

Tubing Data—Engineered Combinations

Scope

This data sheet contains suggested allowable working pressures for assemblies of Swagelok® tube fittings with tubing of diverse materials.

Although matching tubing and fitting materials is common practice for optimal system operation, the performance advantages of Swagelok 316 stainless steel tube fittings enable successful mixed-material combinations, even in severe environments. These advantages include:

- Higher chromium and nickel concentrations than standard 316 stainless steel for enhanced corrosion resistance.
- Superior tube grip achieved with Swagelok's patented hinging-colleting™ back ferrule design that translates axial motion into radial swaging action on the tube yet operates with a low assembly torque requirement.

Consequently, for example, the combination of Swagelok 316 tube fittings and alloy 254 tubing can provide an economical, corrosion-resistant solution for installations that might be exposed to sea water. As with any mixed-material assembly, pressure ratings for tubing and fittings from different alloys will be governed by the lower material rating.

See the Swagelok *Gaugeable Tube Fittings and Adapter Fittings* catalog (MS-01-140) for more information about Swagelok tube fitting features and performance.

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Tubing Selection

Proper selection, handling, and installation of tubing, when combined with proper selection of Swagelok® tube fittings, are essential to reliable tubing systems.

The following variables should be considered when ordering tubing for use with Swagelok tube fittings:

- Surface finish
- Material
- Hardness
- Wall thickness.

Tubing Surface Finish

Many ASTM specifications cover the above requirements, but they often are not very detailed on surface finish. For example, ASTM A450, a general tubing specification, reads:

11. Straightness and Finish

11.1 Finished tubes shall be reasonably straight and have smooth ends free of burrs. They shall have a workmanlike finish. Surface imperfections (Note) may be removed by grinding, provided that a smooth curved surface is maintained, and the wall thickness is not decreased to less than that permitted by this or the product specification. The outside diameter at the point of grinding may be reduced by the amount so removed.

Note: An imperfection is any discontinuity or irregularity found in the tube.

Tubing Material

Our suggested ordering instructions for each type of tubing are shown under the respective tables.

Tubing Outside Diameter Hardness

The key to selecting proper tubing for use with metal Swagelok tube fittings is that the tubing must be softer than the fitting material. Swagelok tube fittings are designed to work properly with the tubing that is suggested in the ordering instructions.



Tubing Wall Thickness

The accompanying tables show working pressure ratings of tubing in a wide range of wall thicknesses. Allowable pressure ratings are calculated from S values for the lower-strength material as specified by ASME B31.3, ASME BPV Section II, Part D, or based on repeated pressure testing of the Swagelok tube fitting with a 4:1 design factor based on hydraulic fluid leakage.

Swagelok tube fittings have been repeatedly tested in both the minimum and maximum wall thicknesses shown.

Swagelok tube fittings are not recommended for tube wall thicknesses outside the ranges shown in the accompanying tables for each size.

Tubing Handling

Good handling practices can greatly reduce scratches on tubing and protect the good surface finish that reliable tube manufacturers supply.

- Tubing should never be dragged out of a tubing rack or across a rough surface.
- Tube cutters or hacksaws should be sharp. Do not take deep cuts with each turn of the cutter or stroke of the saw.
- Tube ends should be deburred. This helps to ensure that the tubing will go all the way through the ferrules without damaging the ferrule sealing edge.

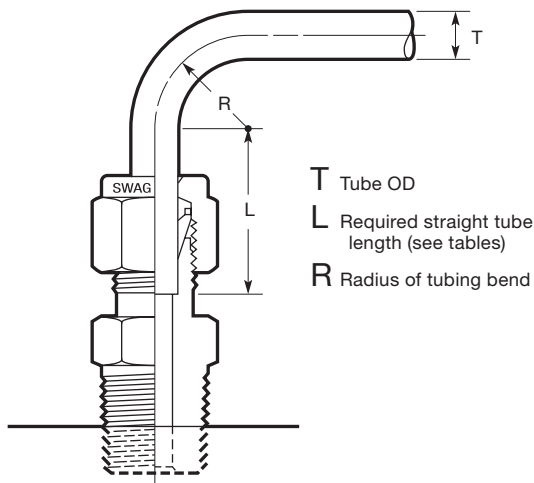
Gas Service

Gases (air, hydrogen, helium, nitrogen, etc.) have very small molecules that can escape through even the most minute leak path. Some surface defects on the tubing can provide such a leak path. As tube outside diameter (OD) increases, so does the likelihood of a scratch or other surface defect interfering with proper sealing.

The most successful connection for gas service will occur if all installation instructions are carefully followed and the heavier wall thicknesses of tubing on the accompanying tables are selected.

A heavy-wall tube resists ferrule action more than a thin-wall tube, allowing the ferrules to coin out minor surface imperfections. A thin-wall tube offers less resistance to ferrule action during installation, reducing the chance of coining out surface defects, such as scratches. Within the applicable suggested allowable working pressure table, select a tube wall thickness whose working pressure is *outside* of the shaded areas.

Tubing Installation



Tubing properly selected and handled, combined with properly installed Swagelok tube fittings, will give you a leak-tight system and provide reliable service in a wide variety of applications.

For maximum assurance of reliable performance, use:

- properly selected and handled high-quality tubing—such as provided by Swagelok
- Swagelok tube fittings assembled in accordance with catalog instructions
- an appropriate tube support system to limit the movement of tubing and fluid system components.

When installing fittings near tube bends, there must be a sufficient straight length of tubing to allow the tube to be bottomed in the Swagelok fitting (see tables).

Fractional, in.	
T Tube OD	L ^①
1/16	1/2
1/8	23/32
3/16	3/4
1/4	13/16
5/16	7/8
3/8	15/16
1/2	1 3/16
5/8	1 1/4
3/4	
7/8	1 5/16
1	1 1/2

Metric, mm	
T Tube OD	L ^①
3	19
6	21
8	23
10	25
12	31
14	32
15	
16	
18	34
20	
22	40
25	

① Required straight tube length.

Suggested Allowable Working Pressure Tables

Figure and tables are for reference only. No implication is made that these values can be used for design work. Applicable codes and practices in industry should be considered. ASME Codes are the successor to and replacement of ASA Piping Codes.

- All pressures are calculated from equations in ASME B31.3, Process Piping. See factors for calculating working pressures in accordance with ASME B31.1, Power Piping.
- Calculations are based on maximum OD and minimum wall thickness, except as noted in individual tables.

Example: 1/2 in. OD × 0.035 in. wall alloy 254 tubing purchased to ASTM A269:

OD Tolerance ± 0.005 in. / Wall Thickness ± 10 %

Calculations are based on 0.505 in. OD × 0.0315 in. wall tubing.

- No allowance is made for corrosion, erosion, welding, or bending.

Pressure Ratings at Elevated Temperatures

Elevated temperature factors were derived from allowable stress in accordance with ASME B31.3 or ASME BPV Section II, Part D.

Table 1—Elevated Temperature Factors^①

Temperature		Tubing Materials					
°F	°C	Alloy 6Mo	UNS C69100 Temper TF00	Type 904L	Alloy 825	316, 316/316L ^②	Alloy 2507
200	93	0.90	1.00	0.82	1.00	1.00	0.99
400	204	0.74	0.96	0.68	0.90	0.96	0.91
600	315	0.67		0.58	0.84	0.85	0.89 ^③
800	426				0.81	0.80	
1000	537					0.76	

^① Elevated temperature factor means suggested allowable working pressure at elevated temperature / suggested allowable working pressure at room temperature.

^② Dual-certified grades such as 304/304L, 316/316L, and 317/317L meet the requirements for the lower maximum carbon content of the L grades and the higher minimum yield and tensile strength of the non-L grades.

^③ Use of alloy 2507 super duplex stainless steel at temperatures above 482°F (250°C) causes microstructural changes that lead to embrittlement and loss of corrosion resistance. Derating factor at 482°F (250°C) is 0.90.

To determine allowable working pressure at elevated temperatures, multiply allowable working pressures from Tables 2 through 7 by a factor shown in Table 1.

Example 1: 316 tube fitting with alloy 6Mo tubing 1/2 in. OD × 0.065 in. wall at 600°F

1. The allowable working pressure at –20 to 100°F (–28 to 37°C) is 5100 psig (Table 2, page 4).
2. The elevated temperature factor for 600°F (315°C) for alloy 6Mo is 0.67 (Table 1, above); 5100 psig × 0.67 = 3417 psig.
3. The elevated temperature factor for 600°F (315°C) for alloy 316 is 0.85 (Table 1, above); 5100 psig × 0.85 = 4335 psig.
4. Selecting the lowest calculated pressure as the allowable working pressure at 600°F is 3417 psig.

Example 2: Alloy 2507 tube fitting with 316 tubing 1/2 in. OD × 0.065 in. wall at 400°F

1. The allowable working pressure at –20 to 100°F (–28 to 37°C) is 5100 psig (Table 10, page 8).
2. The elevated temperature factor for 400°F (204°C) for alloy 2507 is 0.91 (Table 1, above); 5100 psig × 0.91 = 4641 psig.
3. The elevated temperature factor for 400°F (204°C) for alloy 316 is 0.96 (Table 1, above); 5100 psig × 0.96 = 4896 psig.
4. Selecting the lowest calculated pressure as the allowable working pressure at 400°F is 4641 psig.

316 Stainless Steel Tube Fittings with Alloy 254 Tubing

Swagelok 316 stainless steel tube fittings in 1/4 to 1 in. and 6 to 25 mm sizes may be used with high quality, fully annealed (seamless or welded and drawn) alloy 254 hydraulic tubing.

For welded and drawn tubing, a derating factor must be applied for weld integrity: for double-welded tubing, multiply working pressure by 0.85; for single-welded tubing, multiply working pressure by 0.80.

Table 2—Fractional Sizes

Allowable working pressures are based on repeated pressure testing of the Swagelok tube fitting with a 4:1 design factor based on hydraulic fluid leakage

Tube OD in.	Tube Wall Thickness, in.								Fitting Series	Installation Method	
	0.028	0.035	0.049	0.065	0.083	0.095	0.109	0.120		1 1/4 Turns	Pre-swage
	Working Pressure, psig Note: For gas service, select a tube wall thickness outside of the shaded area. (See Gas Service , page 2.)										
1/4	4000	5100	7500	10 200					400	Yes	Yes
3/8		3300	4800	6 500					600	Yes	Yes
1/2		2600	3700	5 100	6700				800	Yes	Yes
5/8 ^①			4000	5 400	6000	6000			1010	No	Yes
3/4 ^①			3300	4 400	4900	4900	4900		1210	No	Yes
7/8 ^①			2800	3 700	4800	4800	4800		1410	No	Yes
1 ^①				3 300	3600	3600	3600	3600	1610	No	Yes

^① Requires a preswage tool or the Swagelok multihead hydraulic swaging unit (MHSU) for installation. See the Swagelok *Gaugeable Tube Fittings and Adapter Fittings* catalog (MS-01-140) for more information.

Table 3—Metric Sizes

Allowable working pressures are based on repeated pressure testing of the Swagelok tube fitting with a 4:1 design factor based on hydraulic fluid leakage

Tube OD mm	Tube Wall Thickness, mm										Fitting Series	Installation Method	
	0.8	1.0	1.2	1.5	1.8	2.0	2.2	2.5	2.8	3.0		1 1/4 Turns	Pre-swage
	Working Pressure, bar Note: For gas service, select a tube wall thickness outside of the shaded area. (See Gas Service , page 2.)												
6	310	420	540	710							6M0	Yes	Yes
8		310	390	520							8M0	Yes	Yes
10		240	300	400							10M0	Yes	Yes
12		200	250	330	410	470					12M0	Yes	Yes
18 ^①			210	280	320	320	320				18M0	No	Yes
20 ^①			190	250	290	290	290				20M0	No	Yes
22 ^①			170	220	260	260	260				22M0	No	Yes
25 ^①					240	240	240	240	240	240	25M0	No	Yes

^① Requires a preswage tool or the Swagelok multihead hydraulic swaging unit (MHSU) for installation. See the Swagelok *Gaugeable Tube Fittings and Adapter Fittings* catalog (MS-01-140) for more information.

Suggested Ordering Information

High-quality, fully annealed seamless or welded and drawn alloy 254 hydraulic tubing, ASTM A269 or ASTM A213, or equivalent. Hardness not to exceed 96 HRB. Tubing to be free of scratches, suitable for bending and flaring.

316 Stainless Steel Tube Fittings with Type 904L Stainless Steel Tubing

Swagelok 316 stainless steel tube fittings in 1/4 to 1 in. and 6 to 25 mm sizes may be used with high quality, seamless Type 904L stainless steel hydraulic tubing.

Table 4—Fractional Sizes

Allowable working pressures are based on equations from ASME B31.3 and B31.1 for a maximum S value of 20 000 psi (137.8 MPa).

Tube OD in.	Tube Wall Thickness, in.								Fitting Series
	0.028	0.035	0.049	0.065	0.083	0.095	0.109	0.120	
	Working Pressure, psig Note: For gas service, select a tube wall thickness outside of the shaded area. (See Gas Service , page 2.)								
1/4	4000	5100	7500	10 200					400
5/16		4000	5800	8 000					500
3/8		3300	4800	6 500	7500				600
1/2		2600	3700	5 100	6700				800
5/8			2900	4 000	5200	6000			1010
3/4			2400	3 300	4200	4900	5800		1210
7/8			2000	2 800	3600	4200	4800		1410
1				2 400	3100	3600	4200	4700	1610

Table 5—Metric Sizes

Allowable working pressures are based on equations from ASME B31.3 and B31.1 for a maximum S value of 137.8 MPa (20 000 psi).

Tube OD mm	Tube Wall Thickness, mm										Fitting Series
	0.8	1.0	1.2	1.5	1.8	2.0	2.2	2.5	2.8	3.0	
	Working Pressure, bar Note: For gas service, select a tube wall thickness outside of the shaded area. (See Gas Service , page 2.)										
6	310	420	540	710							6M0
8		310	390	520							8M0
10		240	300	400	510	580					10M0
12		200	250	330	410	470					12M0
14		160	200	270	340	380	430				14M0
15		150	190	250	310	360	400				15M0
16			170	230	290	330	370	400			16M0
18			150	200	260	290	320	370			18M0
20			140	180	230	260	290	330	380		20M0
22			140	160	200	230	260	300	340		22M0
25					180	200	230	260	290	320	25M0

Suggested Ordering Information

High quality, fully annealed, Type 904L, seamless hydraulic tubing, ASTM 269 and ASTM B677 or equivalent. Hardness not to exceed 90 HRB or 200 HV. Tubing to be free of scratches, suitable for bending and flaring.

316 Stainless Steel Tube Fittings with UNS C69100 Copper Alloy (Tungum) Tubing

Swagelok 316 stainless steel tube fittings in 1/4 to 1 in. and 6 to 25 mm sizes may be used with high-quality, precipitation-hardened, temper TF00, seamless UNS C69100, ASTM B706 copper alloy hydraulic tubing.

Table 6—Fractional Sizes

Allowable working pressures are calculated from an S value of 20 000 psi (137.8 MPa) for precipitation hardened, temper TF00, seamless UNS C69100, ASTM B706 copper alloy (Tungum or equivalent) tubing at -20 to 100°F (-28 to 37°C) as listed in ASME B31.3.

Tube OD in.	Tube Wall Thickness, in.							Fitting Series
	0.028	0.035	0.049	0.065	0.083	0.109	0.120	
	Working Pressure, psig Note: For gas service, select a tube wall thickness outside of the shaded area. (See Gas Service , page 2.)							
1/4	4000	5100	7500	10 200				400
5/16		4000	5800	8 000				600
3/8		3300	4800	6 500				800
1/2		2600	3700	5 100	6700			1010
5/8			2900	4 000	5200			1210
3/4			2400	3 300	4200	5800		1410
1				2 400	3100	4200	4700	1610

Table 7—Metric Sizes

Allowable working pressures are calculated from an S value of 137.8 MPa (20 000 psi) for precipitation hardened, temper TF00, seamless UNS C69100, ASTM B706 copper alloy (Tungum or equivalent) tubing at -28 to 37°C (-20 to 100°F) as listed in ASME B31.3.

Tube OD mm	Tube Wall Thickness, mm								Fitting Series
	0.8	1.0	1.2	1.5	2.0	2.2	2.5	3.0	
	Working Pressure, bar Note: For gas service, select a tube wall thickness outside of the shaded area. (See Gas Service , page 2.)								
6	310	420	540						6M0
8		310	390	520					8M0
10		240	300	400	580				10M0
12		200	250	330	470				12M0
14		160	200	270	380	430			14M0
16			170	230	330	370	400		16M0
20				180	260	290	330		20M0
25					200	230	260	320	25M0

Suggested Ordering Information

High-quality, precipitation-hardened, temper TF00, seamless copper alloy tubing, UNS C69100, ASTM B706 or equivalent. Hardness not to exceed 90 HRB. Tubing to be free of scratches, suitable for bending and flaring.

316 Stainless Steel Tube Fittings with Alloy 825 Tubing

Swagelok 316 stainless steel tube fittings in 1/4 to 1 in. and 6 to 25 mm sizes may be used with high quality, seamless Alloy 825 hydraulic tubing.

Table 8—Fractional Sizes

Allowable working pressures are based on repeated pressure testing of the Swagelok tube fitting with a 4:1 design factor based on hydraulic fluid leakage.

Tube OD in.	Tube Wall Thickness, in.						Fitting Series
	0.035	0.049	0.065	0.083	0.095	0.109	
	Working Pressure, psig Note: For gas service, select a tube wall thickness outside of the shaded area. (See Gas Service , page 2.)						
1/4	6400	9300	10200				400
3/8	4100	5900	7500				600
1/2	3000	4300	5900				800
3/4			3800	4900	5800		1210
1			2800	3600	4200	4200	1610

Table 9—Metric Sizes

Allowable working pressures are based on repeated pressure testing of the Swagelok tube fitting with a 4:1 design factor based on hydraulic fluid leakage.

Tube OD mm	Tube Wall Thickness, mm								Fitting Series
	0.8	1.0	1.2	1.5	1.8	2.0	2.2	2.5	
	Working Pressure, bar Note: For gas service, select a tube wall thickness outside of the shaded area. (See Gas Service , page 2.)								
6	410	530	660						6M0
10		300	370	480					10M0
12		250	300	390	470				12M0
18				240	300	340	370	370	18M0
25						240	260	300	25M0

Suggested Ordering Information

High-quality, fully annealed seamless alloy 825 tubing, ASTM B163, ASTM B423, or equivalent. Fully annealed welded alloy 825 tubing, ASTM B704, class 1 or equivalent. Hardness not to exceed HR15T90 or 201 HV. Tubing to be free of scratches, suitable for bending and flaring. Wall thickness tolerances not to exceed $\pm 10\%$.

Alloy 2507 Tube Fittings with 316 Stainless Steel Tubing

Swagelok alloy 2507 tube fittings in 1/4 to 1 in. and 6 to 12 mm sizes may be used with high quality, fully annealed (Type 304, 304/304L, 316, 316/316L, 317, 317/317L, 321, 347) (seamless or welded and drawn) stainless steel hydraulic tubing.

For welded and drawn tubing, a derating factor must be applied for weld integrity: for double-welded tubing, multiply working pressure by 0.85; for single-welded tubing, multiply working pressure by 0.80.

Table 10—Fractional Sizes

Allowable working pressures are based on repeated pressure testing of the Swagelok tube fitting with a 4:1 design factor based on hydraulic fluid leakage.

Tube OD in.	Tube Wall Thickness, in.						Fitting Series
	0.035	0.049	0.065	0.083	0.095	0.109	
	Working Pressure, psig Note: For gas service, select a tube wall thickness outside of the shaded area. (See Gas Service , page 2.)						
1/4	5100	7500	10 200				400
3/8	3300	4800	6500	7500			600
1/2	2600	3700	5100	6700			800
5/8				5200	6000		1010
3/4		2400	3300	4200	4900	5800	1210
1	Contact your authorized Swagelok representative						1610

Suggested Ordering Information

High-quality, fully annealed (Type 304, 304/304L, 316, 316/316L, 317, 317/317L, 321, 347) (seamless or welded and drawn) stainless steel hydraulic tubing, ASTM A269 and A213, or equivalent. Hardness not to exceed 90 HRB or 200 HV. Tubing to be free of scratches, suitable for bending and flaring.

Note: Certain austenitic stainless tubing has an allowable ovality tolerance double the OD tolerance and may not fit into Swagelok precision tube fittings. Dual-certified grades such as 304/304L, 316/316L, and 317/317L meet the minimum chemistry and the mechanical properties of both alloy grades.

Table 11—Metric Sizes

Allowable working pressures are based on repeated pressure testing of the Swagelok tube fitting with a 4:1 design factor based on hydraulic fluid leakage.

Tube OD mm	Tube Wall Thickness, mm					Fitting Series
	1.0	1.2	1.5	1.8	2.0	
	Working Pressure, psig Note: For gas service, select a tube wall thickness outside of the shaded area. (See Gas Service , page 2.)					
6	420	540	710			6M0
10	240	300	400	510	580	10M0
12	200	250	330	410	470	12M0

Suggested Ordering Information

High-quality, fully annealed (Type 304, 304/304L, 316, 316/316L, 317, 317/317L, 321, 347) stainless steel tubing, EN ISO 1127 or equivalent. Hardness not to exceed 90 HRB or 200 HV. Tubing to be free of scratches, suitable for bending or flaring.

Note: Dual-certified grades such as 304/304L, 316/316L, and 317/317L meet the minimum chemistry and the mechanical properties of both alloy grades.

Safe Product Selection

When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

Swagelok, hinging-colleting—TM Swagelok Company
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