

# Tubing Data

## Contents

|                                                    |   |
|----------------------------------------------------|---|
| Gas Service .....                                  | 2 |
| Tubing Installation .....                          | 2 |
| <b>Suggested Allowable Working Pressure Tables</b> |   |
| Carbon Steel Tubing .....                          | 3 |
| Stainless Steel Tubing .....                       | 4 |
| Copper Tubing .....                                | 5 |
| Aluminum Tubing .....                              | 5 |
| Alloy 400 Tubing .....                             | 6 |
| Alloy C-276 Tubing .....                           | 6 |
| Alloy 20 Tubing .....                              | 7 |
| Alloy 600 Tubing .....                             | 7 |
| Grade 2 Titanium Tubing .....                      | 7 |
| SAF 2507™ Super Duplex Tubing .....                | 8 |
| <b>Elevated Temperature Factors</b> .....          | 8 |

## 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.

Most misunderstandings about tubing hardness are in the area of stainless steel tubing. Swagelok stainless steel tube fittings have been repeatedly tested successfully with tubing with hardness up to Vickers 200 (HV) and 90 HRB.

Although such tubing hardness is permissible and Swagelok tube fittings will perform satisfactorily on such tubing, we suggest that, whenever possible, you specify

- 180 HV (metric) and
- 80 HRB (fractional)

maximum when ordering tubing. Such tubing lowers installed cost because it is more easily bent and installed. Tubing installers should be particularly careful when installing harder tubing, ensuring that the fitting is installed according to the installation and gaugeability instructions in the Swagelok *Gaugeable Tube Fittings and Adapter Fittings* catalog.

## 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.

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.

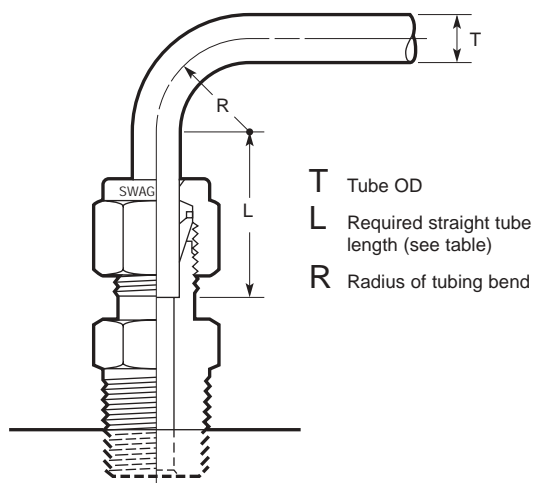
## Gas Service

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, when combined with the quality of Swagelok fittings, will give you leak-tight systems. Properly installed on such tubing, Swagelok fittings provide reliable service under a wide variety of fluid applications.

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).

For maximum assurance of reliable performance, use Swagelok tube fittings assembled in accordance with catalog instructions, and use properly selected and handled high-quality tubing—such as provided by Swagelok.

| Fractional, in. |                |
|-----------------|----------------|
| T<br>Tube OD    | L <sup>①</sup> |
| 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<br>Tube OD | L <sup>①</sup> |
| 3            | 19             |
| 6            | 21             |
| 8            | 23             |
| 10           | 25             |
| 12           | 31             |
| 14           | 32             |
| 15           |                |
| 16           |                |
| 18           | 34             |
| 20           |                |
| 22           | 40             |
| 25           | 46             |
| 28           | 50             |
| 30           | 54             |
| 32           | 63             |
| 38           | 80             |
| 50           |                |

## Hydraulic Swaging Unit

When installing carbon steel or stainless steel Swagelok tube fittings over 1 in. (25 mm), a Swagelok hydraulic swaging unit must be used. This unit provides sufficient pre-swaging of the ferrules onto the tubing for 1 1/4, 1 1/2 and 2 in. and 28, 30, 32, 38, and 50 mm Swagelok tube fittings. Ask your authorized Swagelok sales and service representative for a demonstration.

## Suggested Allowable 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 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 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 (108 200 kPa) for ASTM A179 tubing at –20 to 100°F (–28 to 37°C), as listed in ASME B31.3. Multiply carbon steel rating by 0.75 for working pressure in accordance with ASME B31.1.

| Tube<br>OD<br>in. | Tube Wall Thickness, in.                                                                                                                     |        |       |       |       |       |       |       |       |       |       |       |       | Swagelok<br>Fitting<br>Series |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------------------------------|
|                   | 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<br>Note: For gas service, select a tube wall thickness outside of the shaded area. (See <b>Gas Service</b> , page 2.) |        |       |       |       |       |       |       |       |       |       |       |       |                               |
| 1/8               | 8000                                                                                                                                         | 10 200 |       |       |       |       |       |       |       |       |       |       |       | 200                           |
| 3/16              | 5100                                                                                                                                         | 6 600  | 9600  |       |       |       |       |       |       |       |       |       |       | 300                           |
| 1/4               | 3700                                                                                                                                         | 4 800  | 7000  | 9600  |       |       |       |       |       |       |       |       |       | 400                           |
| 5/16              |                                                                                                                                              | 3 700  | 5500  | 7500  |       |       |       |       |       |       |       |       |       | 500                           |
| 3/8               |                                                                                                                                              | 3 100  | 4500  | 6200  |       |       |       |       |       |       |       |       |       | 600                           |
| 1/2               |                                                                                                                                              | 2 300  | 3200  | 4500  | 5900  |       |       |       |       |       |       |       |       | 810                           |
| 5/8               |                                                                                                                                              | 1 800  | 2600  | 3500  | 4600  | 5300  |       |       |       |       |       |       |       | 1010                          |
| 3/4               |                                                                                                                                              |        | 2100  | 2900  | 3700  | 4300  | 5100  |       |       |       |       |       |       | 1210                          |
| 7/8               |                                                                                                                                              |        | 1800  | 2400  | 3200  | 3700  | 4300  |       |       |       |       |       |       | 1410                          |
| 1                 |                                                                                                                                              |        | 1500  | 2100  | 2700  | 3200  | 3700  | 4100  |       |       |       |       |       | 1610                          |
| 1 1/4             |                                                                                                                                              |        |       | 1 600 | 2100  | 2500  | 2900  | 3200  | 3600  | 4000  | 4600  | 5000  |       | 2000                          |
| 1 1/2             |                                                                                                                                              |        |       |       | 1800  | 2000  | 2400  | 2600  | 2900  | 3300  | 3700  | 4100  | 5100  | 2400                          |
| 2                 |                                                                                                                                              |        |       |       |       | 1500  | 1700  | 1900  | 2100  | 2400  | 2700  | 3000  | 3700  | 3200                          |

### Suggested Ordering Information

High-quality, soft annealed seamless carbon steel hydraulic tubing ASTM A179 or equivalent. Hardness 72 HRB (130 HV) or less. 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 1130 bar (16 400 psi) and tensile strength of 3400 bar (49 300 psi).

| Tube<br>OD<br>mm | Tube Wall Thickness, mm                                                                                                                     |     |     |     |     |     |     |     |     |     |     |     |     | Swagelok<br>Fitting<br>Series |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------------------------------|
|                  | 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<br>Note: For gas service, select a tube wall thickness outside of the shaded area. (See <b>Gas Service</b> , page 2.) |     |     |     |     |     |     |     |     |     |     |     |     |                               |
| 3                | 630                                                                                                                                         | 790 |     |     |     |     |     |     |     |     |     |     |     | 3M0                           |
| 6                | 290                                                                                                                                         | 370 | 460 | 590 |     |     |     |     |     |     |     |     |     | 6M0                           |
| 8                |                                                                                                                                             | 270 | 330 | 430 |     |     |     |     |     |     |     |     |     | 8M0                           |
| 10               |                                                                                                                                             | 210 | 260 | 330 |     |     |     |     |     |     |     |     |     | 10M0                          |
| 12               |                                                                                                                                             | 170 | 210 | 270 | 330 | 380 | 420 |     |     |     |     |     |     | 12M0                          |
| 14               |                                                                                                                                             | 150 | 180 | 230 | 280 | 320 | 350 |     |     |     |     |     |     | 14M0                          |
| 15               |                                                                                                                                             | 140 | 170 | 210 | 260 | 290 | 330 |     |     |     |     |     |     | 15M0                          |
| 16               |                                                                                                                                             | 130 | 150 | 200 | 240 | 270 | 300 | 350 |     |     |     |     |     | 16M0                          |
| 18               |                                                                                                                                             |     | 140 | 170 | 210 | 240 | 270 | 310 |     |     |     |     |     | 18M0                          |
| 20               |                                                                                                                                             |     | 120 | 160 | 190 | 210 | 240 | 270 | 310 |     |     |     |     | 20M0                          |
| 22               |                                                                                                                                             |     | 110 | 140 | 170 | 190 | 210 | 240 | 280 |     |     |     |     | 22M0                          |
| 25               |                                                                                                                                             |     | 100 | 120 | 150 | 170 | 180 | 210 | 240 | 260 |     |     |     | 25M0                          |
| 28               |                                                                                                                                             |     |     |     |     | 150 | 160 | 190 | 210 | 230 | 270 |     |     | 28M0                          |
| 30               |                                                                                                                                             |     |     |     |     | 140 | 150 | 170 | 200 | 210 | 250 |     |     | 30M0                          |
| 32               |                                                                                                                                             |     |     |     |     | 130 | 140 | 160 | 180 | 200 | 230 | 270 |     | 32M0                          |
| 38               |                                                                                                                                             |     |     |     |     |     | 120 | 130 | 150 | 160 | 190 | 230 | 260 | 38M0                          |

### Suggested Ordering Information

High-quality, soft annealed carbon steel tubing to DIN 2391 or equivalent. Hardness 130 HV (72 HRB) or less. 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 (137 800 kPa) 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 pressure rating by 0.85
- for single-welded tubing, multiply pressure rating by 0.80.

| Tube<br>OD<br>in. | Tube Wall Thickness, in.                                                                                                                            |       |       |       |        |       |        |        |                     |                    |       |       |       |       |       |       | Swagelok<br>Fitting<br>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<br><b>Note:</b> For gas service, select a tube wall thickness outside of the shaded area. (See <b>Gas Service</b> , 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  | 10 200 <sup>②</sup> |                    |       |       |       |       |       |       | 400                           |
| 5/16              |                                                                                                                                                     |       |       |       |        |       | 4 000  | 5 800  | 8 000               |                    |       |       |       |       |       |       | 500                           |
| 3/8               |                                                                                                                                                     |       |       |       |        |       | 3 300  | 4 800  | 6 500               | 7500 <sup>①②</sup> |       |       |       |       |       |       | 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 Rating based on repeated pressure testing of the Swagelok tube fitting with a 4:1 design factor based upon hydraulic fluid leakage.

② For higher pressures and tubing with heavier wall thicknesses, see the Swagelok *High-Pressure Fittings* catalog.

**Suggested Ordering Information**

Fully annealed, high-quality (Type 304, 316, etc.) (seamless or welded and drawn) stainless steel hydraulic tubing ASTM A269 or A213, or equivalent. Hardness 80 HRB (180 HV) or less. 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.

**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 1370 bar (20 000 psi) and tensile strength of 5170 bar (75 000 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 pressure rating by 0.85
- for single-welded tubing, multiply pressure rating by 0.80.

| Tube<br>OD<br>mm | Tube Wall Thickness, mm                                                                                                                        |     |     |     |     |     |     |                  |     |     |     |     |     |     | Swagelok<br>Fitting<br>Series |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|------------------|-----|-----|-----|-----|-----|-----|-------------------------------|
|                  | 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<br>Note: For gas service, select a tube wall thickness outside of the shaded area.<br>(See <b>Gas Service</b> , page 2.) |     |     |     |     |     |     |                  |     |     |     |     |     |     |                               |
| 3                | 670                                                                                                                                            |     |     |     |     |     |     |                  |     |     |     |     |     |     | 3M0                           |
| 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 <sup>①</sup> |     |     |     |     |     |     | 16M0                          |
| 18               |                                                                                                                                                |     | 150 | 200 | 260 | 290 | 320 | 370              |     |     |     |     |     |     | 18M0                          |
| 20               |                                                                                                                                                |     | 140 | 180 | 230 | 260 | 290 | 330              | 380 |     |     |     |     |     | 20M0                          |
| 22               |                                                                                                                                                |     | 120 | 160 | 200 | 230 | 260 | 300              | 340 |     |     |     |     |     | 22M0                          |
| 25               |                                                                                                                                                |     |     |     | 180 | 200 | 230 | 260              | 290 | 320 |     |     |     |     | 25M0                          |
| 28               |                                                                                                                                                |     |     |     |     | 180 | 200 | 230              | 260 | 280 | 330 |     |     |     | 28M0                          |
| 30               |                                                                                                                                                |     |     |     |     | 170 | 180 | 210              | 240 | 260 | 310 |     |     |     | 30M0                          |
| 32               |                                                                                                                                                |     |     |     |     | 160 | 170 | 200              | 220 | 240 | 290 | 330 |     |     | 32M0                          |
| 38               |                                                                                                                                                |     |     |     |     |     | 140 | 160              | 190 | 200 | 240 | 270 | 310 |     | 38M0                          |
| 50               |                                                                                                                                                |     |     |     |     |     |     |                  |     | 150 | 180 | 210 | 240 | 270 | 50M0                          |

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

**Suggested Ordering Information**

Fully annealed, high-quality (Type 304, 316, etc.) stainless steel tubing to EN ISO 1127 or equivalent. Hardness 180 HV (80 HRB) or less. Tubing to be free of scratches, suitable for bending and flaring.

## Suggested Allowable Working Pressure for Copper Tubing

**Table 5—Fractional Copper Tubing**

Allowable working pressures are calculated from an S value of 6000 psi (41 300 kPa) for ASTM B75 tubing at –20 to 100°F (–28 to 37°C), as listed in ASME B31.3.

| Tube<br>OD<br>in. | Tube Wall Thickness, in.                                                                                                                            |       |       |       |       |       |       |       |       | Swagelok<br>Fitting<br>Series |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------------------------------|
|                   | 0.028                                                                                                                                               | 0.035 | 0.049 | 0.065 | 0.083 | 0.095 | 0.109 | 0.120 | 0.134 |                               |
|                   | Working Pressure, psig<br><b>Note:</b> For gas service, select a tube wall thickness outside of the shaded area. (See <b>Gas Service</b> , page 2.) |       |       |       |       |       |       |       |       |                               |
| 1/8               | 2700                                                                                                                                                | 3600  |       |       |       |       |       |       |       | 200                           |
| 3/16              | 1800                                                                                                                                                | 2300  | 3400  |       |       |       |       |       |       | 300                           |
| 1/4               | 1300                                                                                                                                                | 1600  | 2500  | 3500  |       |       |       |       |       | 400                           |
| 5/16              |                                                                                                                                                     | 1300  | 1900  | 2700  |       |       |       |       |       | 500                           |
| 3/8               |                                                                                                                                                     | 1000  | 1600  | 2200  |       |       |       |       |       | 600                           |
| 1/2               |                                                                                                                                                     | 800   | 1100  | 1600  | 2100  |       |       |       |       | 810                           |
| 5/8               |                                                                                                                                                     |       | 900   | 1200  | 1600  | 1900  |       |       |       | 1010                          |
| 3/4               |                                                                                                                                                     |       | 700   | 1000  | 1300  | 1500  | 1800  |       |       | 1210                          |
| 7/8               |                                                                                                                                                     |       | 600   | 800   | 1100  | 1300  | 1500  |       |       | 1410                          |
| 1                 |                                                                                                                                                     |       | 500   | 700   | 900   | 1100  | 1300  | 1500  |       | 1610                          |
| 1 1/8             |                                                                                                                                                     |       |       | 600   | 800   | 1000  | 1100  | 1300  | 1400  | 1810                          |

### Suggested Ordering Information

**Fractional**—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 Aluminum Tubing

**Table 6—Fractional Aluminum Tubing**

Allowable working pressures are calculated from an S value of 14 000 psi (96 500 kPa) for ASTM B210, Type 6061-T6 tubing at –20 to 100°F (–28 to 37°C), as listed in ASME B31.3. Multiply aluminum rating by 0.75 for working pressure in accordance with ASME B31.1.

| Tube OD<br>in. | Tube Wall Thickness, in.                                                                                                                        |       |       |       |       | Swagelok<br>Fitting<br>Series |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------------------------------|
|                | 0.035                                                                                                                                           | 0.049 | 0.065 | 0.083 | 0.095 |                               |
|                | Working Pressure, psig<br>Note: For gas service, select a tube wall thickness outside of<br>the shaded area. (See <b>Gas Service</b> , page 2.) |       |       |       |       |                               |
| 1/8            | 8600                                                                                                                                            |       |       |       |       | 200                           |
| 3/16           | 5600                                                                                                                                            | 8000  |       |       |       | 300                           |
| 1/4            | 4000                                                                                                                                            | 5900  |       |       |       | 400                           |
| 5/16           | 3100                                                                                                                                            | 4600  |       |       |       | 500                           |
| 3/8            | 2600                                                                                                                                            | 3700  |       |       |       | 600                           |
| 1/2            | 1900                                                                                                                                            | 2700  | 3700  |       |       | 810                           |
| 5/8            | 1500                                                                                                                                            | 2100  | 2900  |       |       | 1010                          |
| 3/4            |                                                                                                                                                 | 1700  | 2400  | 3100  |       | 1210                          |
| 7/8            |                                                                                                                                                 | 1500  | 2000  |       |       | 1410                          |
| 1              |                                                                                                                                                 | 1300  | 1700  | 2300  | 2700  | 1610                          |

### Suggested Ordering Information

High-quality aluminum alloy drawn seamless tubing ASTM B210 (Type 6061-T6) or equivalent.

## Suggested Allowable Working Pressure for Additional Alloys

A limited amount of test data is available on Swagelok 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 Swagelok representative to forward to the factory.

**Table 7—Fractional Alloy 400 Tubing**

Allowable working pressures are calculated from an S value of 18 700 psi (128 800 kPa) for ASTM B165 tubing at –20 to 100°F (–28 to 37°C), as listed in ASME B31.3. Multiply alloy 400 rating by 0.93 for working pressure in accordance with ASME B31.1.

| Tube<br>OD<br>in. | Tube Wall Thickness, in.                                                                                                                        |        |       |       |       |       |       |       | Swagelok<br>Fitting<br>Series |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------|-------|-------|-------|-------|-------|-------------------------------|
|                   | 0.028                                                                                                                                           | 0.035  | 0.049 | 0.065 | 0.083 | 0.095 | 0.109 | 0.120 |                               |
|                   | Working Pressure, psig<br>Note: For gas service, select a tube wall thickness outside of the shaded area.<br>(See <b>Gas Service</b> , page 2.) |        |       |       |       |       |       |       |                               |
| 1/8               | 7900                                                                                                                                            | 10 100 |       |       |       |       |       |       | 200                           |
| 1/4               | 3700                                                                                                                                            | 4 800  | 7000  | 9500  |       |       |       |       | 400                           |
| 3/8               |                                                                                                                                                 | 3 100  | 4400  | 6100  |       |       |       |       | 600                           |
| 1/2               |                                                                                                                                                 | 2 300  | 3200  | 4400  |       |       |       |       | 810                           |
| 3/4               |                                                                                                                                                 |        | 2200  | 3000  | 4000  | 4600  |       |       | 1210                          |
| 1                 |                                                                                                                                                 |        |       | 2200  | 2900  | 3400  | 3900  | 4300  | 1610                          |

### Suggested Ordering Information

**Fractional**—Fully annealed, quality seamless alloy 400 hydraulic tubing ASTM B165 or equivalent. Hardness 75 HRB maximum. Tubing to be free of scratches, suitable for bending and flaring.

**Table 8—Fractional Alloy C-276 Tubing**

Allowable working pressures are based on equations from ASME B31.3 and a maximum S value of 20 000 psi (137 800 kPa).

| Tube<br>OD<br>in. | Tube Wall Thickness, in.                                                                                                                        |       |       |        | Swagelok<br>Fitting<br>Series |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|--------|-------------------------------|
|                   | 0.028                                                                                                                                           | 0.035 | 0.049 | 0.065  |                               |
|                   | Working Pressure, psig<br>Note: For gas service, select a tube wall thickness outside of<br>the shaded area. (See <b>Gas Service</b> , page 2.) |       |       |        |                               |
| 1/4               | 4000                                                                                                                                            | 5100  | 7500  | 10 200 | 400                           |
| 3/8               |                                                                                                                                                 | 3300  | 4800  | 6 500  | 600                           |
| 1/2               |                                                                                                                                                 | 2600  | 3700  | 5 100  | 810                           |

### Suggested Ordering Information

Fully annealed quality alloy C-276 tubing ASTM B622 or equivalent. Hardness 100 HRB maximum. Tubing to be free of scratches, suitable for bending and flaring. OD tolerances not to exceed  $\pm 0.005$  in.

**Table 9—Fractional Alloy 20 Tubing**

Allowable working pressures are based on equations from ASME B31.3 and a maximum S value of 20 000 psi (137 800 kPa).

| Tube<br>OD<br>in. | Tube Wall Thickness, in.                                                                                                             |       |       |        | Swagelok<br>Fitting<br>Series |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------|-------|-------|--------|-------------------------------|
|                   | 0.028                                                                                                                                | 0.035 | 0.049 | 0.065  |                               |
|                   | Working Pressure, psig<br>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                           |
| 3/8               |                                                                                                                                      | 3300  | 4800  | 6 500  | 600                           |
| 1/2               |                                                                                                                                      | 2600  | 3700  | 5 100  | 810                           |

**Suggested Ordering Information**

Fully annealed, seamless or welded and drawn alloy 20 alloy tubing, ASTM B729, B468 or equivalent. Hardness 95 HRB or less. Tubing to be free of scratches, suitable for bending and flaring. OD tolerances not to exceed  $\pm 0.005$  in.

**Table 10—Fractional Alloy 600 Tubing**

Allowable working pressures are based on equations from ASME B31.3 and a maximum S value of 20 000 psi (137 800 kPa).

| Tube<br>OD<br>in. | Tube Wall Thickness, in.                                                                                                             |       |       |        | Swagelok<br>Fitting<br>Series |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------|-------|-------|--------|-------------------------------|
|                   | 0.028                                                                                                                                | 0.035 | 0.049 | 0.065  |                               |
|                   | Working Pressure, psig<br>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                           |
| 3/8               |                                                                                                                                      | 3300  | 4800  | 6 500  | 600                           |
| 1/2               |                                                                                                                                      | 2600  | 3700  | 5 100  | 810                           |

**Suggested Ordering Information**

Cold drawn, fully annealed, #1 temper alloy 600 seamless alloy tubing, ASTM B167 or equivalent. Hardness 92 HRB or less. 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  $\pm 0.005$  in.

**Table 11—Fractional Grade 2 Titanium Tubing**

Allowable working pressures are calculated from an S value of 16 700 psi (115 000 kPa) for ASTM B338 tubing at  $-20$  to  $100^{\circ}\text{F}$  ( $-28$  to  $37^{\circ}\text{C}$ ), as listed in ASME B31.3. Multiply grade 2 titanium rating by 0.75 for working pressure in accordance with ASME B31.1.

| Tube<br>OD<br>in. | Tube Wall Thickness, in.                                                                                   |       |       |       | Swagelok<br>Fitting<br>Series |
|-------------------|------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------------------------------|
|                   | 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. (See Gas Service, page 2.) |       |       |       |                               |
| 1/4               | 3500                                                                                                       | 4500  | 6700  | 9100  | 400                           |
| 3/8               |                                                                                                            | 2900  | 4200  | 5800  | 600                           |
| 1/2               |                                                                                                            | 2100  | 3100  | 4200  | 810                           |

**Suggested Ordering Information**

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  $\pm 0.005$  in.



**Table 12—Fractional SAF 2507 Super Duplex Tubing**

Allowable working pressures are calculated from an S value of 38 700 psi (266 000 kPa) for ASTM A789 tubing at –20 to 100°F (–28 to 37°C), as listed in ASME B31.3. For tubing suitable for SAF 2507 super duplex weld fittings with working pressures calculated based on ASME B31.3 Chapter IX, see the Swagelok *SAF 2507 Super Duplex Weld Fittings* catalog.

| Tube<br>OD<br>in. | Tube Wall Thickness, in.                                                                                                                        |        |                     |                     |                    |                     | Swagelok<br>Fitting<br>Series |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|--------|---------------------|---------------------|--------------------|---------------------|-------------------------------|
|                   | 0.028                                                                                                                                           | 0.035  | 0.049               | 0.065               | 0.083              | 0.095               |                               |
|                   | Working Pressure, psig<br>Note: For gas service, select a tube wall thickness outside of the shaded area.<br>(See <b>Gas Service</b> , page 2.) |        |                     |                     |                    |                     |                               |
| 1/4               | 7800                                                                                                                                            | 10 000 | 15 000 <sup>①</sup> |                     |                    |                     | 400                           |
| 3/8               |                                                                                                                                                 | 6 500  | 10 100 <sup>①</sup> | 12 700              |                    |                     | 600                           |
| 1/2               |                                                                                                                                                 | 5 000  | 7 200               | 10 100 <sup>①</sup> | 12 900             |                     | 810                           |
| 5/8               |                                                                                                                                                 |        | 5 800               | 7 600               | 10 100             |                     | 1010                          |
| 3/4               |                                                                                                                                                 |        | 4 700               | 6 300               | 8 500 <sup>①</sup> | 10 000 <sup>①</sup> | 1210                          |

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

### Suggested Ordering Information

Fully annealed SAF 2507 super duplex tubing, ASTM A789 or equivalent. Hardness 32 HRC or less. Tubing to be free of scratches, suitable for bending and flaring.

## Pressure Ratings at Elevated Temperatures

**Table 13—Elevated Temperature Factors**

| Temperature |     | Tubing Materials |        |                           |        |        |           |                       |                          |                        |          |          |
|-------------|-----|------------------|--------|---------------------------|--------|--------|-----------|-----------------------|--------------------------|------------------------|----------|----------|
| °F          | °C  | Aluminum         | Copper | Carbon Steel <sup>①</sup> | 304 SS | 316 SS | Alloy 400 | Alloy 20 <sup>②</sup> | Alloy C-276 <sup>②</sup> | Alloy 600 <sup>②</sup> | Titanium | SAF 2507 |
| 200         | 93  | 1.00             | 0.80   | 0.95                      | 1.00   | 1.00   | 0.87      | 1.00                  | 1.00                     | 1.00                   | 0.86     | 0.90     |
| 400         | 204 | 0.40             | 0.50   | 0.87 <sup>①</sup>         | 0.93   | 0.96   | 0.79      | 0.96                  | 0.96                     | 0.96                   | 0.61     | 0.82     |
| 600         | 315 |                  |        |                           | 0.82   | 0.85   | 0.79      | 0.85                  | 0.85                     | 0.85                   | 0.45     | 0.80     |
| 800         | 426 |                  |        |                           | 0.76   | 0.79   | 0.75      | 0.79                  | 0.79                     | 0.79                   |          |          |
| 1000        | 537 |                  |        |                           | 0.69   | 0.76   |           |                       | 0.76                     | 0.35                   |          |          |

① Based on 375°F (190°C) max.

② 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 12 by a factor shown in Table 13.

**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 13, above):

$$2600 \text{ psig} \times 0.76 = 1976 \text{ psig}$$

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.