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safe tube pressures

Safe working pressures have traditionally been expressed as proportions of either the burst pressure or yield point of a tube. These proportions have varied over time as production methods have improved and steels have evolved. Different industries and pressure vessel codes have also adopted different standard practices.

The most common ratio used over the past 50 years has probably been 4:1 burst pressure max. operating pressure. However, some codes are now reducing this factor to 3.5 or even 3. The problem with using this factor for modern austenitic stainless steels is that it does not permit the mechanical properties of such steels to be used to their maximum potential. Therefore for such materials a factor of 1.5 or 1.6 x yield pressure has become customary.

Pressure calculating formulae

For calculating internal pressure (hoop stress) the most common formulae are the simple.

Barlow formula $P = \frac{2St}{D}$

or the more precise **Lamé formula** which can be calculated using either OD/WT or OD/ID.
The two versions are as follows:

OD/WT $P = \frac{2St\,(D - t)}{D^2 - 2Dt + 2t^2}$

OD/ID $P = S\,(D^2 - d^2)$

The Barlow formula is useful for quick ballpark calculations but in general it is best to use the Lamé formula as this will give a more precise answer.

For all the formulae, the symbols have the following meanings:

- **P** = Internal pressure
- **S** = Proof Stress or UTS for calculating yield or burst pressure respectively
- **t** = Wall thickness
- **D** = Outside diameter
- **d** = Inside diameter
- **WT** = Wall thickness
- **UTS** = Ultimate tensile strength

The suitable "working or operating" pressure is taken as the pressure at which the tube will permanently yield (Rp 0.2 or Rp 1.0) minus a safety factor. The pressure at which a tube will fail or burst is taken as the pressure required to exceed the tensile strength (Rm) minus a safety factor.

When asked "What pressure is a tube good for?", Fine Tubes can only state the minimum (theoretical) yield and burst pressures of a particular tube at room temperature and state that the end user must decide what the safe maximum working pressure should be based on this information. It should also be noted that these results assume the tubing is subject to no other stresses that would influence the calculations. This is because Fine Tubes can never be sure of the environmental conditions in which the tube will be used or the appropriate safety factor for that application.

Calculating Collapse Pressure

The formula for calculating collapse pressure is

$$\mathbf{P = \frac{2St\,(D-t)}{D^2}}$$

In this case S = UTS only.

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Based on the shown formulae the nominal yield, burst and collapse pressures of common sizes at room temperature have been calculated and are shown below.

Size	Material	Burst	Distension (0.2% Proof)	Distension (1% Proof)	Collapse
¼" x 0.035	316L	22,200	8,700	10,400	16,900
¼" x 0.035	Alloy 400	22,200	8,900	9,400	16,900
¼" x 0.035	Alloy 825	27,000	11,100	12,200	20,500
¼" x 0.035	Alloy 625	38,100	19,100	20,500	28,900
¼" x 0.049	316L	32,100	12,600	14,900	22,000
¼" x 0.049	Alloy 400	32,100	12,800	13,600	22,000
¼" x 0.049	Alloy 825	39,000	16,000	17,600	26,700
¼" x 0.049	Alloy 625	55,000	27,500	29,600	37,700
¼" x 0.065	316L	43,800	17,200	20,400	26,900
¼" x 0.065	Alloy 400	43,800	17,500	18,600	26,900
¼" x 0.065	Alloy 825	53,100	21,900	24,000	32,700
¼" x 0.065	Alloy 625	75,100	37,500	40,300	46,200
3/8" x 0.035	316L	14,300	5,600	6,700	11,900
3/8" x 0.035	Alloy 400	14,300	5,700	6,100	11,900
3/8" x 0.035	Alloy 825	17,300	7,100	7,800	14,400
3/8" x 0.035	Alloy 625	24,500	12,200	13,200	20,300
3/8" x 0.049	316L	20,500	8,100	9,600	15,900
3/8" x 0.049	Alloy 400	20,500	8,200	8,700	15,900
3/8" x 0.049	Alloy 825	24,900	10,300	11,200	19,300
3/8" x 0.049	Alloy 625	35,200	17,600	18,900	27,200
3/8" x 0.065	316L	28,100	11,100	13,100	20,100
3/8" x 0.065	Alloy 400	28,100	11,200	11,900	20,100
3/8" x 0.065	Alloy 825	34,100	14,100	15,400	24,400
3/8" x 0.065	Alloy 625	48,200	24,100	25,900	34,400

Appropriate working pressures will depend on the environment, application and design code. These must be decided by the end user on the basis of the mechanical data given above.

Typical mechanical properties are as follows:

Material	Rp 0.2		Rp 1.0		Rm		Elongation 2"
	MPa	ksi	MPa	ksi	MPa	ksi	GL or 5.65 √ 50
316L	190	27.55	225	33	485	70	35%
A825	241	35	265	38	586	85	30%
A400	193	28	205	30	483	70	35%
A625	414	60	445	64	827	120	30%
4429	295	43	330	48	580	84	35%
S31803	450	65			620	90	25%
S32750	550	80			800	116	15%
Alloy 33	380	55	420	61	720	104	40%
Ti325	730	105			900	130	15%
Ti64	795	115			1034	150	10%
904L	220	31	250	36	490	71	35%

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