Tubing Data

Contents

Tubing Selection

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

The following variables should be considered when ordering tubing for use with 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 tube fittings is that the tubing must be softer than the fitting material. Tube fittings are designed to work properly with the tubing that is suggested in the ordering instructions.

stainless steel tube fittings have been repeatedly tested successfully with tubing with hardness up to 200 HV and 90 HRB.

Tubing Wall Thickness

The accompanying tables show working pressure ratings of tubing in a wide range of wall thicknesses. Except as noted, allowable pressure ratings are calculated from *S* values as specified by ASME B31.3, Process Piping.

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

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.

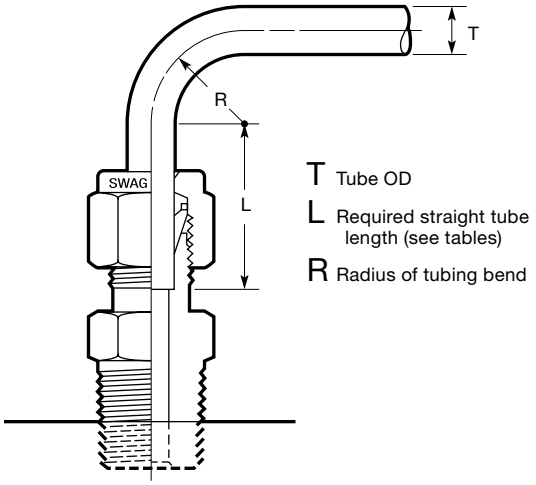
Gas Service

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 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—
- 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 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
1 1/4	2
1 1/2	2 13/32
2	3 1/4

① Required straight tube length.

Metric, mm	
T Tube OD	**L**①
3	19
6	21
8	23
10	25
12	31
14	32
15	
16	
18	
20	34
22	
25	40
28	46
30	50
32	54
38	63
50	80

Special Alloy Tubing

For sizes not listed in the following tables the Suggested Allowable Working Pressure is 500 psig (34.5 bar).

A limited amount of test data is available on tube fittings used with special alloy tubing. For sizes not listed in the following tables, we recommend that a sample of the tubing be provided for evaluation before installation. Please include all pertinent information relating to system parameters. Give tubing sample to your authorized representative to forward to the factory.

Suggested Allowable Working Pressure for *Stainless Steel Tubing*

Table 3—Fractional Stainless Steel Seamless Tubing

Allowable working pressures are calculated from an S value of 20 000 psi (138 MPa) for ASTM A269 tubing at –20 to 100°F (–28 to 37°C), as listed in ASME B31.3, except as noted.

For Welded 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.

Tube OD in.	**Tube Wall Thickness**, in.																**Fitting Series**
	0.010	**0.012**	**0.014**	**0.016**	**0.020**	**0.028**	**0.035**	**0.049**	**0.065**	**0.083**	**0.095**	**0.109**	**0.120**	**0.134**	**0.156**	**0.188**	
	Working Pressure, psig **Note:** For gas service, select a tube wall thickness outside of the shaded area. (See **Gas Service,** page 2.)																
1/16	5600	6800	8100	9400	12 000												100
1/8						8500	10 900										200
3/16						5400	7 000	10 200									300
1/4						4000	5 100	7 500	10 200①								400
5/16							4 000	5 800	8 000								500
3/8							3 300	4 800	6 500	7500①②							600
1/2							2 600	3 700	5 100	6700							810
5/8								2 900	4 000	5200	6000						1010
3/4								2 400	3 300	4200	4900	5800					1210
7/8								2 000	2 800	3600	4200	4800					1410
1									2 400	3100	3600	4200	4700				1610
1 1/4										2400	2800	3300	3600	4100	4900		2000
1 1/2											2300	2700	3000	3400	4000	4900	2400
2												2000	2200	2500	2900	3600	3200

① For higher pressures, see the *Medium- and High-Pressure Fittings, Tubing, Valves, and Accessories* catalog,

② Rating based on repeated pressure testing of the tube fitting with a 4:1 design factor based upon hydraulic fluid leakage.

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. OD tolerances not to exceed ± 0.003 in. for 1/16 in. OD tubing.

Note: Certain austenitic stainless tubing has an allowable ovality tolerance double the OD tolerance and may not fit into 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.

Suggested Allowable Working Pressure for *Stainless Steel Tubing*

Table 4—Metric Stainless Steel Seamless Tubing

Allowable working pressures are calculated from an S value of 138 MPa (20 000 psi) for EN ISO 1127 tubing (D4, T4 tolerance for 3 to 12 mm; D4, T3 tolerance 14 to 50 mm), at –28 to 37°C (–20 to 100°F), as listed in ASME B31.3, except as noted.

For Welded 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.

Tube OD mm	**Tube Wall Thickness**, mm															Fitting Series
	0.3	**0.8**	**1.0**	**1.2**	**1.5**	**1.8**	**2.0**	**2.2**	**2.5**	**2.8**	**3.0**	**3.5**	**4.0**	**4.5**	**5.0**	
	Working Pressure, bar **Note:** For gas service, select a tube wall thickness outside of the shaded area. (See **Gas Service,** page 2.)															
1	430①															1M0
2	210	660①														2M0
3		680														3M0
4		500	670													4M0
6		320	430	550	720											6M0
8			310	390	530											8M0
10			240	310	410	510	580									10M0
12			200	250	330	420	480									12M0
14			160	200	270	340	390	430								14M0
15			150	190	250	310	360	400								15M0
16				180	230	290	330	370	400①							16M0
18				150	210	260	290	330	380							18M0
20				140	180	230	260	290	330	380						20M0
22				120	170	210	240	260	300	340						22M0
25						180	200	230	260	300	320					25M0
28							180	200	230	260	280	330				28M0
30							170	190	210	240	260	310				30M0
32							160	170	200	230	240	290	330			32M0
38								140	170	190	200	240	270	310		38M0
50											150	180	200	230	260	50M0

① Rating based on repeated pressure testing of the tube fitting with a 4:1 design factor based upon hydraulic fluid leakage.

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. OD tolerances not to exceed ± 0.076 mm for 3 mm OD tubing.

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.

Pressure Ratings at Elevated Temperatures

Table 26—Elevated Temperature Factors

Temperature		Tubing Materials							
°F	°C	Aluminum	Copper	Carbon Steel②	304, 304/304L③	316, 316/316L③	317, 317/317L③	321④	347④
200	93	1.00	0.80	0.95	1.00	1.00	1.00	1.00	1.00
400	204	0.40	0.50	0.87①	0.93	0.96	0.96	0.96	0.96
600	315				0.82	0.85	0.85	0.85	0.85
800	426				0.76	0.80	0.80	0.80	0.80
1000	537				0.69	0.76	0.76	0.76	0.76

Temperature		Tubing Materials								
°F	°C	Alloy 400	Alloy 20④	Alloy C-276④	Alloy 600④	Ti	Alloy 2507	Alloy 825	Alloy 625	Alloy 6Mo
200	93	0.87	1.00	1.00	1.00	0.86	0.99	1.00	0.93	0.90
400	204	0.79	0.96	0.96	0.96	0.61	0.91	0.90	0.85	0.74
600	315	0.79	0.85	0.85	0.85	0.45	0.89⑤	0.84	0.79	0.67
800	426	0.75	0.79	0.79	0.79			0.81	0.75	
1000	537			0.76	0.35				0.73	

① To determine allowable working pressure at elevated temperature, multiply allowable room temperature working pressure by temperature factor from table above. (elevated temperature factor = suggested allowable working pressure at elevated temperature / suggested allowable working pressure at room temperature.)

② Based on 375°F (190°C) max.

③ 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.

④ Based on the lower derating factor for stainless steel, in accordance with ASME B31.3.

⑤ Use of 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 1 through 25 by a factor shown in Table 26.

Example: Type 316 stainless steel 1/2 in. OD × 0.035 in. wall at 1000°F

1. The allowable working pressure at –20 to 100°F (–28 to 37°C) is 2600 psig (Table 3, page 5).
2. The elevated temperature factor for 1000°F (537°C) is 0.76 (Table 26, above):

   2600 psig × 0.76 = 1976 psig

The allowable working pressure for 316 SS 1/2 in. OD × 0.035 in. wall tubing at 1000°F (537°C) is 1976 psig.

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.