Parker

Ermeto Original

Tubes

General recommendations for tubes

1. Steel types, mechanical properties, conditions

Steel types, mechanical properties and conditions of EO steel tubes

Steel type	Tensile strength Rm	Yield point ReH	Ductile yield A5 (longit.)	Condition
Fine grain E235N acc. to EN 10305-4 (St. 37.4 acc. to DIN 1630/DIN 2391 old designation)	340 N/mm² min. 49,000 lb/in²	235 N/mm² min. 34,000 lb/in²	25% min.	Seamless, cold drawn, normal annealed, DIN EN 10305-1 and -4

Steel types, mechanical properties and conditions of EO stainless steel tubes

Steel type	Tensile strength Rm	Yield point (1% proof stress)	Ductile yield A5 (longit.)	Condition
1.4571 X6CrNiMoTi17122	500 N/mm² min. 72,500 lb/in²	245 N/mm² min. 35,500 lb/in²	35% min.	Seamless, cold drawn free of scale, heat treated in accordance with DIN EN 10216-5 tab. 6

2. **Tests and certifications**
   All tubes are subjected to a non-destructive leak test and marked accordingly as proof. This marking replaces a works certificate DIN EN 10204-2.2. Test class 1 DIN EN 10216-5 Table 7 applies for tubes made of 1.4571.
3. **Recommended bend radius**
   A bend radius of 3x the external tube diameter is recommended for cold bending of tubes with tube benders or by hand.
4. **Welding suitability and weldability**
   Tubes of E235N are weldable according to usual techniques. Types made of 1.4571 (stainless) are suitable for arc welding. The welding filler should be selected in accordance with DIN EN 1600 and DIN EN 12072 part 1 taking into account the type of application and the welding technique.
5. **Approximate calculation of the flow resistance in straight tubelines**
   The flow resistance and thus the tubeline efficiency is influenced by the tube inside diameter, the volume flow (measured or calculated) and the properties of the medium. Laminar flow should be considered in order to keep losses in the system down to a minimum. The transition from laminar to turbulent flow, which brings an increase in the flow resistance is generally defined by the Reynolds number Re 2320. Since the transition cannot be pinpointed exactly, the transition range can only be determined by measuring. If, for simplified calculation, transition at Re 2320 and a "technically smooth" tube inner surface are assumed, the limit speeds w crit. and the laminar to turbulent flow volume flow $\dot{V}$ crit. when transition takes place, can be estimated according to the following formulas:

$$w_{crit.} = \frac{2.32 \cdot \upsilon}{d_i} \text{ [m/s]}$$

$$q_{v,\,crit.} = 0.109 \cdot d_i \cdot \upsilon \text{ [l/min]}$$

d_i = tube bore Ø in mm

υ = kinematic viscosity in mm²/s

For approximate calculation of the pressure drop in bar/1 m tube length, the following formulas can be used:

1. Laminar range:

$$p_v = \frac{0.32 \cdot w \cdot \upsilon \cdot \rho}{d_i^2 \cdot 10^3} = \frac{6.79 \cdot q_v \cdot \upsilon \cdot \rho}{d_i^4 \cdot 10^3} \text{ [bar/1 m]}$$

2. Turbulent range:

$$p_v = \frac{0.281 \cdot w^{1.75} \cdot \upsilon^{0.25} \cdot \rho}{d_i^{1.25} \cdot 10^3}$$

$$= \frac{59 \cdot q_v^{1.75} \cdot \upsilon^{0.25} \cdot \rho}{d_i^{4.75} \cdot 10^3} \text{ [bar/1 m]}$$

w = flow speed in m/s; υ = kinetic viscosity in mm²/s; q = volume flow in l/min.; ρ = density of the medium in kg/m³; d_i = pipe internal diameter in mm.
Detailed calculations of the flow resistance require an exact knowledge of the tubeline system and the operating conditions. Refer to the relevant literature for other methods of calculations.

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Tube and pipe specification

Recommended carbon steel tubes and pipes
Parker recommends the use of cold drawn seamless and regular annealed (abbreviation +N) hydraulic tubes and pipes acc.: DIN-EN 10305 (old DIN 2391) and ISO 3304
For the assembly of steel fittings, steel tubes made of material E235 (ST37.4 +N) and E355 (ST52.4 +N) are recommended.

+ precision dimension/shape
+ high pressure capability
+ clean inside (no scale)
+ excellent scaling surface after roll flaring

Recommended stainless steel tubes and pipes
Parker reccommends the use of seamless cold drawn stainless steel tubes and pipes acc. to:
DIN EN 10216-5, ASTM A269/A213, ASTM A312.

EO precision stainless steel tube meets and exceeds these standards. The tolerances of the pipe outer diameter and wall thickness are even closer to ensure a safe interplay with our fitting systems.

For the assembly of stainless steel tube fittings, EO precision stainless steel tubes made of material 316 Ti and 316L are recommended.

+ precision dimension/shape
+ high pressure capability
+ excellent scaling surface after roll flaring

Welded tubes and pipes
Tubes and pipes acc. to below specification but welded and cold redrawn instead of seamless drawn are usually suitable. Pressure capability might be reduced due to the welding seam zone.
Welding seam quality might effect roll flaring surface results.

Hot rolled pipes
Hot rolled pipes are not recommended for the following reasons:
Hot rolled pipes do not have precision dimensions and may slip in machine dies.
They have scales inside and outside. The inside scales effect the cleanliness level of the fluid and reduces fatigue levels. Used in roll flaring process the scales will contaminate the flaring tools (high cleaning effort) and cause poor flare surface quality.

The required maximum working pressure is calculated either acc. to DIN or DNV.

Material specifications & values

E235+N / St.37.4 (1.0308) acc. to DIN EN 10305-4	
Tensile strength	min. 340 N/mm^2
Yield strength	min. 235 N/mm^2
Fatigue strength	225 N/mm^2 [1]
Elongation at break	min. 25%

E355+N / St.52.4 (1.0580) acc. to DIN EN 10305-4	
Tensile strength	min. 490 N/mm^2
Yield strength	min. 355 N/mm^2
Fatigue strength	265 N/mm^2 [2]
Elongation at break	min. 22 %

316Ti (1.4571) cold drawn (CFA) acc. to DIN EN 10216-5	
Tensile strength	min. 500 N/mm^2
0.2 % proof stress	min. 210 N/mm^2
1 % proof stress	min. 245 N/mm^2
Fatigue strength	220 N/mm^2 [2]
Elongation at break	min. 35 %

316L (1.4404) cold drawn (CFA)[3] acc. to DIN EN 10216-5	
Tensile strength	min. 500 N/mm^2
0.2 % proof stress	min. 210 N/mm^2
1 % proof stress	min. 245 N/mm^2
Elongation at break	min. 35 %

316L (1.4404) acc. to ASTM A269 / A213	
Tensile strength	min. 530 N/mm^2
Yield strength	min. 276 N/mm^2
0.2 % proof stress / 1.6 [4]	172.5 N/mm^2

316L (1.4404) acc. to ASTM A312 / A530	
Tensile strength	min. 515 N/mm^2
Yield strength	min. 234 N/mm^2
0.2 % proof stress / 1.6 [4]	146 N/mm^2

1) DIN 2413, 6.331
2) No standard value, Experience value
3) Strength increase due to cold forming following 1.4571
4) Pressure rating calculation based on this mechanical properties require certification according to 3.1 - EN 10204 that confirmes the mechanical properties.

Tube calculation for industrial and mobile applications acc. to DIN rules

DIN 2413 I, only for static load

Calculation of working pressure of steel tubes for static stress up to 120°C. Corrosion - additional allowancess are not considered for the calculation of pressures. Tubes with a diameter of OD/ ID > 2 are calculated for static stress in accordance with DIN 2413 III, but with K = yield strength.

$$P = \frac{20 * K * s * c}{S * D}$$

P = permissible working pressure [bar]
K = yield strength [N/mm²]
s = tube wall thickness [mm]
c = factor for wall thickness allowance
  = 0.8 for Tube-OD 4-5
  = 0.85 for Tube-OD 6-8
  = 0.9 from Tube-OD 10
  = 0.9 for all stainless steel tubes
S = Safety factor = 1.5
D = tube outside diameter [mm]

Burst pressure calculation

Calculation of static burst pressure for seamless tubes acc. to Faupel-von-Mises.

$$BP = R_{p0.2} * 10 \frac{2}{\sqrt{3}} \ln \frac{D}{d} * (2 - \frac{R_{p0.2}}{R_m})$$

BP = Min. static burst pressure [bar]
R = tensile strength [N/mm²]
R_{p02} = 0.2% proof stress, yield strength [N/mm²]
D = Tube outside diameter [mm]r
d = Tube inside diameter [mm]

DIN 2413 III, for dynamic load

Calculation of working pressure of steel tubes for dynamic stress up to 120°C.
Corrosion - additional allowances are not considered for the calculation of pressures.

$$P = \frac{20 * K * s * c}{S * (D + s * c)}$$

P = permissible working pressure [bar]
K = fatigue strength [N/mm²]
s = tube wall thickness [mm]
c = factor for wall thickness allowance
  = 0.8 for Tube-OD 4-5
  = 0.85 for Tube-OD 6-8
  = 0.9 for Tube-OD 10-80
  = 0.9 for all stainless steel tubes
S = safety factor = 1.5
D = tube outside diameter [mm]

Tube calculation for marine and offshore acc. to DNV rules

Calculation of working pressure of steel and stainless steel tubes for ship building acc. to DNV Part 4, Chapter 6, Section 6.

$$P = \frac{20 * \sigma_t * e * t_0}{D - t_0}$$

Calculation of burst pressure:

$$BP = \frac{20 * R_m * t_n * a}{D - t_n * a}$$

P = permissible working pressure [bar]
BP = approximate burst pressure [bar]
σ_t = permissible stress [N/mm²]
calculated from the lower value off:

stainless steel: $\sigma_t = \frac{R_m}{2.7}$ or $\frac{K}{1.6}$

carbon steel: $\sigma_t = \frac{R_m}{2.7}$ or $\frac{K}{1.8}$

t_0 = tube wall thickness without allowences [mm]

$t_0 = t_n \cdot a - c - b$

t_n = tube wall thickness nominal [mm]
a = factor for wall thickness allowence
  = 0.8 for Tube-OD 4-5, 0.85 for Tube-OD 6-8, 0.9 for Tube-OD >=10
  = 0.875 for Schedule Pipes
  = 0.9 for all stainless steel tubes
b = bending allowence

$$b = \frac{1}{2.5} * \frac{D}{R} * t_0$$

$b = 0.1333 * t_0$ (at R/D=3) $\rightarrow t_0 = \frac{t_n * a - c}{1.1333}$

c = corrosion tolerance, c = 0.3 mm for hydraulic steel tube, c = 0 mm for SS tubes
e = strength ratio: for seamless tubes e = 1
D = tube outside diameter [mm]
R_m = min. tensile strength [N/mm²]
K = min. yield strength or min 0.2% proof stress [N/mm²]

R

Pressure reductions and temperatures

Required pressure reductions (depending on the material) with reference to the catalogue pressures for higher temperatures.
Both metal fitting material and elastomeric sealing compound have to be selected according to the temperature range of the system.

DNV may require different pressure reduction based on application

Material	Pressure reduction of permissible operating temperatures TB in °C														
	-60	-54	-40	-35	-25	+20	+50	+100	+120	+150	+175	+200	+250	+300	+400
Steel components			10%			0%				11%	19%				
Steel, tubes			10%			0%				19%			27%		
Stainless steel components	0%						5%	15%	23%		29%		33%	37%	42%
Stainless steel, tubes	0%						5.5%	11.5%	21.5%				29%		34%
Sealing material NBR (e.g. Perbunan)															
Sealing material FKM															
Sealing material Polyurethan (P5008)															

Permissible
Ambient temperature of hydraulic and pneumatic applications
Temperature not permissible

Calculation example:
Temperature = 200°C
Material = Stainless steell
Pressure reduction = 29%
Pressure reduction tubes = 21.5%
PN tube 16x2.5/71. DIN2413 III = 362 bar

Formula:

$$PN_{200°C} = \frac{400\ \text{bar}}{100\%} \times (100\% - 29\%) = 284\ \text{bar}$$

$$PN_{tube\ 200°C} = \frac{362\ \text{bar}}{100\%} \times (100\% - 21.5\%) = 284\ \text{bar}$$

Flow diameter of tube lines

Determining tube sizes for hydraulic systems

Proper tube material, type and size for a given application and type of fitting are critical for efficient and trouble-free operation of the fluid system. Selection of proper tubing involves choosing the right tube material, and determining the optimum tube size (O.D. and wall thickness).

Proper sizing of the tube for various parts of a hydraulic system results in an optimum combination of efficient and cost effective performance.

A tube that is too small causes high fluid velocity, which has many detrimental effects. In pressure lines, it causes high friction losses and turbulence, both resulting in high pressure drops and heat generation. High heat accelerates wear in moving parts and rapid aging of seals and hoses, all resulting in reduced component life. High heat generation also means wasted energy, and hence, low efficiency. Too large tubes increase system cost. Thus, optimum tube sizing is very critical. The following is a simple procedure for sizing tubes.

Determine required flow diameter

Use table to determine recommended flow diameter for the required flow rate and type of line.

The table is based on the following recommended flow rates that are common in the shipbuilding and offshore engineering.

Pressure lines – 3 → 7.2 $\left[\frac{m}{s}\right]$

Return lines – 2 → 4.5 $\left[\frac{m}{s}\right]$

Suction lines – 1 → 1.8 $\left[\frac{m}{s}\right]$

Avoid flow rates > 8 m/s!
The resulting forces are high and can destroy the tube lines.
If you desire to use different velocities than the above, use the following formula to determine the required flow diameter.

$$\text{Tube – I.D. [mm]} = 4{,}61 \times \sqrt{\frac{\text{Flow}\left[\frac{\text{ltr.}}{\text{min}}\right]}{\text{Velocity}\left[\frac{m}{s}\right]}}$$

Determine required wall thickness

Use tube/pressure calculation tables shown in the tube chapter to determine recommended wall thickness for the required working pressure and flow diameter of the line.
Therefore choose a working pressure which is equal or higher than the required working pressure.

Flow characteristics

Hydraulic systems are in most cases only rated with a flow velocity defined on the basis of experience. The pressure losses in lines are not taken into account, or measured later on when testing the system. As the pressure losses increase porportionally greater than the flow resistance, it is important to achieve the best rating of the system, so that they are already taken into account when planning the tube connections. Calculation is not as difficult as it is often thought, and this chapter is intended to provide a guideline. Besides, it provides information on how excessive pressure losses can be avoided, because pressure losses result in losses in performance and excessive heat. Noise occurs and possibly cavitation in suction lines.

Medium

All indication given with regard to flow restrictions and to flow properties refer exclusively to liquids. For gaseous media, the variable density of the gas must additionally be taken into account.

Units

c = Flow velocity $\left[\frac{m}{s}\right]$

d = Pipe inside diameter [m]
L = Pipe length [m]
p = Pressure [Pa], 1 bar = 100000 Pa

$\dot{V}$ = Flow rate $\left[\frac{m^3}{s}\right]$, $1\frac{m^3}{s} = 60000\frac{l}{min}$
λ = Pipe friction factor

$\upsilon(T)$ = Kinematic viscosity of the medium depending on temperature $\left[\frac{m^2}{s}\right]$

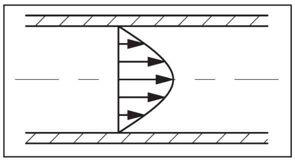
$\rho(T)$ = Density of the medium depending on temperature $\left[\frac{kg}{m^3}\right]$

ζ = Individual pressure loss coefficient

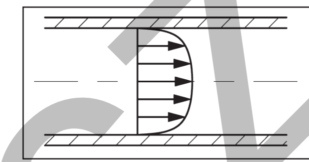
Only base units have been used. This has the advantage that the formula do not contain correction factors and there is no danger of confusion, e.g. that values are used with the wrong unit. In case values are given in other units - the flow rate is e.g. often given in l/min - it is advisable to convert them into the base units before starting calculation.

Pressure losses in pipe lines

To calculate pressure losses in pipe lines, it must first be determined whether there is a laminar or a turbulent flow. Laminar flow is homogenous and without turbulance. In case of turbulent flow, the losses increase much more quickly.



Flow profile
with laminar flow



Flow profile
with turbulent flow

The kind of flow is defined by the Reynolds' number. With a Reynolds' number of more than 2320, the flow changes to turbulent. The Reynolds' number is calculated according to the formula:

$$Re = \frac{c \cdot d}{\upsilon(T)}$$

The Reynolds' number is a non-dimensional number. The critical fluid velocity at which the flow regime can change, is thus calculated from:

$$c_{cr} = 2320 \cdot \frac{\upsilon(T)}{d} \left[\frac{m}{s}\right]$$

With a given flow rate, the fluid velocity can be calculated according to the formula:

$$c = \frac{\dot{V} \cdot 4}{d^2 \cdot \pi} \left[\frac{m}{s}\right]$$

Subsequenctly, the pipe friction factor λ can be calculated. The pipe friction factor λ is a function of the Reynolds' number and also depends on the roughness of the pipe. As hydraulically smooth pipes can generally be assumed in hydraulic applications, the pipe friction factor λ is calculated according to the following formula:

$$\text{laminar flow, } (Re < 2320)\text{: } \lambda = \frac{64}{Re}$$

$$\textit{turbulent flow, } (Re > 2320)\text{: } \lambda = \frac{0.3164}{\sqrt[4]{Re}}$$

Finally, if all factors are known, the pressure loss in a certain pipe line can be calculated according to the formula:

$$\Delta p = \lambda \cdot \frac{L}{d} \cdot \frac{\rho(T) \cdot c^2}{2} \text{ [Pa]}$$

Calculation of individual losses

A hydraulic system does not only incorporate pipes, but also valves, fittings, pipe bends etc. that cause flow losses. These individual losses are often much higher than the pipe losses and are calculated according to the following formula:

$$\Delta p = \zeta \cdot \rho(T) \cdot \frac{c^2}{2} \text{ [Pa]}$$

R

Seamless EO steel tubes | Material E235+N / St.37.4 (1.0308)

Acc. to DIN EN 10305-4

1. DIN 2413 I: Tubes with a diameter of OD/ID>2 are calculated for static stress in accordance with DIN 2413 III but with K=yield strength.
2. Evaluated in Parker Lab and Test Field. ( ) = Burst pressure (B.P.) acc. to Faupel-von-Mises

Material E235+N / St.37.4 (1.0308)		d_a Outer-Ø (mm)	Outer-Ø Tolerance (mm)	s Wall-thickness (mm)	d_i Inner-Ø (mm)	Desgin pressure		2 Burst pressure bar	Weight kg/m
Surface						1 DIN 2413 I static PN bar	DIN 2413 III dynamic PN bar		
Phosphated and oiled	Cr(VI)-free								
Order code									
R04X0.5	**R04X0.5CF**	04		0.50	3.0	313	273	1160	0.047
	R04X0.75CF	04	±0.08	0.75	2.5	470	391	1820	0.063
R04X1	**R04X1CF**	04		1.00	2.0	627	500	2700	0.074
	R05X1CF	05	±0.08	1.00	3.0	501	414	2120	0.099
	R06X0.75CF	06		0.75	4.5	333	288	1150	0.103
R06X1	**R06X1CF**	06		1.00	4.0	444	372	1650	0.123
R06X1.5	**R06X1.5CF**	06	±0,08	1.50	3.0	666	526	2550	0.166
	R06X2CF	06		2.00	2.0	692	662	>3500	0.197
R06X2.25	**R06X2.25CF**	06		2.25	1.5	757	725	>3500	0.208
R08X1	**R08X1CF**	08		1.00	6.0	333	288	1175	0.173
R08X1.5	**R08X1.5CF**	08	±0.08	1.50	5.0	499	412	1925	0.240
R08X2	**R08X2CF**	08		2.00	4.0	666	526	2500	0.296
	R08X2.5CF	08		2.50	3.0	658	630	2650	0.339
R10X1	**R10X1CF**	10		1.00	8.0	282	248	900	0.222
R10X1.5	**R10X1.5CF**	10		1.50	7.0	423	357	1450	0.314
R10X2	**R10X2CF**	10	±0.08	2.00	6.0	564	458	2025	0.395
R10X2.5	**R10X2.5CF**	10		2.50	5.0	705	551	2675	0.462
	R10X3CF	10		3.00	4.0	666	638	>3500	0.518
R12X1	**R12X1CF**	12		1.00	10.0	235	209	750	0.271
R12X1.5	**R12X1.5CF**	12		1.50	9.0	353	303	1150	0.388
R12X2	**R12X2CF**	12	±0.08	2.00	8.0	470	391	1600	0.493
	R12X2.5CF	12		2.50	7.0	588	474	2025	0.586
	R12X3CF	12		3.00	6.0	705	551	2600	0.666
	R12X3.5CF	12		3.50	5.0	651	624	(3109)	0.734
	R14X1.5CF	14		1.50	11.0	302	264	975	0.462
R14X2	**R14X2CF**	14	±0.08	2.00	10.0	403	342	1325	0.592
R14X2.5	**R14X2.5CF**	14		2.50	9.0	504	415	1650	0.709
	R14X3CF	14		3.00	8.0	604	485	2200	0.814
R15X1	**R15X1CF**	15		1.00	13.0	188	170	575	0.345
R15X1.5	**R15X1.5CF**	15	±0.08	1.50	12.0	282	248	950	0.499
R15X2	**R15X2CF**	15		2.00	11.0	376	321	1275	0.641
R16X1.5	**R16X1.5CF**	16		1.50	13.0	264	233	850	0.536
R16X2	**R16X2CF**	16	±0.08	2.00	12.0	353	303	1175	0.691
R16X2.5	**R16X2.5CF**	16		2.50	11.0	441	370	1500	0.832
R16X3	**R16X3CF**	16		3.00	10.0	529	433	1850	0.962
R18X1	**R18X1CF**	18		1.00	16.0	157	143	450	0.419
R18X1.5	**R18X1.5CF**	18		1.50	15.0	235	209	700	0.610
R18X2	**R18X2CF**	18	±0.08	2.00	14.0	313	273	975	0.789
R18X2.5	**R18X2.5CF**	18		2.50	13.0	392	333	1300	0.956
	R18X3CF	18		3.00	12.0	470	391	1575	1.111

Surface finish:
- Tubes with I.D. 1.5-5 mm: outside and inside oiled.
- Tubes from 6 mm I.D.: outside and inside phosphated and oiled.

- Cr(VI)-free:
These dimensions are externally thick coat passivated (thickness of coat 8-12μm), inside oilded.

Seamless EO steel tubes (continued) | Material E235+N / St.37.4 (1.0308)

Acc. to DIN EN 10305-4

1. DIN 2413 I: Tubes with a diameter of OD/ID>2 are calculated for static stress in accordance with DIN 2413 III but with K=yield strength.
2. Evaluated in Parker Lab and Test Field.

Material E235+N / St.37.4 (1.0308)		d_a Outer-Ø (mm)	Outer-Ø Tolerance (mm)	s Wall-thickness (mm)	d_i Inner-Ø (mm)	Design pressure		2 Burst pressure bar	Weight kg/m
Surface						1 DIN 2413 I static PN bar	DIN 2413 III dynamic PN bar		
Phosphated and oiled	Cr(VI)-free								
Order code									
	R20X1.5CF	20	±0.08	1.50	17.0	212	190	675	0.684
R20X2	**R20X2CF**	20		2.00	16.0	282	248	900	0.888
R20X2.5	**R20X2.5CF**	20		2.50	15.0	353	303	1100	1.079
R20X3	**R20X3CF**	20		3.00	14.0	423	357	1400	1.258
	R20X3.5CF	20		3.50	13.0	494	408	1650	1.424
	R20X4CF	20		4.00	12.0	564	458	2000	1.578
R22X1.5	**R22X1.5CF**	22	±0.08	1.50	19.0	192	173	550	0.758
R22X2	**R22X2CF**	22		2.00	18.0	256	227	775	0.986
R22X2.5	**R22X2.5CF**	22		2.50	17.0	320	278	1025	1.202
	R22X3CF	22		3.00	16.0	385	328	1175	1.406
R25X2	**R25X2CF**	25	±0.08	2.00	21.0	226	201	725	1.134
R25X2.5	**R25X2.5CF**	25		2.50	20.0	282	248	850	1.387
R25X3	**R25X3CF**	25		3.00	19.0	338	292	1025	1.628
R25X4	**R25X4CF**	25		4.00	17.0	451	378	1500	2.072
	R25X4.5CF	25		4.50	16.0	508	418	1625	2.275
R28X1.5	**R28X1.5CF**	28	±0.08	1.50	25.0	151	138	425	0.980
R28X2	**R28X2CF**	28		2.00	24.0	201	181	600	1.282
R28X2.5	**R28X2.5CF**	28		2.50	23.0	252	223	750	1.572
R28X3	**R28X3CF**	28		3.00	22.0	302	264	900	1.850
	R30X2CF	30	±0.08	2.00	26.0	188	170	575	1.381
R30X2.5	**R30X2.5CF**	30		2.50	25.0	235	209	725	1.695
R30X3	**R30X3CF**	30		3.00	24.0	282	248	850	1.998
R30X4	**R30X4CF**	30		4.00	22.0	376	321	1175	2.565
R30X5	**R30X5CF**	30		5.00	20.0	470	391	1600	3.083
R35X2	**R35X2CF**	35	±0.15	2.00	31.0	161	147	450	1.628
R35X2.5	**R35X2.5CF**	35		2.50	30.0	201	181	600	2.004
R35X3	**R35X3CF**	35		3.00	29.0	242	215	700	2.367
	R35X4CF	35		4.00	27.0	322	280	960	3.058
	R38X2.5CF	38	±0.15	2.50	33.0	186	168	550	2.189
R38X3	**R38X3CF**	38		3.00	32.0	223	199	675	2.589
R38X4	**R38X4CF**	38		4.00	30.0	297	260	900	3.354
R38X5	**R38X5CF**	38		5.00	28.0	371	318	1150	4.069
	R38X6CF	38		6.00	26.0	445	373	1425	4.735
	R38X7CF	38		7.00	24.0	519	427	1700	5.352
R42X2	**R42X2CF**	42	±0.20	2.00	38.0	134	123	375	1.973
R42X3	**R42X3CF**	42		3.00	36.0	201	181	575	2.885
R42X4	**R42X4CF**	42		4.00	34.0	269	237	850	3.749

R

Other sizes on request!

Seamless EO steel tubes | Material E355+N / St. 52.4 (1.0580)

Acc. to DIN EN 10305-4

1. DIN 2413 I: Tubes with a diameter of OD/ID>2 are calculated for static stress in accordance with DIN 2413 III but with K=yield strength.
2. Burst pressure (B.P.) acc. to Faupel-von-Mises

Material E355+N / St.52.4 (1.0580) – Surface: Phosphated and oiled – Order code	Material E355+N / St.52.4 (1.0580) – Surface: Cr(VI)-free – Order code	d_a Outer-Ø (mm)	Outer-Ø Tolerance (mm)	s Wall-thickness (mm)	d_i Inner-Ø (mm)	Design pressure: 1 DIN 2413 I static PN bar	Design pressure: DIN 2413 III dynamic PN bar	2 Burst pressure bar	Weight kg/m
	R10X2ST52CF	10	±0.08	2.00	6.0	852	539	2671	0.395
	R12X1.5ST52CF	12	±0.08	1.50	9.0	533	357	1504	0.388
	R12X2ST52CF	12		2.00	8.0	710	461	2120	0.493
	R15X1.5ST52CF	15	±0.08	1.50	12.0	426	292	1167	0.499
	R15X2ST52CF	15		2.00	11.0	568	379	1622	0.641
	R16X1.5ST52CF	16		1.50	13.0	399	275	1086	0.536
R16X2ST52	R16X2ST52CF	16	±0.08	2.00	12.0	533	357	1504	0.691
	R16X2.5ST52CF	16		2.50	11.0	666	436	1959	0.832
	R18X1.5ST52CF	18	±0.08	1.50	15.0	355	247	953	0.610
	R18X2ST52CF	18		2.00	14.0	473	321	1314	0.789
	R20X2ST52CF	20		2.00	16.0	426	292	1167	0.888
	R20X2.5ST52CF	20	±0.08	2.50	15.0	533	357	1504	1.079
	R20X3ST52CF	20		3.00	14.0	639	420	185	1.258
	R22X1.5ST52CF	22	±0.08	1.50	19.0	290	204	767	0.758
	R22X2ST52CF	22		2.00	18.0	387	267	1049	0.986
	R25X2.5ST52CF	25		2.50	20.0	426	292	1167	1.387
R25X3ST52	R25X3ST52CF	25	±0.08	3.00	19.0	511	344	1435	1.628
	R25X4ST52CF	25		4.00	17.0	682	445	2016	2.072
	R28X2ST52CF	28	±0.08	2,00	24.0	304	213	806	1.282
R30X3ST52	R30X3ST52CF	30		3.00	24.0	426	292	1167	1.998
	R30X4ST52CF	30	±0.08	4.00	22.0	568	379	1622	2.565
	R30X5ST52CF	30		5.00	20.0	710	461	2120	3.083
	R35X3ST52CF	35	±0.15	3.00	29.0	365	253	983	2.367
	R38X3ST52CF	38		3.00	32.0	336	234	899	2.589
R38X4ST52	R38X4ST52CF	38	±0.15	4.00	30.0	448	306	1236	3.354
	R38X5ST52CF	38		5.00	28.0	561	374	1597	4.069
	R38X6ST52CF	38		6.00	26.0	673	440	1984	4.735
	R42X3ST52CF	42		3.00	36.0	304	213	806	2.885
	R42X4ST52CF	42	±0.20	4.00	34.0	406	279	1105	3.748
	R42X5ST52CF	42		5.00	32.0	507	342	1422	4.562

Surface finish:
- Tubes with I.D. 1.5-5 mm: outside and inside oiled.
- Tubes from 6 mm I.D.: outside and inside phosphated and oiled.

- Cr(VI)-free:
These dimensions are externally thick coat passivated (thickness of coat 8-12µm), inside oilded.

Other sizes on request!

Seamless EO stainless steel tubes | Material 316Ti (1.4571)

Acc. to DIN EN 10216-5, DIN EN 10305-1

1. DIN 2413 I: Tubes with a diameter of OD/ID>2 are calculated for static stress in accordance with DIN 2413 III but with K=yield strength.
2. Evaluated in Parker Lab and Test Field. ( ) = Burst pressure (B.P.) acc. to Faupel-von-Mises

Material 316Ti (1.4571) / Surface bright annealed / Order code	d_a Outer-Ø (mm)	Outer-Ø Tolerance (mm)	s Wall-thickness (mm)	d_i Inner-Ø (mm)	Design pressure: 1 DIN 2413 I static PN bar	Design pressure: DIN 2413 III dynamic PN bar	2 Burst pressure bar	Weight kg/m
R04X171	04	±0.08	1.0	2.0	735	539	(2961)	0.075
R06X171	06	±0.08	1.0	4.0	490	383	1850	0.125
R06X1.571	06		1.5	3.0	735	539	2900	0.169
R08X171	08	±0.08	1.0	6.0	368	297	1300	0.175
R08X1.571	08		1.5	5.0	551	424	2050	0.244
R10X171	10	±0.08	1.0	8.0	294	242	950	0.225
R10X1.571	10		1.5	7.0	441	349	1750	0.319
R10X271	10		2.0	6.0	588	447	2400	0.401
R12X171	12	±0.08	1.0	10.0	245	205	850	0.275
R12X1.571	12		1.5	9.0	368	297	1400	0.394
R12X271	12		2.0	8.0	490	383	1900	0.501
R14X1.571	14	±0.08	1.5	11.0	315	258	1200	0.469
R14X271	14		2.0	10.0	420	334	1550	0.601
R14X2.571	14		2.5	9.0	525	406	2100	0.720
R15X171	15	±0.08	1.0	13.0	196	166	675	0.351
R15X1.571	15		1.5	12.0	294	242	1100	0.507
R15X271	15		2.0	11.0	392	314	1400	0.651
R16X1.571	16	±0.08	1.5	13.0	276	228	950	0.545
R16X271	16		2.0	12.0	368	297	1300	0.701
R16X2.571	16		2.5	11.0	459	362	1850	0.845
R16X371	16		3.0	10.0	551	424	2400	0.977
R18X1.571	18	±0.08	1.5	15.0	245	205	800	0.620
R18X271	18		2.0	14.0	327	267	1150	0.801
R20X271	20	±0.08	2.0	16.0	294	242	1050	0.901
R20X2.571	20		2.5	15.0	368	297	1400	1.095
R20X371	20		3.0	14.0	441	349	1800	1.277
R22X1.571	22	±0.08	1.5	19.0	200	170	650	0.770
R22X271	22		2.0	18.0	267	222	900	1.002
R25X271	25	±0.08	2.0	21.0	235	197	763	1.152
R25X2.571	25		2.5	20.0	294	242	1050	1.408
R25X371	25		3.0	19.0	353	286	1275	1.653
R28X1.571	28	±0.08	1.5	25.0	158	135	550	0.995
R28X271	28		2.0	24.0	210	177	700	1.302
R28X2.571	28		2.5	23.0	263	218	(840)	1.596
R30X2.571	30	±0.08	2.5	25.0	245	205	850	1.722
R30X371	30		3.0	24.0	294	242	1150	2.028
R30X471	30		4.0	22.0	392	314	1500	2.605
R35X271	35	±0.15	2.0	31.0	168	143	550	1.653
R35X2.571	35		2.5	30.0	210	177	(659)	2.035
R35X371	35		3.0	29.0	252	210	(803)	2.404
R38X2.571	38	±0.15	2.5	33.0	193	164	628	2.222
R38X471	38		4.0	30.0	309	254	1150	3.405
R42X271	42	±0.20	2.0	38.0	140	121	475	2.003
R42X371	42		3.0	36.0	210	177	750	2.930

Other sizes on request!

Seamless EO stainless steel tubes | Material 316L (1.4404)

Acc. to ASTM A269/A213

1. DIN 2413 I static pressure (W.P.) capability for straight pipe including manufacturing tolerance.
2. Burst pressure (B.P.) acc. to Faupel-von-Mises

Material 316L (1.4404) Surface Order code pickled	bright annealed	d_a Outer-Ø (mm)	Outer-Ø Tolerance (mm)	s Wall-thickness (mm)	d_i Inner-Ø (mm)	1 Design pressure DIN 2413 I static PN bar	DIN 2413 III dynamic PN bar	2 Burst pressure bar	Weight kg/m
	R04X1-316BA	04	±0.08	1.0	2.0	735	539	2961	0.075
	R06X1-316BA	06	±0.08	1.0	4.0	490	383	1732	0.125
	R06X1.5-316BA	06		1.5	3.0	735	539	2961	0.169
	R08X1-316BA	08	±0.08	1.0	6.0	368	297	1229	0.175
	R10X1-316BA	10	±0.08	1.0	8.0	294	242	953	0.225
	R10X1.5-316BA	10		1.5	7.0	441	349	1524	0.319
	R10X2-316BA	10		2.0	6.0	588	447	2182	0.401
	R12X1-316BA	12	±0.08	1.0	10.0	245	205	779	0.275
	R12X1.5-316BA	12		1.5	9.0	368	297	1229	0.394
	R12X2-316BA	12		2.0	8.0	490	383	1732	0.501
	R15X1.5-316BA	15	±0.08	1.5	12.0	294	242	953	0.507
R16X2-316		16	±0.08	2.0	12.0	368	297	1229	0.701
R16X2.5-316		16		2.5	11.0	459	362	1601	0.845
R18X1.5-316		18	±0.08	1.5	15.0	245	205	779	0.620
R18X2-316		18		2.0	14.0	327	267	1074	0.801
R20X2-316		20	±0.08	2.0	16.0	294	242	953	0.901
R20X2.5-316		20		2.5	15.0	368	297	1229	1.096
R22X2-316		22	±0.08	2.0	18.0	267	222	857	1.002
R25X2-316		25	±0.08	2.0	21.0	235	197	745	1.152
R25X2.5-316		25		2.5	20.0	294	242	953	1.409
R25X3-316		25		3.0	19.0	353	286	1172	1.653
R28X2-316		28	±0.08	2.0	24.0	210	177	659	1.302
R30X2.5-316		30	±0.08	2.5	25.0	245	205	779	1.722
R30X3-316		30		3.0	24.0	294	242	953	2.028
R35X3-316		35	±0.15	3.0	29.0	252	210	803	2.404
R38X3-316		38	±0.15	3.0	32.0	232	195	734	2.629
R38X4-316		38		4.0	30.0	309	254	1010	3.405
R38X5-316		38		5.0	28.0	387	311	1305	4.132
R38X6-316		38		6.0	26.0	464	365	1621	4.808
R42X3-316		42	±0.20	3.0	36.0	210	177	659	2.930

Other sizes on request!

Seamless EO stainless steel tubes | Material 316L (1.4404)

Acc. to DIN EN 10216-5, DIN EN 10305-1

1. DIN 2413 I: Tubes with a diameter of OD/ID>2 are calculated for static stress in accordance with DIN 2413 III but with K=yield strength.
2. Burst pressure (B.P.) calculation acc. to Faupel-von-Mises

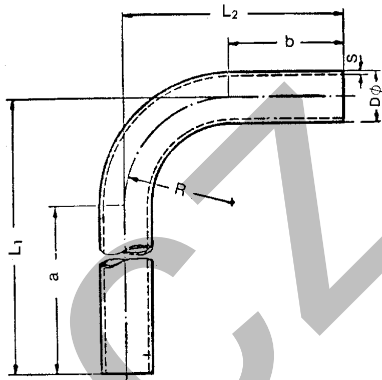
Material 316 L (1.4404) / Surface bright annealed / Order code	d_a Outer-Ø (mm) Inch	mm	s Wallthickness Inch	mm	d Inner-Ø (mm)	1 Design pressure DIN 2413 I static PN bar	DIN 2413 III dynamic PN bar	2 Burst pressure bar	Weight kg/m
R1/8X0.028TP316/L	1/8	3.18	0.028	0.71	1.76	659	492	2538	0.044
R3/16X0.035TP316/L	3/16	4.76	0.035	0.89	2.98	549	422	1996	0.086
R1/4X0.035TP316/L			0.035	0.89	4.57	412	328	1403	0.122
R1/4X0.049TP316/L	1/4	6.35	0.049	1.24	3.87	576	440	2126	0.159
R1/4X0.065TP316/L			0.065	1.65	3.05	619	556	3135	0.194
R3/8X0.035TP316/L			0.035	0.89	7.75	274	227	883	0.193
R3/8X0.049TP316/L	3/8	9.53	0.049	1.24	7.05	384	309	1294	0.257
R3/8X0.065TP316/L			0.065	1.65	6.23	510	396	1818	0.326
R1/2X0.035TP316/L			0.035	0.89	10.92	206	174	644	0.263
R1/2X0.049TP316/L	1/2	12.70	0.049	1.24	10.22	288	238	932	0.356
R1/2X0.065TP316/L			0.065	1.65	9.40	382	307	1286	0.457
R1/2X0.083TP316/L			0.083	2.11	8.48	488	381	1724	0.560
R5/8X0.049TP316/L	5/8	15.88	0.049	1.24	13.40	230	193	729	0.455
R5/8X0.065TP316/L			0.065	1.65	12.58	306	251	996	0.588
R3/4X0.049TP316/L			0.049	1.24	16.57	192	163	598	0.553
R3/4X0.065TP316/L			0.065	1.65	15.75	255	212	813	0.719
R3/4X0.083TP316/L	3/4	19.05	0.083	2.11	14.83	325	266	1069	0.895
R3/4X0.095TP316/L			0.095	2.41	14.23	372	300	1248	1.004
R3/4X0.109TP316/L			0.109	2.77	13.51	427	339	1467	1.129
R1X0.065TP316/L			0.065	1.65	22.10	191	162	595	0.981
R1X0.083TP316/L	1	25.40	0.083	2.11	21.18	244	204	775	1.231
R1X0.095TP316/L			0.095	2.41	20.58	279	231	900	1.387
R1X0.126TP316/L			0.126	3.20	19.00	370	299	1240	1.779

R

Other sizes on request!

Seamless EO tube bends 90° Material E235N (St. 37.4) and 1.4571

For minimum pressure loss



Order code		Tube O.D.	Tolerance	Wall-thickness	Tube I.D.	Bending radius	Leg length		Length		Weight
Cr(VI)-free	1.4571	D	±	S	mm	R	a	b	L1	L2	kg/piece
RB16X2CF	**RB16X271**	16	0.08	2.0	12	30	200	40	230	70	0.198
RB18X1.5CF	**RB18X1.571**	18	0.08	1.5	15	36	200	35	236	71	0.178
RB20X2CF		20	0.08	2.0	16	36	200	45	236	81	0.268
RB20X2.5CF	**RB20X2.571**	20	0.08	2.5	15	36	200	45	236	81	0.326
RB22X1.5CF		22	0.08	1.5	19	38	200	40	238	78	0.227
RB22X2CF	**RB22X271**	22	0.08	2.0	18	38	200	40	238	78	0.296
RB25X2CF		25	0.08	2.0	21	44	200	50	244	94	0.362
RB25X2.5CF	**RB25X2.571**	25	0.08	2.5	20	44	200	50	244	94	0.442
RB25X3CF		25	0.08	3.0	19	44	200	50	244	94	0.519
RB28X1.5CF		28	0.08	1.5	25	48	200	50	248	98	0.319
RB28X2CF	**RB28X271**	28	0.08	2.0	24	48	200	50	248	98	0.417
RB28X3CF		28	0.08	3.0	22	48	200	50	248	98	0.601
RB30X2.5CF		30	0.08	2.5	25	50	200	60	250	110	0.575
RB30X3CF	**RB30X371**	30	0.08	3.0	24	50	200	60	250	110	0.677
RB30X4CF		30	0.08	4.0	22	50	200	60	250	110	0.869
RB35X2CF	**RB35X271**	35	0.15	2.0	31	60	200	65	260	125	0.586
RB35X3CF		35	0.15	3.0	29	60	200	65	260	125	0.852
RB38X2.5CF		38	0.15	2.5	33	65	200	75	265	140	0.827
RB38X3CF		38	0.15	3.0	32	65	200	75	265	140	0.979
RB38X4CF	**RB38X471**	38	0.15	4.0	30	65	200	75	265	140	1.268
RB38X5CF		38	0.15	5.0	28	65	200	75	265	140	1.538
RB42X2CF	**RB42X271**	42	0.20	2.0	38	80	200	85	280	165	0.809
RB42X3CF		42	0.20	3.0	36	80	200	85	280	165	1.183
RB50X6*		50	0.20	6.0	38	180	150	150	330	330	3.496
RB65X8*		65	0.30	8.0	49	180	160	160	330	330	6.294

Tolerances for leg length a, b = ±2.5 mm

For tube bends, contrary to straight tubes of the same wall thickness there is a higher stress at the inside of the bend and a reduction of the fatigue strength, because of the out-of-round of tube. Details see DIN 2413 III section 4.7.

If the elbow end is cut off to a different length, a recalibration of the tube end may be necessary.

Tube bends material E235N (St. 37.4) are phosphated and oiled. (Yellow chromated on request.)

*phosphated and oiled