagelok® to Swagelok® Tube End Reducer (Continued)		
Tube OD (in.)	Swaged Tube End OD (in.)	Swagelok® Basic Part Number *
5/16	1/2	-500-R-8
3/8	1/4	-600-R-4
3/8	3/8	-600-R-6
3/8	1/2	-600-R-8
3/8	5/8	-600-R-10
3/8	3/4	-600-R-12
1/2	1/4	-810-R-4
1/2	3/8	-810-R-6
1/2	1/2	-810-R-8
1/2	5/8	-810-R-10
1/2	3/4	-810-R-12
1/2	1	-810-R-16
5/8	3/4	-1010-R-12
5/8	7/8	-1010-R-14
5/8	1	-1010-R-16
3/4	1/2	-1210-R-8
3/4	1	-1210-R-16
1	1 1/4	-1610-R-20 #
1	1 1/2	-1610-R-24 #
1	2	-1610-R-32 #
1 1/4	1 1/2	-2000-R-24 #
1 1/4	2	-2000-R-32 #
1 1/2	2	-2400-R-32 #
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		
# Ordered part comes with pre-swaged nuts and ferrules on the tube end		

Swagelok® to Swagelok® Tube End Long Reducer		
Tube OD (in.)	Swaged Tube End OD (in.)	Swagelok® Basic Part Number *
3/8	1/2	-600-RF-8
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

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Metric Swagelok® to Metric Swagelok® Tube End Reducer		
Tube OD (mm)	Swaged Tube End OD (mm)	Swagelok® Basic Part Number *
2	3	-2MO-R-3M
3	4	-3MO-R-4M
3	6	-3MO-R-6M
3	10	-3MO-R-10M
4	6	-4MO-R-6M
6	3	-6MO-R-3M
6	8	-6MO-R-8M
6	10	-6MO-R-10M
6	12	-6MO-R-12M
6	18	-6MO-R-18M
8	6	-8MO-R-6M
8	10	-8MO-R-10M
8	12	-8MO-R-12M
10	6	-10MO-R-6M
10	8	-10MO-R-8M
10	12	-10MO-R-12M
10	15	-10MO-R-15M
10	18	-10MO-R-18M
12	6	-12MO-R-6M
12	8	-12MO-R-8M
12	10	-12MO-R-10M
12	16	-12MO-R-16M
12	18	-12MO-R-18M
12	20	-12MO-R-20M
12	22	-12MO-R-22M
12	25	-12MO-R-25M
16	12	-16MO-R-12M
18	12	-18MO-R-12M
18	16	-18MO-R-16M
18	20	-18MO-R-20M
18	22	-18MO-R-22M
18	25	-18MO-R-25M
20	16	-20MO-R-16M
20	18	-20MO-R-18M
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Metric Swagelok® to Metric Swagelok® Tube End Reducer (Continued)		
Tube OD (mm)	Swaged Tube End OD (mm)	Swagelok® Basic Part Number *
20	22	-20MO-R-22M
20	25	-20MO-R-25M
22	18	-22MO-R-18M
22	20	-22MO-R-20M
22	25	-22MO-R-25M
25	18	-25MO-R-18M
25	20	-25MO-R-20M
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Metric Swagelok® to Swagelok® Tube End Reducer		
Tube OD (mm)	Swaged Tube End OD (in.)	Swagelok® Basic Part Number *
2	1/8	-2MO-R-2
3	1/8	-3MO-R-2
3	1/4	-3MO-R-4
4	1/4	-4MO-R-4
6	1/8	-6MO-R-2
6	1/4	-6MO-R-4
6	5/16	-6MO-R-5
6	3/8	-6MO-R-6
6	1/2	-6MO-R-8
8	3/8	-8MO-R-6
8	1/2	-8MO-R-8
10	3/8	-10MO-R-6
10	1/2	-10MO-R-8
12	1/2	-12MO-R-8
12	3/4	-12MO-R-12
18	3/4	-18MO-R-12
18	1	-18MO-R-16
25	1	-25MO-R-16
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

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Swagelok® to Swagelok® Tube End Bulkhead Reducer	
Tube OD (in.)	Swagelok® Basic Part Number *
1/8	-200-R1-2
1/4	-400-R1-4
3/8	-600-R1-6
1/2	-810-R1-8
5/8	-1010-R1-10
1	-1610-R1-16
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

Swagelok® Tube End to Swagelok® Integral Ferrule Tube End Connector	
Tube OD (in.)	Swagelok® Basic Part Number *
1/16	-101-PC
1/8	-201-PC
1/4	-401-PC
5/16	-501-PC
3/8	-601-PC
1/2	-811-PC
3/4	-1211-PC
1	-1611-PC
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

Metric Swagelok® Tube End to Metric Swagelok® Integral Ferrule Tube End Connector	
Tube OD (mm)	Swagelok® Basic Part Number *
3	-3M1-PC
6	-6M1-PC
8	-8M1-PC
10	-10M1-PC
12	-12M1-PC
15	-15M1-PC
16	-16M1-PC
18	-18M1-PC
20	-20M1-PC
25	-25M1-PC
28	-28MO-PC #
32	-32MO-PC #
38	-38MO-PC #
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	
# Ordered part includes nuts & ferrules	

Swagelok® Integral Ferrule Tube End to Reducing Swagelok® Tube End Connector		
Tube OD (in.)	Reduced Tube OD (in.)	Swagelok® Basic Part Number *
1/8	1/16	-201-PC-1
1/4	1/16	-401-PC-1
1/4	1/8	-401-PC-2
3/8	1/8	-601-PC-2
3/8	1/4	-601-PC-4
1/2	1/4	-811-PC-4
1/2	3/8	-811-PC-6
3/4	1/2	-1211-PC-8
1	1/2	-1611-PC-8
1	3/4	-1611-PC-12
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

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Metric Swagelok® Integral Ferrule Tube End to Reducing Metric Swagelok® Tube End Connector		
Tube OD (mm)	Reduced Tube OD (mm)	Swagelok® Basic Part Number *
6	3	-6M1-PC-3M
8	6	-8M1-PC-6M
10	6	-10M1-PC-6M
10	8	-10M1-PC-8M
12	6	-12M1-PC-6M
12	8	-12M1-PC-8M
12	10	-12M1-PC-10M
16	12	-16M1-PC-12M
28	25	-28M1-PC-25M
32	25	-32M1-PC-25M
38	25	-38M1-PC-25M
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Metric Swagelok® Cap	
Tube OD (mm)	Swagelok® Basic Part Number *
2	-2MO-C
3	-3MO-C
4	-4MO-C
6	-6MO-C
8	-8MO-C
10	-10MO-C
12	-12MO-C
14	-14MO-C
15	-15MO-C
16	-16MO-C
18	-18MO-C
20	-20MO-C
22	-22MO-C
25	-25MO-C
28	-28MO-C
32	-32MO-C
38	-38MO-C
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

Swagelok® Cap	
Tube OD (in.)	Swagelok® Basic Part Number *
1/16	-100-C
1/8	-200-C
3/16	-300-C
1/4	-400-C
5/16	-500-C
3/8	-600-C
1/2	-810-C
5/8	-1010-C
3/4	-1210-C
7/8	-1410-C
1	-1610-C
1 1/4	-2000-C
1 1/2	-2400-C
2	-3200-C
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

Swagelok® Plug	
Tube OD (in.)	Swagelok® Basic Part Number *
1/16	-100-P
1/8	-200-P
3/16	-300-P
1/4	-400-P
5/16	-500-P
3/8	-600-P
1/2	-810-P
5/8	-1010-P
3/4	-1210-P
7/8	-1410-P
1	-1610-P
1 1/4	-2000-P
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

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Swagelok® Plug (Continued)	
Tube OD (in.)	Swagelok® Basic Part Number *
1 1/2	-2400-P
2	-3200-P
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

Swagelok® Low Dead Volume Union Tee	
Tube OD (in.)	Swagelok® Basic Part Number *
1/16	-1F0-3GC
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

Metric Swagelok® Plug	
Tube OD (mm)	Swagelok® Basic Part Number *
2	-2MO-P
3	-3MO-P
4	-4MO-P
6	-6MO-P
8	-8MO-P
10	-10MO-P
12	-12MO-P
15	-15MO-P
16	-16MO-P
18	-18MO-P
20	-20MO-P
22	-22MO-P
25	-25MO-P
28	-28MO-P
32	-32MO-P
38	-38MO-P
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

Swagelok® Female Column End Fitting Union		
Tube OD (in.)	Sample End Tube OD (in.)	Swagelok® Basic Part Number *
1/4	1/16	-400-6-1FGC
3/8	1/16	-600-6-1FGC
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® Low Dead Volume Union	
Tube OD (in.)	Swagelok® Basic Part Number *
1/16	-1F0-6GC
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

Swagelok® Low and Zero Volume Reducing Union		
Tube OD (in.)	Sample End Tube OD (in.)	Swagelok® Basic Part Number *
1/8	1/16	SS-200-6-1ZV
1/4	1/16	SS-400-6-1ZV
3/8	1/16	SS-600-6-1ZV
1/2	1/16	SS-810-6-1ZV
1/8	1/16	SS-200-6-1LV
1/4	1/16	SS-400-6-1LV
3/8	1/16	SS-600-6-1LV
* Standard part is made of type 304 or 316 Stainless Steel		

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Swagelok® Tube Fitting with Integral ANSI (Raised Face) Flange		
Tube OD	Swagelok® Basic Part Number	ANSI Flange Class *
1/2"	SS-8F0-F8-150	150
	SS-8F0-F8-300	300
10mm	SS-10MF0-F8-150	150
	SS-10MF0-F8-300	300
12mm	SS-12MF0-F8-150	150
	SS-12MF0-F8-300	300
* Special Order to have Concentric 90° V-Groove Serrations in Flange Face per MSS SP-6 if connected pipe system flanges are required to have this design feature		

Swagelok® Vent Protector (Mud Dauber Fitting)	
Thread Size (in.)	Swagelok® Basic Part Number *
1/4	MS-MD-4M
3/8	MS-MD-6M
1/2	MS-MD-8M
3/4	MS-MD-12M
* Standard part is made of type 304 or 316 Stainless Steel	

Swagelok® Tube End to Male NPT Adapter		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
1/8	1/8	-2-TA-1-2
1/8	1/4	-2-TA-1-4
3/16	1/8	-3-TA-1-2
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel # Ordered part comes assembled with nuts and ferrules		

Swagelok® Tube End to Male NPT Adapter (Continued)		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
3/16	1/4	-3-TA-1-4
1/4	1/8	-4-TA-1-2
1/4	1/4	-4-TA-1-4
1/4	3/8	-4-TA-1-6
1/4	1/2	-4-TA-1-8
5/16	1/8	-5-TA-1-2
5/16	1/4	-5-TA-1-4
3/8	1/8	-6-TA-1-2
3/8	1/4	-6-TA-1-4
3/8	3/8	-6-TA-1-6
3/8	1/2	-6-TA-1-8
1/2	1/4	-8-TA-1-4
1/2	3/8	-8-TA-1-6
1/2	1/2	-8-TA-1-8
5/8	1/2	-10-TA-1-8
3/4	1/2	-12-TA-1-8
3/4	3/4	-12-TA-1-12
1	3/4	-16-TA-1-12
1	1	-16-TA-1-16
1 1/4	1 1/4	-20-TA-1-20 #
1 1/2	1 1/2	-24-TA-1-24 #
2	2	-32-TA-1-32 #
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel # Ordered part comes assembled with nuts and ferrules		

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Metric Swagelok® Tube End to Male NPT Adapter		
Tube OD (mm)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
6	1/8	-6-MTA-1-2
6	1/4	-6-MTA-1-4
8	1/4	-8-MTA-1-4
10	1/4	-10-MTA-1-4
10	3/8	-10-MTA-1-6
10	1/2	-10-MTA-1-8
12	1/4	-12-MTA-1-4
12	1/2	-12-MTA-1-8
28	1	-28-MTA-1-16 #
28	1 1/4	-28-MTA-1-20 #
32	1 1/4	-32-MTA-1-20 #
38	1 1/2	-38-MTA-1-24 #
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel # Ordered part comes assembled with nuts and ferrules		

Swagelok® to Male SAE/MS Straight Thread Adapter		
Tube OD (in.)	SAE/MS Thread Size (in.)	Swagelok® Basic Part Number *
1/8	5/16-24	-2-TA-1-2ST
1/4	7/16-20	-4-TA-1-4ST
3/8	7/16-20	-6-TA-1-4ST
3/8	9/16-18	-6-TA-1-6ST
3/8	3/4-16	-6-TA-1-8ST
1/2	9/16-18	-8-TA-1-6ST
1/2	3/4-16	-8-TA-1-8ST
5/8	7/8-14	-10-TA-1-10ST
3/4	1 1/16-12	-12-TA-1-12ST
1	1 5/16-12	-16-TA-1-16ST
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel # Ordered part comes assembled with nuts and ferrules		

Swagelok® to Male SAE/MS Straight Thread Adapter (Continued)		
Tube OD (in.)	SAE/MS Thread Size (in.)	Swagelok® Basic Part Number *
1 1/4	1 5/8-12	-20-TA-1-20ST #
1 1/2	1 7/8-12	-24-TA-1-24ST #
2	2 1/2-12	-32-TA-1-32ST #
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel # Ordered part comes assembled with nuts and ferrules		

Swagelok® Tube End to Female NPT Adapter		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
1/8	1/8	-2-TA-7-2
1/8	1/4	-2-TA-7-4
3/16	1/4	-3-TA-7-4
1/4	1/8	-4-TA-7-2
1/4	1/4	-4-TA-7-4
1/4	3/8	-4-TA-7-6
1/4	1/2	-4-TA-7-8
5/16	1/4	-5-TA-7-4
3/8	1/8	-6-TA-7-2
3/8	1/4	-6-TA-7-4
3/8	3/8	-6-TA-7-6
3/8	1/2	-6-TA-7-8
1/2	1/4	-8-TA-7-4
1/2	3/8	-8-TA-7-6
1/2	1/2	-8-TA-7-8
5/8	1/2	-10-TA-7-8
3/4	1/2	-12-TA-7-8
3/4	3/4	-12-TA-7-12
3/4	1	-12-TA-7-16
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel # Ordered part comes with assembled nuts & ferrules		

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Swagelok® Tube End to Female NPT Adapter (Continued)		
Tube OD (in.)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
1	3/4	-16-TA-7-12
1	1	-16-TA-7-16
1 1/4	1 1/4	-20-TA-7-20 #
1 1/2	1 1/2	-24-TA-7-24 #
2	2	-32-TA-7-32 #
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel # Ordered part comes with assembled nuts & ferrules		

Swagelok® Tube End to Male SAE/MS Flared End Adapter		
Tube OD (in.)	Flared Tube Size (in.)	Swagelok® Basic Part Number *
1/4	1/4	-4-TA-1-4AN
3/8	1/4	-6-TA-1-4AN
3/8	3/8	-6-TA-1-6AN
1/2	1/2	-8-TA-1-8AN
3/4	3/4	-12-TA-1-12AN
1	1	-16-TA-1-16AN
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Metric Swagelok® Tube End to Female NPT Adapter		
Tube OD (mm)	NPT Nom. Pipe Size (in.)	Swagelok® Basic Part Number *
6	1/8	-6-MTA-7-2
6	1/4	-6-MTA-7-4
8	1/4	-8-MTA-7-4
10	1/4	-10-MTA-7-4
10	3/8	-10-MTA-7-6
10	1/2	-10-MTA-7-8
12	1/4	-12-MTA-7-4
12	1/2	-12-MTA-7-8
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

Swagelok® Tube End to Integral Sleeve Flared Tube End; Equipped with Ferrules & Tube Coupling Nuts		
Tube OD (in.)	Flared Tube Size (in.)	Swagelok® Basic Part Number *
1/8	1/8	-200-A-2ANF
1/8	1/4	-200-A-4ANF
1/4	1/4	-400-A-4ANF
3/8	3/8	-600-A-6ANF
1/2	1/2	-810-A-8ANF
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel		

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Swagelok® Nut **	
Tube OD (in.)	Swagelok® Basic Part Number
1/16	-102-1
1/8	-202-1
3/16	-302-1
1/4	-402-1
5/16	-502-1
3/8	-602-1
1/2	-812-1
5/8	-1012-1
3/4	-1212-1
7/8	-1412-1
1	-1612-1
1 1/4	-2002-1
1 1/2	-2402-1
2	-3202-1
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	
** Knurled Nuts up to one (1) inch are available in the same sizes as shown for SWAGELOK Nuts. To order, add suffix K to part number.	

Metric Swagelok® Nut **	
Tube OD (in.)	Swagelok® Basic Part Number *
2	-2M2-1
3	-3M2-1
4	-4M2-1
6	-6M2-1
8	-8M2-1
10	-10M2-1
12	-12M2-1
14	-14M2-1
15	-15M2-1
16	-16M2-1
18	-18M2-1
20	-20M2-1
22	-22M2-1
25	-25M2-1
28	-28M2-1
32	-32M2-1
38	-38M2-1
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	
** Knurled Nuts up to one (1) inch are available in the same sizes as shown for SWAGELOK Nuts. To order, add suffix K to part number.	

Swagelok® Male Nut	
Tube OD (in.)	Swagelok® Basic Part Number *
1/16	-1F2-1GC
1/8	-2F2-1GC
1/4	-4F2-1
1/2	-8F2-1
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

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Metric Swagelok® Male Nut	
Tube OD (mm)	Swagelok® Basic Part Number *
10	-10MF2-1
12	-12MF2-1
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	

Swagelok® Back Ferrule	
Tube OD (in.)	Swagelok® Basic Part Number *
1/16	-104-1
1/8	-204-1
3/16	-304-1
1/4	-404-1
5/16	-504-1
3/8	-604-1
1/2	-814-1
5/8	-1014-1
3/4	-1214-1
7/8	-1414-1
1	-1614-1
1 1/4	-2004-1 #
1 1/2	-2404-1 #
2	-3204-1 #
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel # Use silver coated ferrules for stainless steel tube & fittings	

Metric Swagelok® Back Ferrule	
Tube OD (mm)	Swagelok® Basic Part Number *
2	-2M4-1
3	-3M4-1
4	-4M4-1
6	-6M4-1
8	-8M4-1
10	-10M4-1
12	-12M4-1
14	-14M4-1
15	-15M4-1
16	-16M4-1
18	-18M4-1
20	-20M4-1
22	-22M4-1
25	-25M4-1
28	-28M4-1 #
32	-32M4-1 #
38	-38M4-1 #
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel # Use silver coated ferrules for stainless steel tube & fittings	

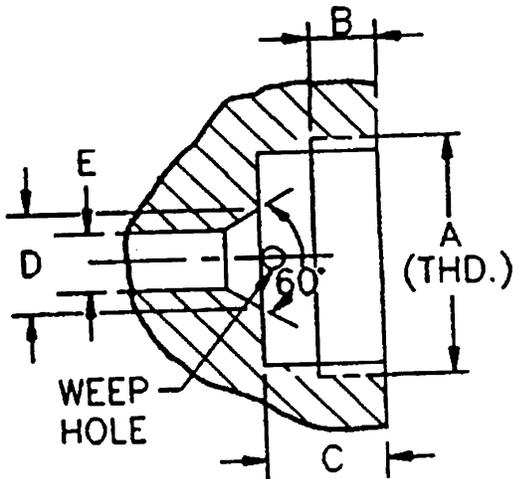
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Swagelok® Front Ferrule	
Tube OD (in.)	Swagelok® Basic Part Number *
1/16	-103-1
1/8	-203-1
3/16	-303-1
1/4	-403-1
5/16	-503-1
3/8	-603-1
1/2	-813-1
5/8	-1013-1
3/4	-1213-1
7/8	-1413-1
1	-1613-1
1 1/4	-2003-1 #
1 1/2	-2403-1 #
2	-3203-1 #
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	
# Use silver coated ferrules for stainless steel tube & fittings	

Metric Swagelok® Front Ferrule	
Tube OD (mm)	Swagelok® Basic Part Number *
2	-2M3-1
3	-3M3-1
4	-4M3-1
6	-6M3-1
8	-8M3-1
10	-10M3-1
12	-12M3-1
14	-14M3-1
15	-15M3-1
16	-16M3-1
18	-18M3-1
20	-20M3-1
22	-22M3-1
25	-25M3-1
28	-28M3-1 #
32	-32M3-1 #
38	-38M3-1 #
* Add "SS" prefix to Basic Part No. for type 316 Stainless Steel	
# Use silver coated ferrules for stainless steel tube & fittings	

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Appendix D - Coned and Left Hand Threaded Tube & Tube Fittings



10,000 psi and 20,000 psi rated tube fittings

Tube OD	A Thread	B	C	D (Dia)	E (Dia) 20,000 psi	E (Dia) 10,000 psi
0.25	7/16 - 20	.28	.50	.19	.109	
0.375	9/16 - 18	.38	.62	.31	.203	
0.5625	13/16 - 16	.44	.75	.50	.312	.359
0.75	3/4 - 14 NPSM	.50	.94	.62	.438	.516
1.00	1-3/8 - 12	.81	1.31	.88	.562	.688

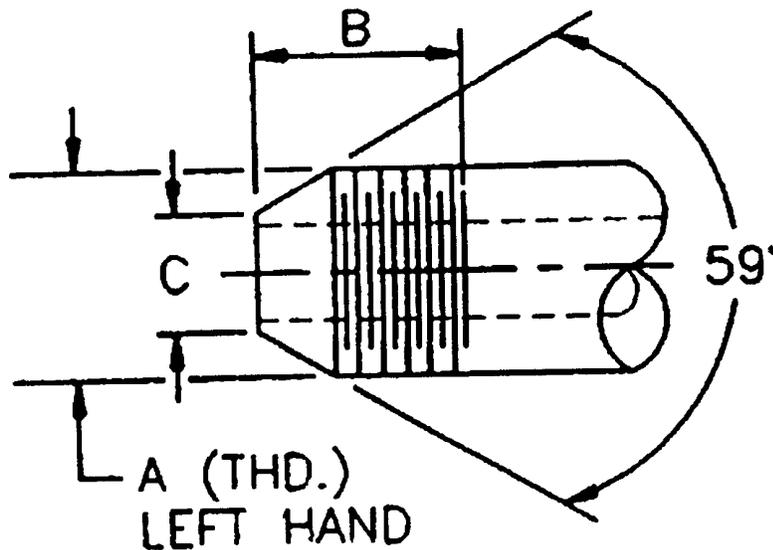
40,000 psi and 60,000 psi rated tube fittings

Tube OD	A Thread	B	C	D (Dia.)	E (Dia) 60,000 psi	E (Dia) 40,000 psi
0.25	9/16 - 18	.38	.44	.17	.094	
0.375	3/4 - 16	.53	.62	.26	.125	
0.5625	1-1/8 - 12	.62	.75	.38	.188	.250

Figure D-1. Female End Connection Dimensions

Note: Dimensions are all in inches, shown for reference only, and should not be considered as actual machining dimensions.

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10,000 psi and 20,000 psi rated tubes

Tube OD	A Thread	B	C (Dia) 20,000 psi	C (Dia) 10,000 psi
0.25	1/4 - 28 L.H.	.34	.141	
0.375	3/8 - 24 L.H.	.44	.250	
0.5625	9/16 - 18 L.H.	.50	.406	.438
0.75	3/4 - 16 L.H.	.62	.562	.578
1.00	1 - 14 L.H.	.78	.719	.812

40,000 psi and 60,000 psi rated tubes

Tube OD	A Thread	B	C (Dia) 60,000 psi	C (Dia) 40,000 psi
0.25	1/4 - 28 L.H.	.56	.125	
0.375	3/8 - 24 L.H.	.75	.219	
0.5625	9/16 - 18 L.H.	.94	.281	.312

Figure D-2. Tubing End Dimensions (inches)

Note: Dimensions are shown for reference only and should not be considered as actual machining dimensions.

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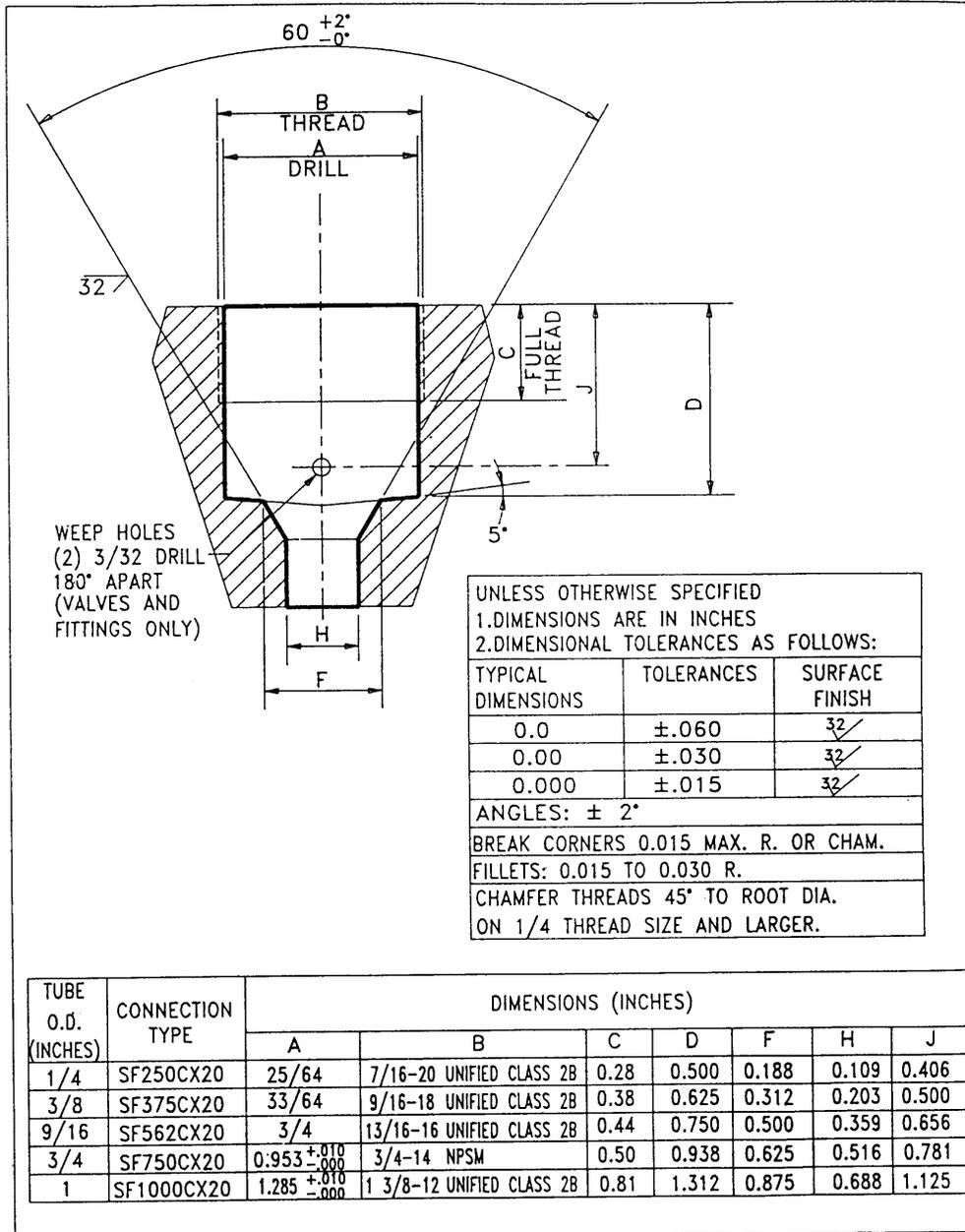


Figure D-3. 20,000 psi Rated Coned & Threaded Tube Fitting Female End Connection Details

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Appendix E - Coned and Left Hand Threaded Tube and Tube Fitting Manufacturers

Coned and Threaded Tube and Tube Fittings are produced by the manufacturers shown below. Use of tube and fittings produced by other manufactures requires an approved Variance or MUA.

AE:

Autoclave Engineers
2930 W. 22nd St., Box 5051
Erie, PA 16512-5051
(818) 838-5700
(800) 458-0409
Fax: (814) 833-0145

BuT:

BuTech Pressure Systems
4928 Pittsburgh Avenue
Erie, PA 16509
(814) 833-4904
Fax (814) 833-2612
e-mail: hq@butech-valve.com
<http://www.butech-valve.com>

HiP:

High Pressure Equipment Company
P.O. Box 8248
1222 Linden Avenue
Erie, PA 16505
(814) 838-2028
(800) 289-7447
Fax: (814) 838-6075
e-mail: sales@highpressure.com
<http://www.highpressure.com>

NSI:

Newport Scientific Inc. (formerly Aminco)
8246-E Sandy Court
Jessup, Maryland 20794
(301) 498-6700
Fax: (301) 490-2313