

Tubes and Pipes



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Tubing Selection

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

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

- ⦿ Surface finish
- ⦿ Material
- ⦿ Hardness
- ⦿ Wall thickness

Surface Finish

Surface finish is very important to proper sealing. Tubing with any kind of depression, scratch, raised portion, or other surface defect will be difficult to seal, particularly in gas service.

Material

Metal tubing material should be softer than fitting material. For example, stainless steel tubing should not be used with brass fittings. When tubing and fittings are made of the same material, tubing must be fully annealed.

Hardness

FITOK tube fittings are designed to work properly with the tubing that is suggested in the ordering instructions. FITOK stainless steel tube fittings have been repeatedly tested successfully with tubing with hardness up to 200 HV and 90 HRB.

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. FITOK tube fittings have been repeatedly tested in both the minimum and maximum wall thicknesses shown. FITOK tube fittings are not recommended for tube wall thicknesses outside the ranges shown in the accompanying tables for each size.

Tubing Handling

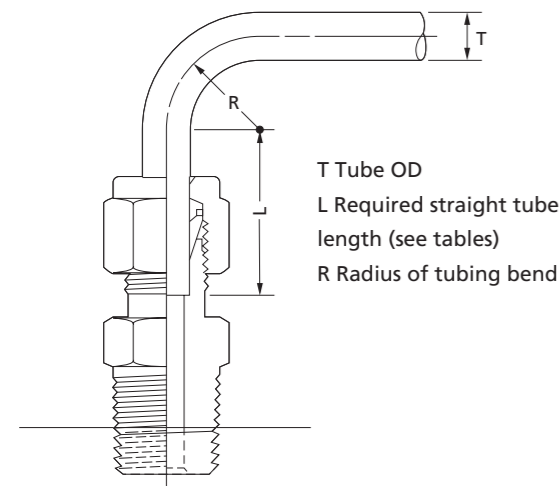
It is important to properly handle the tubing in order to reduce the scratches and protect the surface finish.

- ⦿ 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. 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.

Tubing Installation



Tubing properly selected and handled, combined with properly installed FITOK tube fittings, will give you a leaktight 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 FITOK.
 - ⦿ FITOK 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 FITOK fitting (see tables).

Fractional, in.	
T Tube OD	L [Ⓢ]
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	1 1/4
7/8	1 5/16
1	1 1/2
1 1/4	2
1 1/2	2 13/32
2	3 1/4

Ⓢ Required straight tube length.

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

Hydraulic Swaging Unit

A FITOK multihead hydraulic swaging unit (MHSU) must be used to install 1 1/4, 1 1/2, and 2 in. and 28, 30, 32, 38, and 50 mm FITOK tube fittings. For more information, see the Gaugeable Tube Fittings and Adapter Fittings catalog, MS-01-140.

Suggested Allowable Pressure Tables

Figures 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.

- ⦿ 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 stainless steel 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 thickness tubing.
- ⦿ No allowance is made for corrosion or erosion.

Suggested Allowable Working Pressure for Carbon Steel Tubing

Table 1 — Fractional Carbon Steel Tubing

Allowable working pressures are calculated from an S value of 15 700 psi (108.2 MPa) for ASTM A179 tubing at -20 to 100°F (-28 to 37°C), as listed in ASME B31.3. For working pressure in accordance with ASME B31.1, multiply by 0.85.

Tube OD in.	Tube Wall Thickness, in.												
	0.028	0.035	0.049	0.065	0.083	0.095	0.109	0.120	0.134	0.148	0.165	0.180	0.220
	Working Pressure, psig												
Note: For gas service, select a tube wall thickness outside of the shaded area.													
1/8	8000	10200											
3/16	5100	6600	9600										
1/4	3700	4800	7000	9600									
5/16		3700	5500	7500									
3/8		3100	4500	6200									
1/2		2300	3200	4500	5900								
5/8		1800	2600	3500	4600	5300							
3/4			2100	2900	3700	4300	5100						
7/8			1800	2400	3200	3700	4300						
1			1500	2100	2700	3200	3700	4100					
1 1/4				1600	2100	2500	2900	3200	3600	4000	4600	5000	
1 1/2					1800	2000	2400	2600	2900	3300	3700	4100	5100
2						1500	1700	1900	2100	2400	2700	3000	3700

Suggested Ordering Information

High-quality, soft annealed seamless carbon steel hydraulic tubing, ASTM A179 or equivalent. Hardness not to exceed 72 HRB or 130 HV. Tubing to be free of scratches, suitable for bending and flaring.

Table 2 — Metric Carbon Steel Tubing

Allowable working pressures are based on equations from ASME B31.3 for DIN 2391 tubing, using a stress value of 113 MPa (16 300 psi) and tensile strength of 340 MPa (49 300 psi).

Tube OD mm	Tube Wall Thickness, mm												
	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
	Working Pressure, bar												
Note: For gas service, select a tube wall thickness outside of the shaded area.													
3	630	790											
6	290	370	460	590									
8		270	330	430									
10		210	260	330									
12		170	210	270	330	380	420						
14		150	180	230	280	320	350						
15		140	170	210	260	290	330						
16		130	150	200	240	270	300	350					
18			140	170	210	240	270	310					
20			120	160	190	210	240	270	310				
22			110	140	170	190	210	240	280				
25			100	120	150	170	180	210	240	260			
28						150	160	190	210	230	270		
30						140	150	170	200	210	250		
32						130	140	160	180	200	230	270	
38							120	130	150	160	190	230	260

Suggested Ordering Information

High-quality, soft annealed carbon steel tubing, DIN 2391 or equivalent. Hardness not to exceed 72 HRB or 130 HV. Tubing to be free of scratches, suitable for bending or flaring.

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 (137.8 MPa) for ASTM A269 tubing at -20 to 100°F (-28 to 37°C), as listed in ASME B31.3, except as noted. Multiply stainless steel rating by 0.94 for working pressure in accordance with ASME B31.1.

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.	Nominal Wall Thickness, in.															
	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 thickness outside of the shaded area															
1/16	5660	6870	8180	9490	12100											
1/8					8580	11000										
3/16					5450	7070	10300									
1/4					4040	5150	7570	10300								
5/16						4040	5860	8080								
3/8						3330	4850	5860								
1/2						2600	3530	4750	6260							
5/8							2930	4040	5250	6060						
3/4							2420	3330	4240	4950	5860					
7/8							2020	2830	3640	4240	4850					
1								2420	3130	3640	4240	4750				
1 1/4									2420	2830	3330	3640	4150	4950		
1 1/2										2320	2730	3030	3430	4040	4950	

① For higher pressures, see the FITOK Medium-Pressure Fittings catalog, MS-02-335, or the FITOK High-Pressure Fittings catalog, MS-01-34.

② Rating based on repeated pressure testing of the FITOK 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)(seamless or welded and drawn) stainless steel hydraulic tubing, ASTM A269 or 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 FITOK 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 4—Metric Stainless Steel Seamless Tubing

Allowable working pressures are based on equations from ASME B31.3 for EN ISO 1127 tubing (D4, T4 tolerance for 3 to 12 mm; D4, T3 tolerance 14 to 50 mm), using a stress value of 137.8 MPa (20 000 psi) and tensile strength of 516.4 MPa (74 900 psi), except as noted. Multiply stainless steel rating by 0.94 for working pressure in accordance with ASME B31.1.

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	Nominal Wall Thickness, mm													
	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	
	Working Pressure, bar													
	Note: For gas service, select a tube thickness outside of the shaded area													
3	677													
6	313	424	545	717										
8		313	394	525										
10		242	303	404	515	586								
12		202	252	333	414	475								
14		162	202	273	343	384	434	494						
15		151	192	252	313	364	404	453						
16			172	232	293	333	374	404						
18			151	202	263	293	323	374						
20			141	182	232	263	293	333	384					
22			121	162	202	232	263	303	343					
25					182	202	232	263	293	323				
28						182	202	232	263	283	333			
30						172	182	212	242	263	313			
32						162	172	202	222	242	293	333		
38							141	162	192	202	242	273	313	

① Rating based on repeated pressure testing of the FITOK 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) 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.

Suggested Allowable Working Pressure for Copper Tubing

Table 5 — Fractional Copper Tubing

Allowable working pressures are calculated from an S value of 6000 psi (41.3 MPa) for ASTM B75 and ASTM B88 tubing at -20 to 100°F (-28 to 37°C), as listed in ASME B31.3 and ASME B31.1.

Tube OD in.	Tube Wall Thickness, in.								
	0.028	0.035	0.049	0.065	0.083	0.095	0.109	0.120	0.134
	Working Pressure, psig								
	Note: For gas service, select a tube wall thickness outside of the shaded area.								
1/8	2700	3600							
3/16	1800	2300	3400						
1/4	1300	1600	2500	3500					
5/16		1300	1900	2700					
3/8		1000	1600	2200					
1/2		800	1100	1600	2100				
5/8			900	1200	1600	1900			
3/4			700	1000	1300	1500	1800		
7/8			600	800	1100	1300	1500		
1			500	700	900	1100	1300	1500	
1 1/8				600	800	1000	1100	1300	1400

Suggested Ordering Information

High-quality, soft annealed seamless copper tubing, ASTM B75 or equivalent. Also soft annealed (Temper O) copper water tube, type K or type L to ASTM B88.

Suggested Allowable Working Pressure for Additional Alloys

A limited amount of test data is available on FITOK 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 any of authorized FITOK representatives to forward to the factory.

Table 6 — Fractional Alloy 400 Tubing

Allowable working pressures are calculated from an S value of 18 700 psi (128.9 MPa) for ASTM B165 tubing at -20 to 100°F (-28 to 37°C), as listed in ASME B31.3 and ASME B31.1.

Tube OD in.	Tube Wall Thickness, in.								
	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.								
1/8	7900	10 100							
1/4	3700	4 800	7000	9500					
3/8		3 100	4400	6100					
1/2		2 300	3200	4400					
3/4			2200	3000	4000	4600			
1				2200	2900	3400	3900	4300	

Suggested Ordering Information

High-quality, fully annealed seamless alloy 400 hydraulic tubing, ASTM B165 or equivalent. Hardness not to exceed 75 HRB or 137 HV. Tubing to be free of scratches, suitable for bending and flaring. OD tolerances not to exceed ±0.005 in.

Table 7 — Fractional Alloy C-276 Tubing

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

Tube OD in.	Tube Wall Thickness, in.			
	0.028	0.035	0.049	0.065
	Working Pressure, psig			
	Note: For gas service, select a tube wall thickness outside of the shaded area.			
1/4	4000	5100	7500	10 200
3/8		3300	4800	6 500
1/2		2600	3700	5 100

Suggested Ordering Information

High-quality, fully annealed alloy C-276 tubing, ASTM B622 or equivalent. Hardness not to exceed 100 HRB or 248 HV. Tubing to be free of scratches, suitable for bending and flaring. OD tolerances not to exceed ±0.005 in.

Table 8 — Fractional Alloy 20 Tubing

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

Tube OD in.	Tube Wall Thickness, in.			
	0.028	0.035	0.049	0.065
	Working Pressure, psig			
	Note: For gas service, select a tube wall thickness outside of the shaded area.			
1/4	4000	5100	7500	10 200
3/8		3300	4800	6 500
1/2		2600	3700	5 100

Suggested Ordering Information

High-quality, fully annealed seamless or welded and drawn alloy 20 tubing, ASTM B729, B468 or equivalent. Hardness not to exceed 95 HRB. Tubing to be free of scratches, suitable for bending and flaring. OD tolerances not to exceed ±0.005 in.

Table 9 — Fractional Alloy 600 Tubing

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

Tube OD in.	Tube Wall Thickness, in.			
	0.028	0.035	0.049	0.065
	Working Pressure, psig			
	Note: For gas service, select a tube wall thickness outside of the shaded area.			
1/4	4000	5100	7500	10 200
3/8		3300	4800	6 500
1/2		2600	3700	5 100

Suggested Ordering Information

High-quality, fully annealed, cold drawn #1 temper alloy 600 seamless alloy tubing, ASTM B167 or equivalent. Hardness not to exceed 92 HRB or 198 HV. Tubing to be free of scratches, suitable for bending and flaring. Order to outside diameter and wall thickness only, not to inside diameter, average wall specification. OD tolerances not to exceed ±0.005 in.

Table 10 — Fractional Grade 2 Titanium Tubing

Allowable working pressures are based on equations from ASME B31.3 and a maximum S value of 16 700 psi (115.1 MPa) for ASTM B338 tubing at -20 to 100°F (-28 to 37°C). For working pressure in accordance with ASME B31.1, multiply by 0.85.

Tube OD in.	Tube Wall Thickness, in.			
	0.028	0.035	0.049	0.065
	Working Pressure, psig			
	Note: For gas service, select a tube wall thickness outside of the shaded area.			
1/4	3500	4500	6700	9100
3/8		2900	4200	5800
1/2		2100	3100	4200

Suggested Ordering Information

High-quality, fully annealed seamless or welded and drawn grade 2 titanium tubing, ASTM B338 or equivalent. Tubing to be free of scratches, suitable for bending. OD tolerances not to exceed ±0.005 in.

Table 11 — Fractional SAF 2507 Super Duplex Tubing

Allowable working pressures are calculated from an S value of 38 700 psi (266.8 MPa) for ASTM A789 tubing at -20 to 100°F (-28 to 37°C), as listed in ASME B31.3.

Tube OD in.	Tube Wall Thickness, in.					
	0.028	0.035	0.049	0.065	0.083	0.095
	Working Pressure, psig					
	Note: For gas service, select a tube wall thickness outside of the shaded area.					
1/4	7800	10 000	15 000 ^①			
3/8		6 500	10 100 ^①	12 700		
1/2		5 000	7 200	10 100 ^①	12 900	
5/8			5 800	7 600	10 100	
3/4			4 700	6 300	8 500 ^①	10 000 ^①

^① Pressure ratings based on special wall thickness tolerance for FITOK SAF 2507 tubing.

Suggested Ordering Information

High-quality, fully annealed SAF 2507 super duplex tubing, ASTM A789 or equivalent. Hardness not to exceed 32 HRC. Tubing to be free of scratches, suitable for bending and flaring.

Table 12 — Fractional Alloy 825 Tubing

Allowable working pressures are calculated from an S value of 23 300 psi (160.6 MPa) for ASTM B163 and ASTM B423 seamless tubing at -20 to 100°F (-28 to 37°C), For ASTM B704, Class 1 or equivalent welded and drawn tubing, multiply working pressure by 0.85.

Tube OD in.	Tube Wall Thickness, in.		
	0.035	0.049	0.065
	Working Pressure, psig		
1/4	6400	9300	11 600 ^①
3/8	4100	5900	8 200
1/2	3000	4300	5 900

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

Tube OD in.	Tube Wall Thickness, mm				
	0.8	1.0	1.2	1.5	1.8
	Working Pressure, bar				
6	410	530	660		
10		300	370	480	
12		250	300	390	480

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 ±10%.

Table 13 — Fractional Alloy 625 Tubing

Allowable working pressures are calculated from an S value of 26 700 psi (184.1 MPa) for ASTM B444 Grade 2 tubing at -20 to 100°F (-28 to 37°C), tubing outside diameter and wall thickness tolerances from ASTM B444 for small-diameter tube.

Tube OD in.	Tube Wall Thickness, in.		
	0.035	0.049	0.065
	Working Pressure, psig		
1/4	7300	10 700	14 600
3/8	4700	6 800	9 400
1/2	3500	5 000	6 800

Tube OD mm	Tube Wall Thickness, mm				
	0.8	1.0	1.2	1.5	1.8
	Working Pressure, bar				
6	470	610	750		
10		350	430	550	
12		290	350	450	550

Suggested Ordering Information

High-quality, fully annealed seamless alloy 625 tubing, ASTM B444, Grade 1 or 2, or equivalent. Hardness not to exceed 25 HRC or 266 HV. Tubing to be free of scratches, suitable for bending and flaring.

Pressure Ratings at Elevated Temperatures

Table 14 — Elevated Temperature Factors

Temperature	Tubing Materials														
	°F	°C	Al	Copper	Carbon Steel ^①	304 SS	316 SS	Alloy 400	Alloy 20 ^②	Alloy C-276 ^②	Alloy 600 ^②	Ti	SAF 2507	Alloy 825	Alloy 625
200	93	1.00	0.80	0.95	1.00	1.00	0.87	1.00	1.00	1.00	1.00	0.86	0.90	1.00	0.93
400	204	0.40	0.50	0.87 ^③	0.93	0.96	0.79	0.96	0.96	0.96	0.96	0.61	0.82	0.90	0.85
600	315				0.82	0.85	0.79	0.85	0.85	0.85	0.85	0.45	0.80	0.84	0.79
800	426				0.76	0.79	0.75	0.79	0.79	0.79	0.79			0.81	0.75
1000	537				0.69	0.76			0.76	0.35					0.73

^① Based on 375°F (190°C) max.

^② Dual-certified grades such as 304/304L, 316/316L, and 317/317L meet the minimum chemistry and the mechanical properties of both alloy grades.

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

To determine allowable working pressure at elevated temperatures, multiply allowable working pressures from Tables 1 through 13 by a factor shown in Table 14.

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 4).

2. The elevated temperature factor for 1000°F (537°C) is 0.76 (Table 14, 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.