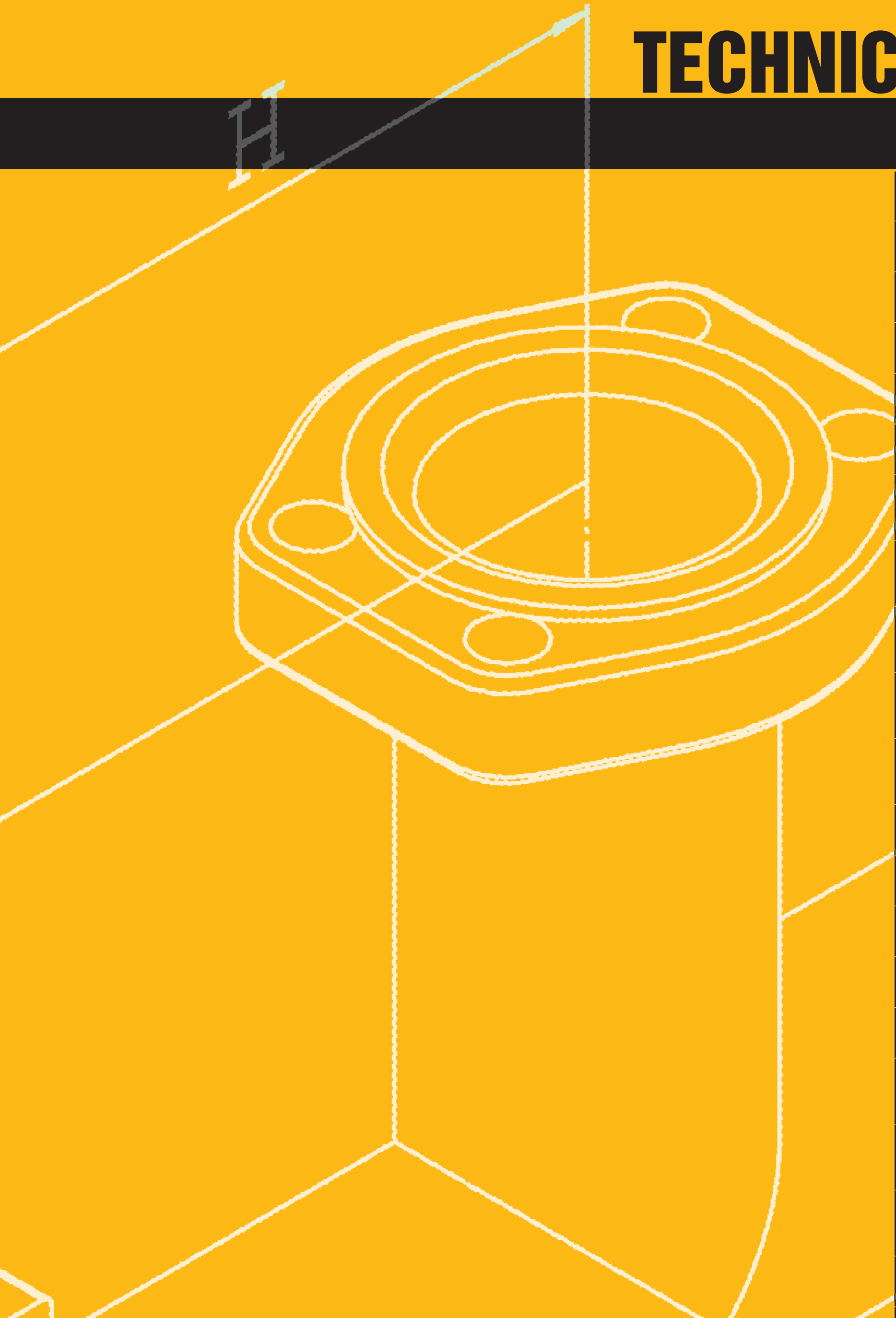
TECHNICAL INFORMATION



TECHNICAL INFO

This technical information is provided as general guidelines how to design hydraulic piping systems. In the design of a specific piping system the environment, the customers specifications as well as local rules, regulations and laws must be followed at all times.

Introduction – Process Design

Hydraulic systems are designed for such a working pressure that the required forces and torques are achieved. The machinery, equipment and components of a hydraulic system are typically designed so that a 15% increase in the working pressure is possible. The components of the system has to be selected in such a manner that the working parameters (pressure, flow rate etc.) are not exceeded taking into account the possible increase in the working pressure.

All design paramaters have to be selected specifically for each case taking into account the customers requirements as well as local rules, regulations and laws.

The pipes are dimensioned in such a manner that the pressure loss in the system does not exceed the maximum allowable value (pressure) at the maximum (or design) flow rate. The pressure loss in a piping system is related to the square of the velocity of the fluid ($p \sim v^2$). Therefore, the initial design is typically done based on the velocity of the fluid. If required, the pressure loss in the systems is then checked in order to verify that the maximum acceptable pressure loss (and the maximum allowable working pressu re of the piping) is not exceeded.
The nomographic charts of pressure drops are shown in **attachment 1**.

Fluid (oil) Velocities

GS-Hydro's recommendation in regards to the oil velocities to be utilised for intial pipe sizing are as follows:

a) Suction lines

Viscosity ν (mm²/s = cSt)	**Maximum velocity** v (m/s)
150	0.6
100	0.75
50	1.2
30	1.3

The suction line is typically dimensioned so that the velocity does not exceed **1.3 m/s**.

b) Pressure lines

Pressure p (bar)	**Maximum velocity** oil flow < 10 l/min v (m/s)	**Maximum velocity** oil flow > 10 l/min v (m/s)
25	1—2	2.5—3
50	1—2	3.5—4
100	1—2	4.5—5
200	2—3	5—(6)
> 200	2—3	5—(6)

The pressure line is typically dimensioned so that the velocity does not exceed **5 m/s**.

c) Return lines

The recommended return line velocity is 1...3 m/s. The return line is typically dimensioned so that the velocity does not exceed **3 m/s**.

The oil flow rates at the recommended velocities are presented in **attachment 2**.

TECHNICAL INFORMATION

Mechanical Design

Introduction – Mechanical Design

When designing the piping system the following has to be taken into account:

- pipe & tube material
- connection technology: fittings, flanges, welding
- hoses and hose couplings
- pipe supports

Pipe & Tube Materials

GS-Hydro recommends the use of cold-drawn, seamless precision (carbon) steel tubes & pipes (St37.4 NBK and St52.4 NBK) and austentic stainless steel (AISI316L) tubes and pipes due to quality (precision in dimension and shape) and cleanliness reasons (no scale). *As a comparison hot rolled tubes will always have some scale both inside and out due to the manufacturing process; by cold forming there will not be any scale inside the tube after the manufacturing.*

The recommended pipe & tube materials to be used in hydraulic applications are as follows:

	Carbon Steel	
Material Specification	DIN 1630	–
Manufacturing Tolerances	DIN 2391-1	EN 10305-4
Technical Terms of Delivery	DIN 2391-2/C	EN 10305-4
	Stainless Steel (mm)	**Stainless Steel (sch)**
Material Specification	ASTM A269/A213 (A.W.)	AST A312
Manufacturing Tolerances	ASTM A269	ASTM A530

GS-Hydro recommends the use of cold drawn seamless high tensile hydraulic tube according to DIN 2391C ST52.4 NBK (E 355N) because the higher tensile strength means higher permissible working pressures and reduced wall thickness, leading to reduced overall weight in both the tube and pipe itself as well as in the necessary supporting steel structures. The use of DIN 2391C ST37.4 NBK (E 255N) – which is also recommendable material grade - leads to thicker tube and pipe walls and thus more weight (and potentially costs). The final selection between St.37.4 and St 52.4 is, however, an economical decision.

Fittings and Flanges

In hydraulic and other piping systems with high quality requirements GS-Hydro recommends the use of non-welded connection technologies (fittings, flanges etc.) for all tube and pipe sizes due to the reliability and inherent cleanliness. The type of jointing technology is selected based on the working pressure and the tube or pipe size. The material is selected based on the environment (and/or the customer's specifications).

For tube and pipe sizes above and including 25 mm GS-Hydro recommends the use of the GS-37° Flare Flange and/or GS-Retain Ring Systems. For tube and pipe sizes below 25 mm GS-Hydro recommends advanced fitting solutions, 37° JIC flare or high quality bite type (profile ring) fittings depending on the application and specific design requirements.

The recommended connection technology for various pipe sizes and pressure classes are shown in **attachment 3**.

Selection of type of connection

In order to select the type of connection (flange, fitting, etc) the following basic design data is needed:

- Working pressure, bar [W.P]
- Pipe/tube material
- Pipe/tube size (OD x s)
- Other conditions such as possible pressure shocks in the system, external forces, environment (thermal movements, corrosion etc.) and noise aot.

Attached tables provide a guideline what type of connection to select for various materials and tube/pipe sizes. The tables which are intended as a general guideline are used as follows:

1. Select the correct table in accordance with the tube/pipe material and maximum system working pressure:
    - 50 bar, carbon steel
    - 50 bar, stainless steel
    - 210 bar (3000 psi), carbon steel
    - 210 bar (3000 psi), stainless steel
    - 280 bar, carbon steel
    - 280 bar, stainless steel
    - 350 bar (6000 psi), carbon steel
    - 350 bar (6000 psi), stainless steel
    - 400 bar
2. Select connection type based on tube/pipe size (or oil flow)

Note! Other connection types than those recommended in the tables are also possible. Prior to making the final selection tubes/pipes, flanges/fittings etc must to checked for compliance with local rules and regulations, system working pressure and other design conditions.

TECHNICAL INFORMATION

Mechanical Design

Hoses & Hose Couplings

Hydraulic hoses are used in wide variety of industrial hydraulic systems. Dimensions, performance specifications, construction options, and features are all important parameters to consider when searching for hydraulic hose.

Dimensions for the selection of hydraulic hose include inside diameter, outside diameter, and minimum bend radius The inside diameter refers to the inside of the hose or liner. The outside diameter is often a nominal specification for hoses of corrugated or pleated construction. Minimum bend radius is based on a combination of acceptable hose cross-section deformation and mechanical bending limit of any reinforcement.

Important performance specifications to consider when searching for hydraulic hose & hose couplings include application, material to be conveyed, working pressure and temperature range. The working pressure is the maximum service design pressure. The temperature range is the full required range of ambient operating temperature. See **attachment 4.**

Pipe Supports

When designing the piping system supports the following should be taken into account:

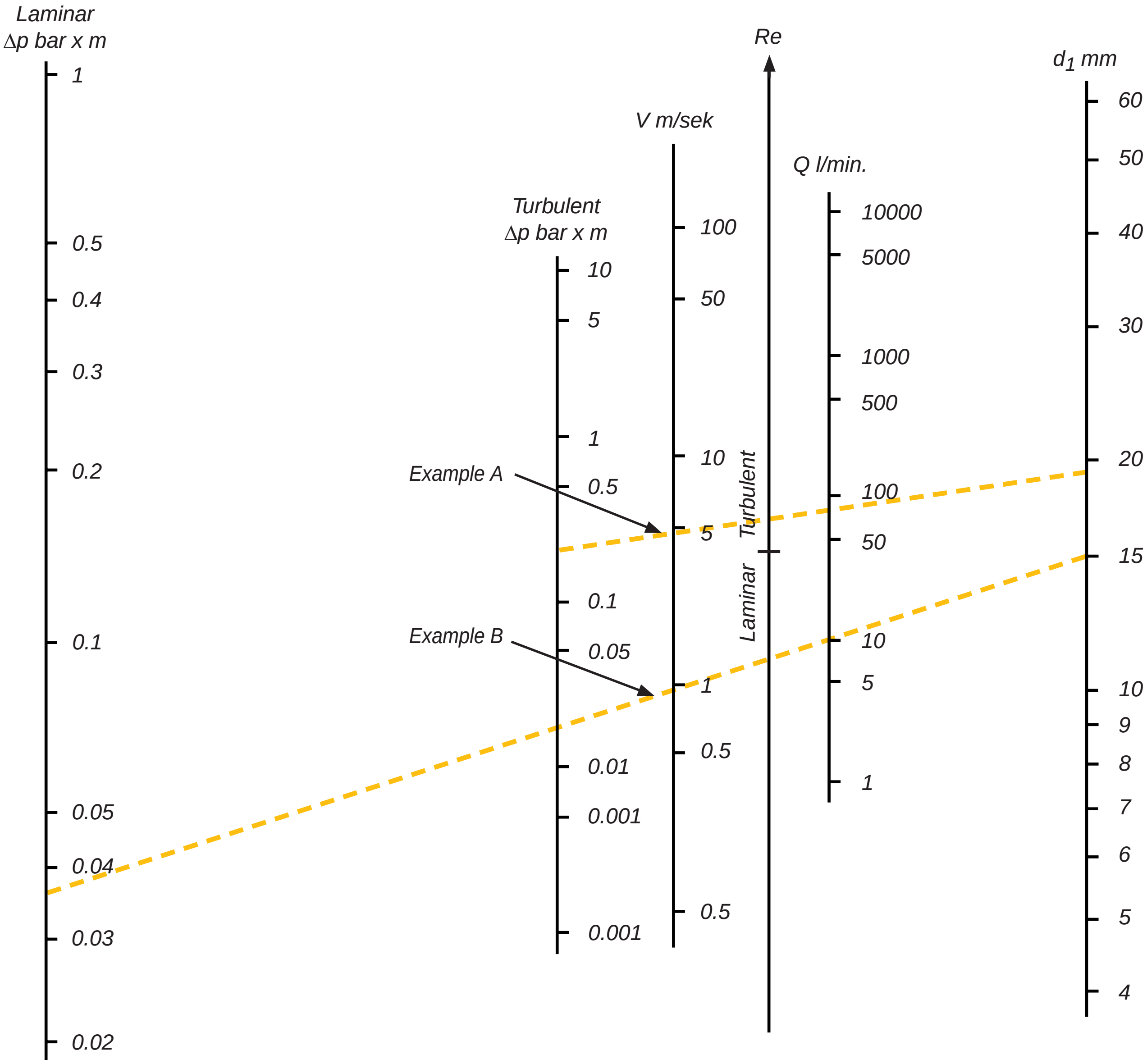
- The pipes shall not be supported from other pipes nor should the pipes be utilised to support other components
- The transfer of vibration from other equipment and machinery should be avoided to the extent possible
- Thermal expansions shall be taken into account when designing the supports
- A pipe bend should be supported as close to the bend as possible (whenever needed on both sides of the bend)
- The support should be located as close to the end of the pipe as possible when connecting to hose.

The pipe clamps should be made of both a muffling material and a which resists wear (when the pipe moves). Pipe clamps conforming to DIN 3015-1...3 should be utilised.

The recommended (typical) maximum spacing between clamps in Marine and Industrial applications is shown in **attachment 5**. The final spacing of the clamps has to be selected based on the specific requirements of the application in question.

There can be large varioations in tempearture in hydraulic systems, especially in marine and offshore applications. Under certain conditions the temperature can vary from for instance –40ºC during periods in the winter to +40ºC in the summer. This results in the thermal expansion of the pipes. For instance with a temperature difference of 80ºC the lenght will vary almost 1.0 mm per 1 meter of pipe. The linear expansion of steel pipes is presented in **attachment 6**.

Attachment 1a. Pressure Drop in Pipes



Q = 80 l/min., pipe 22/19

Pressure drop per meter pipeline is searched for.

Example A is drawn from d_1 = 19 mm through Q = 80 l/min. It crosses the Re-line in the turbulent area and the result can be read on the turbulent scale. Δp = 0.23 bar x m

Example B is drawn from d_1 = 15 mm through Q = 10 l/min. It crosses the Re-line in the laminar area and the result can be read on the laminar scale. Δp = 0.038 bar x m

The nomographic chart applies to the viscosity 25 cSt ≈ 3.5°E and the density 900 kg/m³.

At another viscosity a correction is to be made as follows:

$$\Delta p \approx \sqrt{\frac{\nu}{\nu_{nomogr}}} \times \Delta p_{nomogr}$$

$$\Delta p = \frac{\nu}{\nu_{nomogr}} \times \Delta p_{nomogr}$$

ν = the oil viscosity in cSt.

At another density a correction is to be made as follows:

$$\Delta p \approx \sqrt{\frac{\varsigma}{\varsigma_{nomogr}}} \times \Delta p_{nomogr}$$

ς = the oil density in kg/m³.

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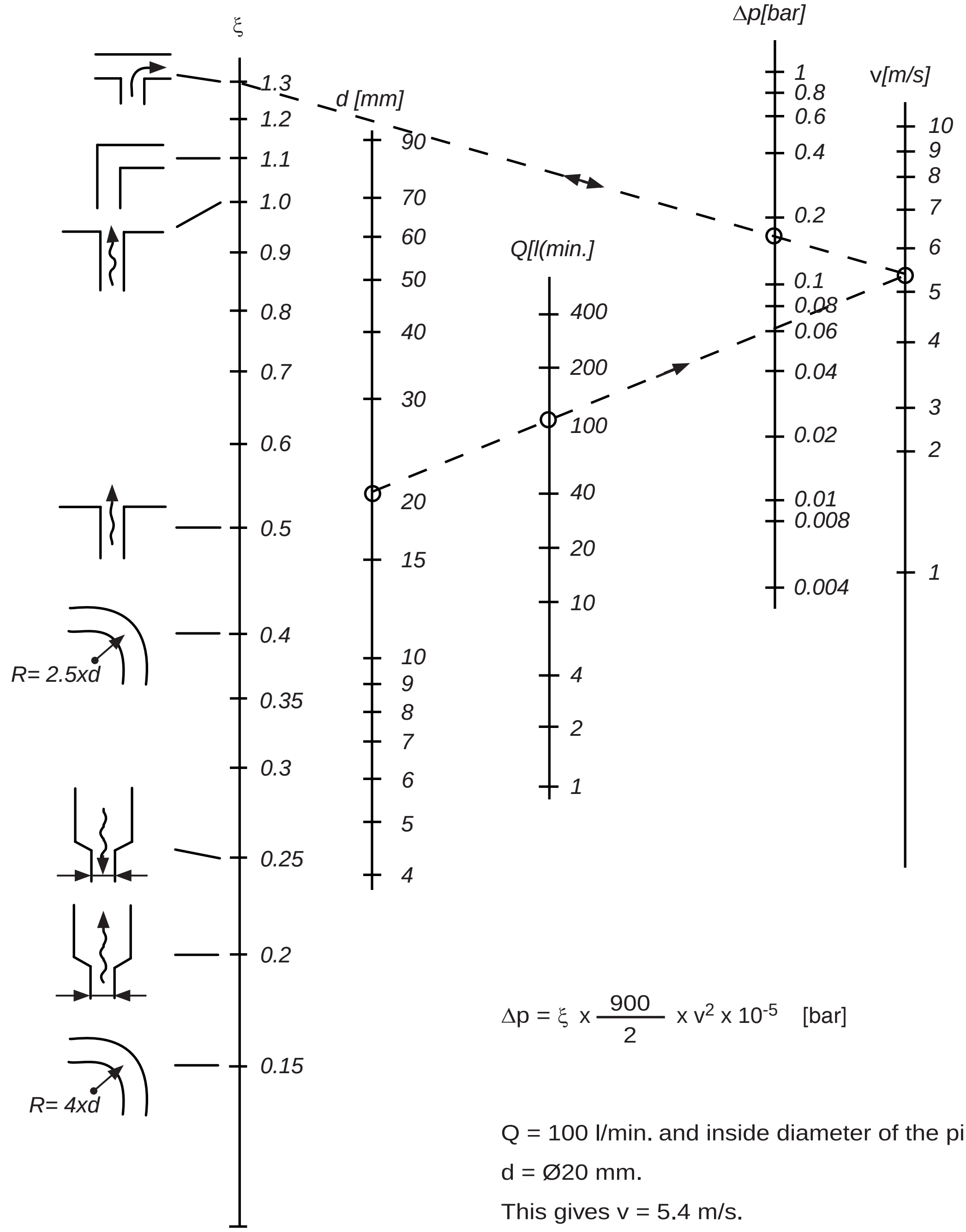
Attachment 1b. Pressure Drop in Bends, Couplings etc.

The nomographic chart applies to turbulent flow and a density of the oil of 900 kg/m^3.



$$\Delta p = \xi \times \frac{900}{2} \times v^2 \times 10^{-5} \quad [\text{bar}]$$

Q = 100 l/min. and inside diameter of the pipe d = Ø20 mm.

This gives v = 5.4 m/s.

For T-connection with a coefficient of resistance $\xi = 1.3$ the pressure drop is $\Delta p = 0.17$ bar.

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Attachment 2. Oil Flow Rates at Recommended Max. Velocities

O.D. x d_s	Oil flow rate (l/min.)		
	Suction line v= 1.3 m/s	Pressure line v= 5 m/s	Return line v= 3 m/s
6 x 1.0	1.0	3.8	2.3
6 x 1.5	0.6	2.1	1.3
8 x 1.0	2.2	8.5	5.1
8 x 1.5	1.5	5.9	3.5
8 x 2.0	1.0	3.8	2.3
8 x 2.5	0.6	2.1	1.3
10 x 1.0	3.9	15.1	9.0
10 x 1.5	3.0	11.5	6.9
10 x 2.0	2.2	8.5	5.1
10 x 2.5	1.5	5.9	3.5
12 x 1.5	5.0	19.1	11.4
12 x 2.0	3.9	15.1	9.0
12 x 2.5	3.0	11.5	6.9
14 x 1.5	7.4	28.5	17.1
14 x 2.0	6.1	23.6	14.1
15 x 1.5	8.8	33.9	20.3
15 x 2.0	7.4	28.5	17.1
16 x 1.5	10.3	39.8	23.9
16 x 2.0	8.8	33.9	20.3
16 x 2.5	7.4	28.5	17.1
16 x 3.0	6.1	23.6	14.1
18 x 1.5	13.8	53.0	31.8
18 x 2.0	12.0	46.2	27.7
20 x 2.0	15.7	60.3	36.2
20 x 2.5	13.8	53.0	31.8
20 x 3.0	12.0	46.2	27.7
20 x 4.0	8.8	33.9	20.3
22 x 1.5	22.1	85.0	51.0
22 x 2.0	19.8	76.3	45.8
22 x 2.5	17.7	68.1	40.8
25 x 2.0	27.0	103.9	62.3
25 x 2.5	24.5	94.2	56.5
25 x 3.0	22.1	85.0	51.0
25 x 4.0	17.7	68.1	40.8

O.D. x d_s	Oil flow rate (l/min.)		
	Suction line v= 1.3 m/s	Pressure line v= 5 m/s	Return line v= 3 m/s
28 x 2.0	35.3	135.6	81.4
28 x 2.5	32.4	124.6	74.7
28 x 3.0	29.6	114.0	68.4
30 x 2.0	41.4	159.2	95.5
30 x 3.0	35.3	135.6	81.4
30 x 4.0	29.6	114.0	68.4
35 x 2.0	58.8	226.3	135.8
35 x 3.0	51.5	198.1	118.8
38 x 2.5	66.7	256.5	153.9
38 x 3.0	62.7	241.2	144.7
38 x 4.0	55.1	212.0	127.2
38 x 5.0	48.0	184.6	110.8
42 x 2.0	88.4	340.1	204.0
42 x 3.0	79.4	305.2	183.1
42 x 4.0	70.8	272.2	163.3
50 x 3.0	118.5	455.9	273.6
50 x 5.0	98.0	376.8	226.1
56 x 8.5	93.1	358.2	214.9
60 x 3.0	178.5	686.7	412.0
60 x 5.0	153.1	588.8	353.3
65 x 8.5	141.1	542.6	325.6
66 x 8.5	147.0	565.4	339.3
75 x 3.0	291.5	1121.2	672.7
75 x 5.0	258.7	995.0	597.0
80 x 10	220.4	847.8	508.7
90 x 3.5	421.8	1622.4	973.4
90 x 5.0	391.9	1507.2	904.3
97 x 12	326.3	1255.0	753.0
115 x 4.0	701.0	2696.2	1617.7
115 x 15	442.4	1701.5	1020.9
130 x 15	612.3	2355.0	1413.0
140 x 4.5	1050.8	4041.4	2424.8
150 x 15	881.7	3391.2	2034.7
165 x 5.0	1471.1	5657.9	3394.7
220 x 6.0	2649.1	10188.7	6113.2

Attachment 3. Recommended Connection Technology

50 bar – Section Table — Carbon Steel Pipes

Pipe	Volume Flow* (l/min)	Weight (kg/m)	Connection Type	Flange Size	Flange Type
4X1ST37.4NBK	1	0.05	Advanced/bite type/JIC –fittings		
6X1ST37.4NBK	2	0.07			
8X1ST37.4NBK	5	0.17			
10X1ST37.4NBK	9	0.22			
12X1.5ST37.4NBK	11	0.39			
15X1.5ST37.4NBK	20	0.50			
16X1.5ST37.4NBK	24	0.54			
18X1.5ST37.4NBK	32	0.61			
20X2ST37.4NBK	36	0.89			
22X1.5ST37.4NBK	51	0.76			
25X2ST37.4NBK	62	1.13	37° Flare flange	1/2"	308F
28X2ST37.4NBK	81	1.28	37° Flare flange	3/4"	312F
30X3ST37.4NBK	81	2.00	37° Flare flange	3/4"	312F
35X2ST37.4NBK	136	1.63	37° Flare flange	1"	316F
38X3ST37.4NBK	145	2.59	37° Flare flange	1"	316F
42X3ST37.4NBK	183	2.89	37° Flare flange	1 1/4"	320F
50X3ST37.4NBK	274	3.48	37° Flare flange	1 1/2"	124F
60X3ST37.4NBK	412	4.22	37° Flare flange	2"	132F
75X3ST37.4NBK	673	5.82	37° Flare flange	2 1/2"	140F
90X3.5ST37.4NBK	974	7.47	37° Flare flange	3"	148F
100X4ST37.4NBK	1197	9.47	37° Flare flange	3 1/2"	156F
115X4ST37.4NBK	1619	11.0	37° Flare flange	4"	164F
140X4.5ST37.4NBK	2415	15.0	37° Flare flange	5"	180F
165XST37.4NBK	3396	18.7	37° Flare flange	6"	196F
220X6ST37.4NBK	6116	31.9	37° Flare flange	8"	228F
273X6ST37.4NBK	9630	39.4	37° Flare flange	10"	260F

50 bar – Section Table — Stainless Steel Pipes

Pipe	Volume Flow* (l/min)	Weight (kg/m)	Connection Type	Flange Size	Flange Type
6X1AISI316L	2	0.07	Advanced/bite type/JIC –fittings		
8X1AISI316L	5	0.17			
10X1AISI316L	9	0.22			
12X1.5AISI316L	11	0.39			
15X1.5AISI316L	20	0.50			
16X2AISI316L	20	0.69			
18X2AISI316L	28	0.79			
20X2AISI316L	36	0.89			
22X2AISI316L	46	0.99			
25X2.5AISI316L	57	1.39	37° Flare flange	1/2"	308F
28X2AISI316L	81	1.28	37° Flare flange	3/4"	312F
30X3AISI316L	81	2.00	37° Flare flange	3/4"	312F
35X2.5AISI316L	127	2.00	37° Flare flange	1"	316F
38X3AISI316L	145	2.59	37° Flare flange	1"	316F
42X3AISI316L	183	2.89	37° Flare flange	1 1/4"	320F
50X3AISI316L	274	3.48	37° Flare flange	1 1/2"	324F
60X3AISI316L	412	4.22	37° Flare flange	2"	332F

*) v = 3 m/s

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Attachment 3. Recommended Connection Technology

210 bar – Section Table — Carbon Steel Pipes

Pipe	Volume Flow* (l/min)	Weight (kg/m)	Connection Type	Flange Size	Flange Type
6X1ST37.4NBK	4	0.07	Advanced/bite type/JIC –fittings		
8X1ST37.4NBK	8	0.17			
10X1ST37.4NBK	15	0.22			
12X1.5ST52.4NBK	19	0.39			
16X2ST52.4NBK	34	0.69			
20X2.5ST52.4NBK	53	1.08			
25X2.5ST52.4NBK	94	1.39	37° Flare flange	1/2”	308F
30X3ST52.4NBK	136	2.00	37° Flare flange	3/4”	312F
38X3ST52.4NBK	241	2.59	37° Flare flange	1”	316F
42X4ST52.4NBK	272	3.75	37° Flare flange	1 1/4”	320F
50X5ST52.4NBK	377	5.55	37° Flare flange	1 1/2”	324F
60X5ST52.4NBK	589	6.18	37° Flare flange	2”	332F
75X5ST52.4NBK	995	8.63	37° Flare flange	2 1/2”	340F
80X10ST52.4NBK	848	17.2	Retain ring flange	2 1/2”	340
97X12ST52.4NBK	1256	25.2	Retain ring flange	3”	348
115X15ST52.4NBK	1702	37.0	Retain ring flange	3 1/2”	456
130X15ST52.4NBK	2356	42.5	Retain ring flange	3 3/4”	860
150X15ST52.4NBK	3393	49.9	Retain ring flange	4”	864
190X20ST52.4NBK	5301	83.8	Retain ring flange	5”	880
250X25ST52.4NBK	9425	138.7	Retain ring flange	6”	896

210 bar – Section Table — Stainless Steel Pipes

Pipe	Volume Flow* (l/min)	Weight (kg/m)	Connection Type	Flange Size	Flange Type
6X1AISI316L	4	0.07	Advanced/bite type/JIC –fittings		
8X1AISI316L	8	0.17			
10X1.5AISI316L	12	0.31			
12X1.5AISI316L	19	0.39			
16X2AISI316L	34	0.69			
18X2AISI316L	46	0.79			
20X2.5AISI316L	53	1.08			
22X2AISI316L	76	0.99			
25X2.5AISI316L	94	1.39	37° Flare flange	1/2”	308F
30X3AISI316L	136	2.00	37° Flare flange	3/4”	312F
38X4AISI316L	212	3.38	37° Flare flange	1”	316F
42X4AISI316L	272	3.75	37° Flare flange	1 1/4”	320F
50X5AISI316L	377	5.55	37° Flare flange	1 1/2”	324F
60X5AISI316L	589	6.78	37° Flare flange	2”	332F
80X10AISI316L	848	17.5	Retain ring flange	2 1/2”	340
97X12AISI316L	1256	25.5	Retain ring flange	3”	348
114.3X13.49AISI316L	1702	37.5	Retain ring flange	3 1/2”	456

*) v = 5 m/s

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Attachment 3. Recommended Connection Technology

280 bar – Section Table — Carbon Steel Pipes

Pipe	Volume Flow* (l/min)	Weight (kg/m)	Connection Type	Flange Size	Flange Type
6X1.5ST37.4NBK	2	0.17	Advanced/bite type/JIC –fittings		
8X1.5ST37.4NBK	6	0.24			
10X2ST37.4NBK	8	0.40			
12X1.5ST52.4NBK	19	0.39			
16X2ST52.4NBK	34	0.69			
20X2.5ST52.4NBK	53	1.08			
25X2.5ST52.4NBK	94	1.39	37° Flare flange	1/2”	308F
30X3ST52.4NBK	136	2.00	37° Flare flange	3/4”	312F
38X4ST52.4NBK	212	3.35	37° Flare flange	1”	316F
42X4ST52.4NBK	272	3.75	37° Flare flange	1 1/4”	320F
50X5ST52.4NBK	377	5.55	37° Flare flange	1 1/2”	324F
60X6ST52.4NBK	543	8.04	37° Flare flange	2”	332F
72X7ST52.4NBK	792	11.3	37° Flare flange	2 1/2”	440F
80X10ST52.4NBK	848	17.2	Retain ring flange	2 1/2”	440
97X12ST52.4NBK	1256	25.2	Retain ring flange	3”	448
115X15ST52.4NBK	1702	37.0	Retain ring flange	3 1/2”	456
130X15ST52.4NBK	2356	42.5	Retain ring flange	3 3/4”	860
150X15ST52.4NBK	3393	49.9	Retain ring flange	4”	864
190X20ST52.4NBK	5301	83.8	Retain ring flange	5”	880
250X25ST52.4NBK	9425	138.7	Retain ring flange	6”	896

280 bar – Section Table — Stainless Steel Pipes

Pipe	Volume Flow* (l/min)	Weight (kg/m)	Connection Type	Flange Size	Flange Type
6X1AISI316L	4	0.07	Advanced/bite type/JIC –fittings		
8X1.5AISI316L	6	0.24			
10X1.5AISI316L	12	0.31			
12X1.5AISI316L	19	0.39			
16X2AISI316L	34	0.69			
20X2.5AISI316L	53	1.08			
25X3AISI316L	85	1.63	37° Flare flange	1/2”	308F
30X4AISI316L	114	3.35	37° Flare flange	3/4”	312F
38X4AISI316L	212	3.38	37° Flare flange	1”	316F
56X8.5AISI316L	358	9.96	Retain ring flange	1 1/2”	324
66X8.5AISI316L	566	12.2	Retain ring flange	2”	332
80X10AISI316L	848	17.5	Retain ring flange	2 1/2”	440
97X12AISI316L	1256	25.5	Retain ring flange	3”	448
114.3X13.49AISI316L	1702	37.5	Retain ring flange	3 1/2”	456

NOTE! From 97 and up to 12” use ASTM A312 pipe.

*) v = 5 m/s

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Attachment 3. Recommended Connection Technology

350 bar – Section Table — Carbon Steel Pipes

Pipe	Volume Flow* (l/min)	Weight (kg/m)	Connection Type	Flange Size	Flange Type
6X1.5ST37.4NBK	2	0.17	Advanced/bite type/JIC –fittings		
8X1.5ST37.4NBK	6	0.24			
10X2ST37.4NBK	8	0.40			
12X2.5ST52.4NBK	12	0.59			
16X2.5ST52.4NBK	29	0.83			
20X3ST52.4NBK	46	1.25			
25X3ST52.4NBK	85	1.63	37° Flare flange	3/4”	612F
30X4ST52.4NBK	114	2.51	37° Flare flange	3/4”	612F
39X7.5ST52.4NBK	136	5.86	Retain ring flange	1”	616
46X8ST52.4NBK	198	7.84	Retain ring flange	1 1/4”	620
56X8.5ST52.4NBK	358	9.96	Retain ring flange	1 1/2”	624
66X8.5ST52.4NBK	566	12.1	Retain ring flange	2”	632
80X10ST52.4NBK	848	17.2	Retain ring flange	2 1/2”	440
97X12ST52.4NBK	1256	25.2	Retain ring flange	3”	448
115X15ST52.4NBK	1702	37.0	Retain ring flange	3 1/2”	456
130X15ST52.4NBK	2356	42.5	Retain ring flange	3 3/4”	860
150X15ST52.4NBK	3393	49.9	Retain ring flange	4”	864
190X20ST52.4NBK	5301	83.8	Retain ring flange	5”	880
250X25ST52.4NBK	9425	138.7	Retain ring flange	6”	896

350 bar – Section Table — Stainless Steel Pipes

Pipe	Volume Flow* (l/min)	Weight (kg/m)	Connection Type	Flange Size	Flange Type
6X1AISI316L	4	0.07	Advanced/bite type/JIC –fittings		
8X1.5AISI316L	6	0.24			
10X1.5AISI316L	12	0.31			
12X2AISI316L	15	0.49			
16X2.5AISI316L	29	0.83	37° Flare flange	1/2”	608F
20X3AISI316L	46	1.21	37° Flare flange	1/2”	608F
25X4AISI316L	68	2.07	37° Flare flange	1/2”	608F
30X4AISI316L	114	3.35	37° Flare flange	3/4”	612F
38X5AISI316L	185	4.07	37° Flare flange	1”	616F
56X8.5AISI316L	358	9.96	Retain ring flange	1 1/2”	624
66X8.5AISI316L	566	12.2	Retain ring flange	2”	632
80X10AISI316L	848	17.5	Retain ring flange	2 1/2”	440
97X12AISI316L	1256	25.5	Retain ring flange	3”	448

NOTE! From 97 and up to 12” use ASTM A312 pipe.

*) v = 5 m/s

Attachment 3. Recommended Connection Technology

400 bar – Section Table — Carbon Steel Pipes

Pipe	Volume Flow* (l/min)	Weight (kg/m)	Connection Type	Flange Size	Flange Type
6X1.5ST37.4NBK	2	0.17	Advanced/bite type/JIC –fittings		
8X2ST37.4NBK	4	0.30			
10X2ST37.4NBK	8	0.40			
12X2.5ST52.4NBK	12	0.59			
16X2.5ST52.4NBK	29	0.83			
20X3ST52.4NBK	46	1.25			
25X3ST52.4NBK	85	1.63	37° Flare flange	3/4”	612F
30X4ST52.4NBK	114	2.51	37° Flare flange	3/4”	612F
39X7.5ST52.4NBK	136	5.86	Retain ring flange	1”	616
46X8ST52.4NBK	198	7.84	Retain ring flange	1 1/4”	620
56X8.5ST52.4NBK	358	9.96	Retain ring flange	1 1/2”	624
66X8.5ST52.4NBK	566	12.1	Retain ring flange	2”	632
80X10ST52.4NBK	848	17.2	Retain ring flange	2 1/2”	440
97X12ST52.4NBK	1256	25.2	Retain ring flange	3”	448
115X15ST52.4NBK	1702	37.0	Retain ring flange	3 1/2”	456

400 bar – Section Table — Stainless Steel Pipes

Pipe	Volume Flow* (l/min)	Weight (kg/m)	Connection Type	Flange Size	Flange Type
8X1.5AISI316L	6	0.24	Advanced/bite type/JIC –fittings		
10X2AISI316L	8	0.40			
12X2AISI316L	15	0.49			
16X2.5AISI316L	29	0.83			
20X3AISI316L	46	1.21			
25X4AISI316L	68	2.07	37° Flare flange	1/2”	608F
38X5AISI316L	185	4.07	37° Flare flange	1”	616F
56X8.5AISI316L	358	9.96	Retain ring flange	1 1/2”	624

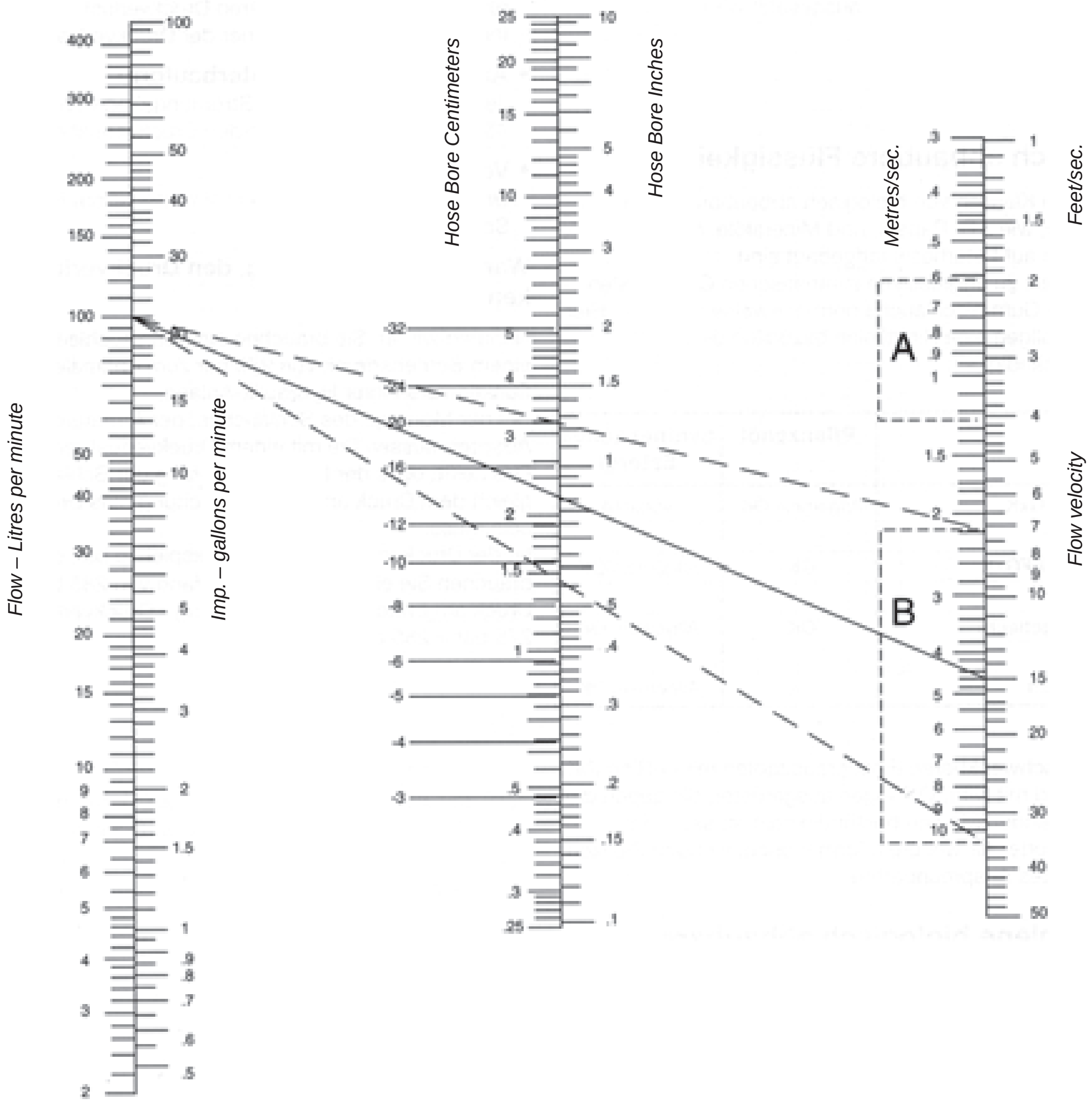
*) v = 5 m/s

Attachment 4a.
Hose Size Selection Nomogram

To determine the recommended hose assembly size where the flow rate is known, lay a straight edge across the three colums so that the edge registers with the flow rate figure in the left hand scale, and the recommended velocity range in the right hand scale. The point at which the straight edge intersects the centre scale indicates the recommended hose bore size.

Should this reading not coincide with a standard hose assembly bore size, the right hand edge of the straight edge may be adjusted up or down, within the recommended velocity range, until the straight edge registers with a standard bore size in the centre scale.

Example: Where flow rate is 100 litres per minute and recommended flow velocity is 4.5 metres per second a 25 mm (1 inch) bore size hose assembly is indicated.



Note:
Flow velocities in range A are recommended for suction and return lines.
Flow velocities in range B are recommended for delivery lines.

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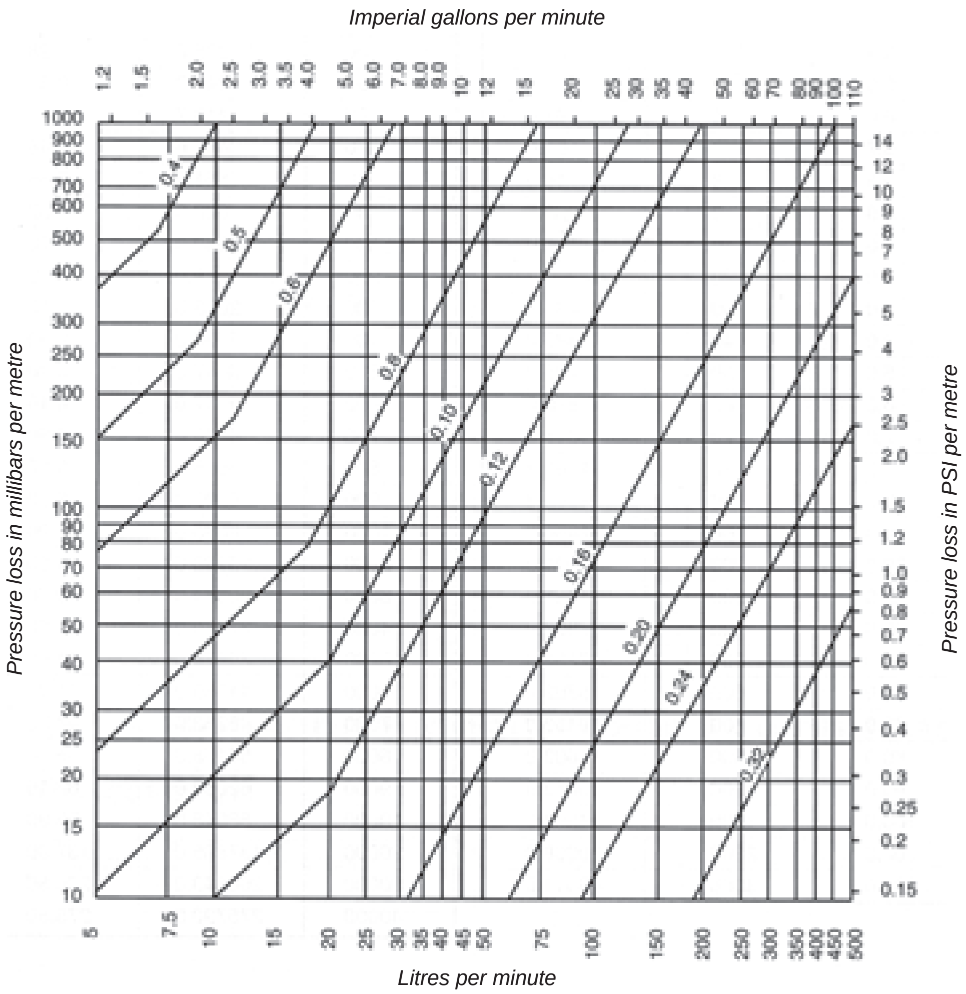
Attachment 4b. Pressure Drop in Hoses

The pressure drop in hoses is determined based on the following information: type of application, fluid type and viscosity (at desired temperature), fluid temperature, fluid flow rate, hose size and length, number and type of fittings.
The following graph will help you to determine the amount of pressure drop.



Based on: fluid viscosity 20 cSt
specific gravity 0.875

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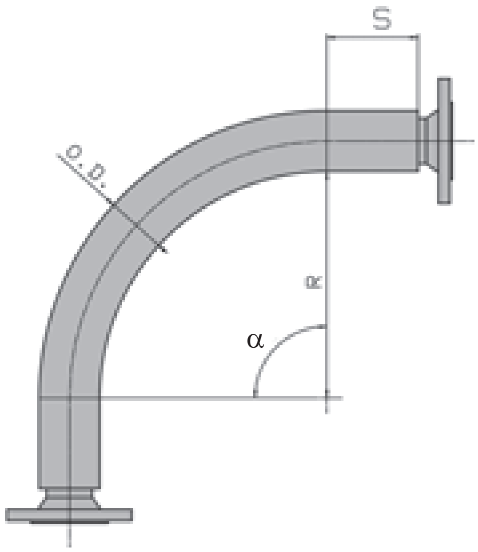
Attachment 4c. Bending Radius Theory for Hoses



When a hose is bent between two points, it should not bend more than its minimum bend radius, under given maximum working pressure.
When hose is used beyond specified recommendations, unnecessary strain on the reinforcement and/or hose / coupling interface will shorten assembly life.
Minimum bend radius for steel reinforced hose is determined under impulse testing and is specified on GS' data sheet for each hose type.

To identify the hose length necessary to respect the minimum

$$L = \left(R + \frac{d_{OD}}{2} \right) \pi \times 2 \times \frac{\alpha}{360} + 2S$$

where
L = hose length
R = bend radius, in mm
d_{OD} = outside diameter, in mm
α = bend angle
S = straight hose portion on coupling

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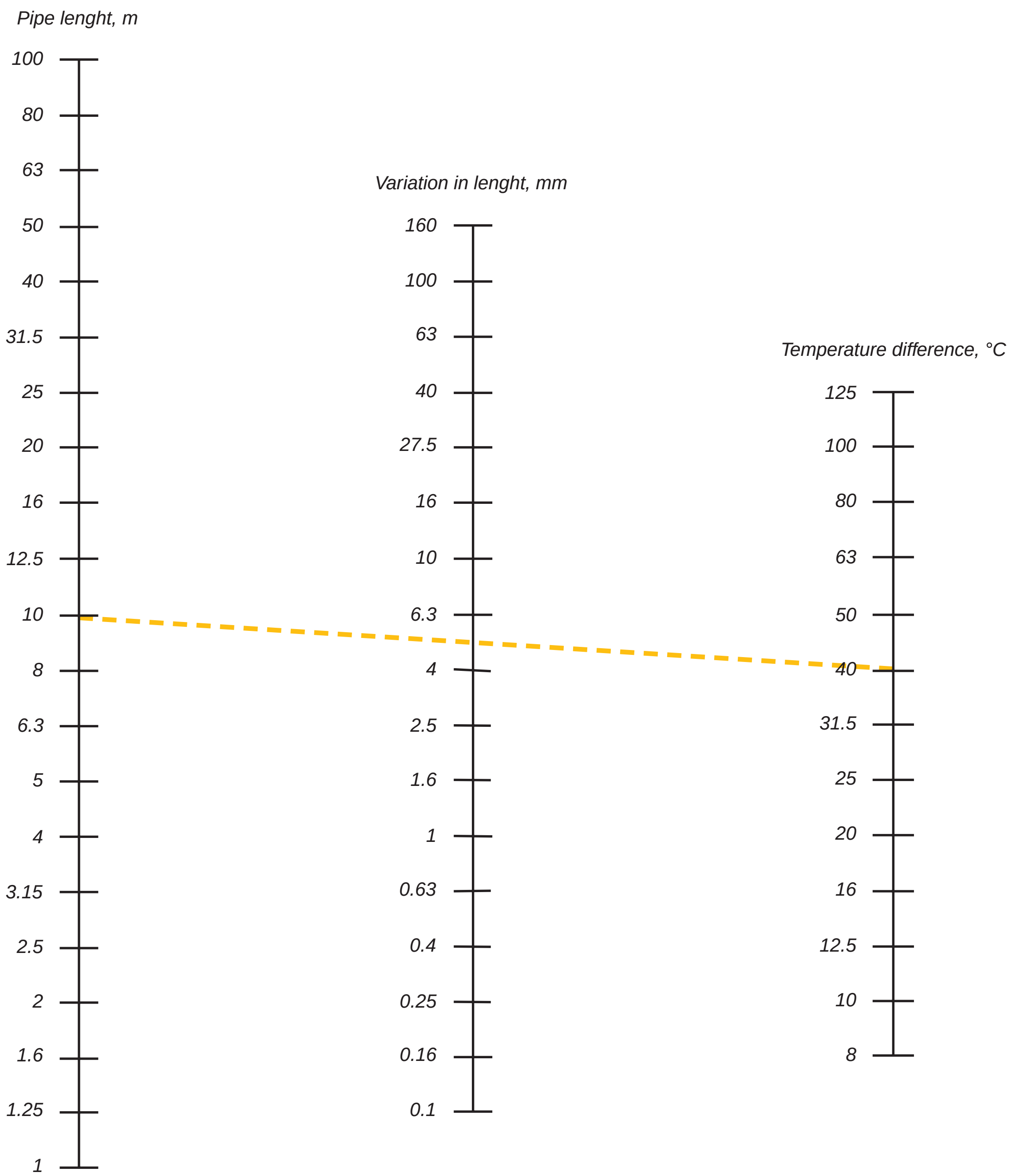
Attachment 5. Spacing for Clamps

Max. distances between clamps for GS-pipes		
Pipe size (mm)	Marine hydraulics* (m)	Industrial hydraulics (m)
20 X 2	1.1	1.2
25 X 2.5	1.3	1.5
30 X 3	1.4	2.1
38 X 4	1.5	2.1
42 X 4	1.6	2.3
50 X 3	1.7	2.7
50 X 5	1.8	2.7
56 X 8.5	1.9	2.8
60 X 3	1.9	3.0
60 X 5	2.0	3.0
66 X 8.5	2.0	3.2
75 X 3	2.1	3.5
80 X 10	2.2	3.6
90 X 3.5	2.3	3.7
90 X 5	2.4	3.7
97 X 12	2.5	4.0
100 X 4	2.4	4.0
115 X 4	2.6	4.3
115 X 15	2.7	4.3
130 X 15	2.9	4.6
140 X 4.5	2.8	4.9
150 X 15	3.1	5.0
165 X 5	3.0	5.2
190 X 20	3.5	5.4
220 X 6	3.5	5.8
250 X 25	4.0	6.0
273 X 6	3.5	5.4

* = Vibration calculations are based on ships with max. propeller speed 2 rev/sec and max. number of propeller blades 6 (frequence 12 Hz)

Note! Detailed engineering performed by GS-Hydro is recommended in order to ensure proper clamp locations and spacing. GS-Hydro's engineering services can also include a FEM-analysis of the stresses in the piping system (the FEM analysis is performed upon separate order).

Attachment 6. Linear Expansion of Steel Pipes



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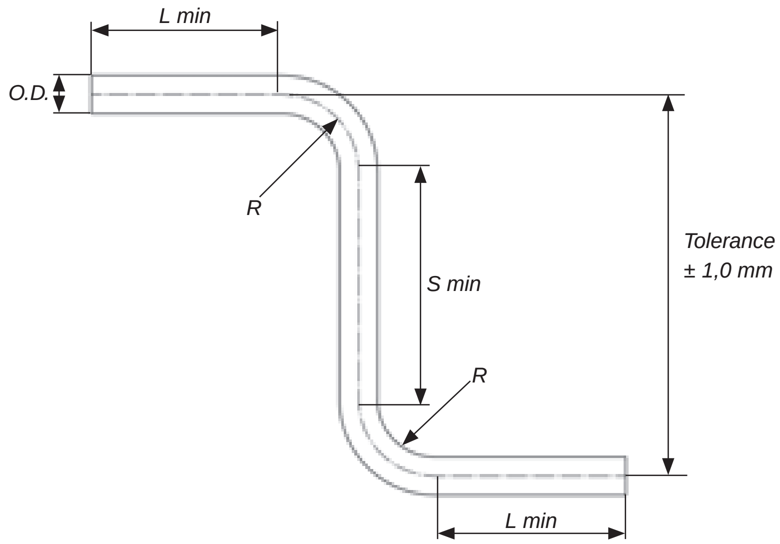
Attachments

Attachment 7a. Bending Radius for Pipes

Minimum dimension for coldbending of tube and pipe with TUBOMAT 2060

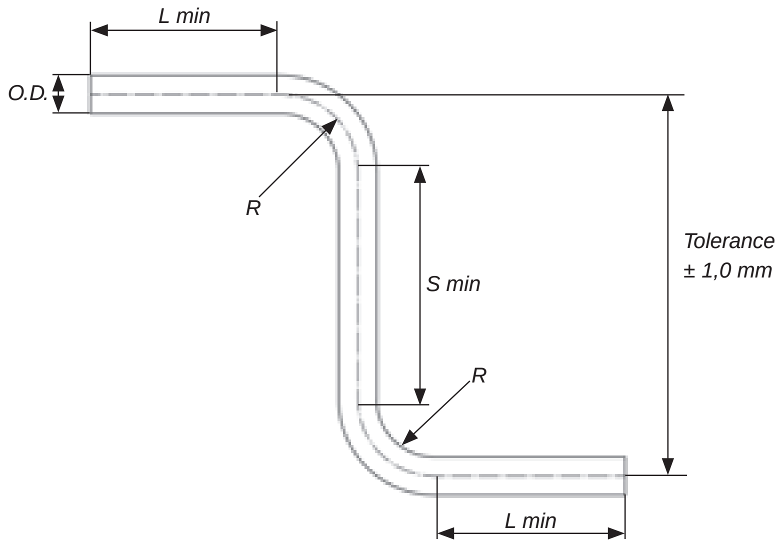


Bending Machine Tubomat 2060			
O.D.	R	S	L
20	50	100	60
22	45	100	60
25	50	100	60
28	55	100	60
30	60	100	60
35	70	100	80
38	75	120	80
42	85	120	100
48.3	145	120	100
50	100	120	100
60	120	150	100

L= Minimum length for flaring or grooving

Attachment 7b. Bending Radius for Pipes

Minimum dimension for coldbending of tube and pipe with TRANSFLUID 40–115



Bending Machine Transfluid DB 40–115			
O.D.	**R**	**S**	**L**
56	112	170	120
60.3	181	180	120
66	165	190	120
73	219	250	120
75	188	250	120
80	200	250	120
88.9	267	270	150
90	225	270	150
97	243	280	150
114.3	343	320	150
115	288	320	150

L= Minimum length for flaring or grooving

TECHNICAL INFORMATION

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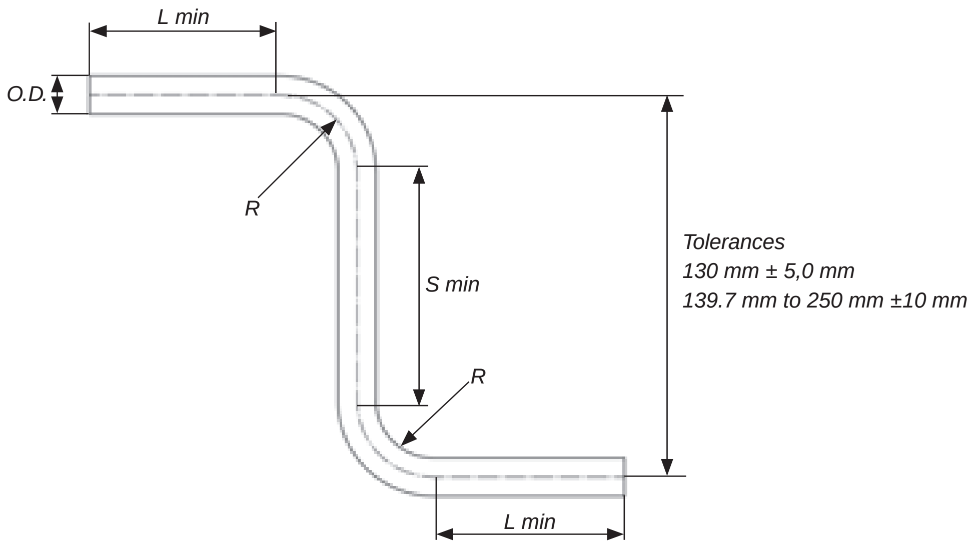
Attachment 7c. Bending Radius for Pipes

Minimum dimension for induction bending of tube and pipe



Induction Bending			
O.D.	R	S	L
130	390	280	200
139.7	420	280	200
140	420	280	200
141.3	420	280	200
150	450	280	200
165	493	280	200
168.3	505	280	200
190	570	460	200
219.1	600	460	200
220	660	460	200
250	750	460	200

L= Minimum length for flaring or grooving

Attachment 8. Chemical Requirement

Identi-fication Symbol	UNS Desig-nation	Composition %										
		Carbon	Manga-nese	Phos-phorus Max.	Silfur Max.	Silicon	Nickel	Chro-mium	Molyb-denum	Min. Tensil MPa	Min. Yield MPa	Elonga-tion Min%
Austenitic Steels												
F304	S30400	0,08max	2,0max	0,04	0,03	1,0max	8,0-11	18-20		515	205	30
F304H	S30409	0,04-0,10	2,0max	0,04	0,03	1,0max	8,0-11	18-20		515	205	30
F304L	S30403	0,035max	2,0max	0,04	0,03	1,0max	8,0-13	18-20		485	170	30
F304N	S30451	0,08max	2,0max	0,04	0,03	0,75max	8,0-10,5	18-20		550	240	30
F304LN	S30453	0,03max	2,0max	0,04	0,03	0,75max	8,0-10,5	18-20		515	205	30
F310	S31000	0,15max	2,0max	0,04	0,03	1,0max	19-22	24-26		515	205	30
F316	S31600	0,08max	2,0max	0,04	0,03	1,0max	10-14	16-18,3	2,0-3,0	515	205	30
F316H	S31609	0,04-0,10	2,0max	0,04	0,03	1,0max	10-14	16-18	2,0-2,0	515	205	30
F316L	S31603	0,035max	2,0max	0,04	0,03	1,0max	10-15	16-18	2,0-3,0	485	170	30
F316N	S31651	0,08max	2,0max	0,04	0,03	0,75max	11-14	16-18	2,0-3,0		240	30
F316LN	S31653	0,03max	2,0max	0,04	0,03	0,75max	11-14	16-18	2,0-3,0	515	205	30
F317	S31700	0,08max	2,0max	0,045	0,03	1,0max	11-15	18-20	3,0-4,0	515	205	30
F317L	S31703	0,03max	2,0max	0,045	0,03	1,0max	11-15	18-20	3,0-4,0	485	170	30
F321	S32100	0,08max	2,0max	0,04	0,03	1,0max	9,0-12	17max		515	205	30
F321H	S32109	0,04-0,10	2,0max	0,04	0,03	1,0max	9,0-12	17max		515	205	30
F347	S34700	0,08max	2,0max	0,04	0,03	1,0max	9,0-13	17-20		515	205	30
F347H	S34706	0,04-0,10	2,0max	0,04	0,03	1,0max	9,0-13	17-20		515	205	30
F348	S34800	0,08max	2,0max	0,04	0,03	1,0max	9,0-13	17-20		515	205	30
F348H	S34809	0,04-0,10	2,0max	0,04	0,03	1,0max	9,0-13	17-20		515	205	30
FXM-11	S21904	0,04max	8,0-10,0	0,06	0,03	1,0max	5,5-7,5	19-21,5		620	345	45
FXM-19	S20910	0,06max	4,0-6,0	0,04	0,03	1,0max	11,5-13,5	20,5-23,5	1,5-3,0	690	380	35
F 10	S33100	0,10-0,20	0,5-0,8	0,04	0,03	1,0-1,4	19-22	7,0-9,0		550	205	30
6 Mo	S31254	0,02max	1,0max	0,03	0,01	0,80max	17,5-18,5	19,5-20,5	6,0-6,5	650	300	35
F 45	S30815	0,05-0,10	0,8max	0,04	0,03	1,4-2,0	10-12	20-22		600	310	40
F 48	S31736	0,03max	2,0max	0,045	0,03	0,75max	13,5-17,5	17-20	4,0-5,0	550	240	40
Ferritic – Austenitic Steels												
	S31200	0,03max	2,0max	0,045	0,03	1,0max	5,5-6,5	24-26	1,2-2,0	690-900	450	25
Duplex	S31803	0,03max	2,0max	0,03	0,02	1,0max	4,5-6,5	21-23	2,5-3,5	620	450	25
Super	S32750	0,03	1,2	0,035	0,02	0,8	7,0	25	4,0	750	550	25
Duplex	S32750	0,03	2,0	0,03	0,01	1,0	8,0	26	4,0	750	550	25
Gr 660	S66286	0,08	2,0max	0,04	0,03	1,0	24-27	13,5-16	1,0-1,5	895	855	25

Titan												
Grade	UNS	Fe	O	N	C	H	Pd	At	V	Min Tensile	Min Yield	Elonga-tion
1		0,20max	0,18max	0,03max	0,10max	0,015max	0	0	0	295-410	195	30
2		0,30max	0,25max	0,03max	0,10max	0,015max	0	0	0	395-540	275	22
3		0,30max	0,35max	0,05max	0,10max	0,015max	0	0	0	460-590	350	18

Minimum Tensile, Yield and Elongation for Carbon Steel Alloy Pipe			
Identification Symbol	Min. Tensile (MPa)	Min. Yield (MPa)	Min. Elongation
A106 Gr A	330	205	35
A106 Gr B	415	240	30
A333 Gr I	387	211	28
St.37.4	340 - 480	235	25
St.52.4	490 - 650	355	21
API-5L-X52	464	358	22
API-5L-X56	499	386	19
API-5L-X60	527	413	18
A 519-4130 Hot Rolled	621	483	20
A 519-4140 Hot Rolled	855	621	15

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Attachment 9.

Threads		
Outside Diameter	Inside Diameter	Type of Thread
8,00	6,92	MM 8x1
9,73	8,57	R 1/8”x28
10,00	8,92	MM 10x1
10,27	8,77	NPTF 1/8”x27
11,11	9,74	JIC 7/16”x20
12,00	10,38	MM 12x1.5
12,70	11,33	JIC 1/2”x20
13,16	11,45	R 1/4”x19
13,57	11,31	NPTF 1/4”x18
14,00	12,38	MM 14x1.5
14,27	12,76	JIC 9/16”x18
15,88	14,35	SAE 5/8”x18
16,00	14,38	MM 16x1.5
16,66	14,95	R 3/8”x19
17,06	14,80	NPTF 3/8”x18
18,00	16,38	MM 15x1.5
19,05	17,33	JIC 1/4”x16
20,00	18,38	MM 20x1.5
20,96	18,63	R 1/2”x14

Threads		
Outside Diameter	Inside Diameter	Type of Thread
21,22	18,32	NPTF 1/2”x14
22,00	20,38	MM 22x1.5
22,23	20,26	JIC 7/8”x14
22,91	20,59	R 5/8”x14
24,00	22,38	MM 24x1.5
26,00	24,38	MM 26x1.5
26,44	24,12	R 3/4”x14
26,57	23,67	NPTF 3/4”x14
26,99	25,10	JIC 1 1/16”x12
28,00	26,38	MM 28x1.5
30,00	27,83	MM 30x2
30,16	28,20	JIC 1 3/16”x12
30,20	27,88	R 7/8”x14
31,23	29,61	NPTF 1”x11.5
33,25	30,29	R 1”x11
33,34	31,40	JIC 1 5/16”x12
36,00	33,83	MM 36x2
41,28	39,30	JIC 1 5/8”x12
41,91	38,95	R 1 1/4”x11.5

Threads		
Outside Diameter	Inside Diameter	Type of Thread
41,99	38,95	NPTF 1 1/4”x11.5
42,00	39,83	MM 42x2
45,00	42,83	MM 45x2
47,63	45,80	JIC 1 7/8”x12
47,80	44,85	R 1 1/2”x11
48,05	44,52	NPTF 1 1/2”x11.5
52,00	49,83	MM 52x2
59,61	56,66	R 2”x11
60,09	56,56	NPTF 2”x11.5
6,20	60,80	JIC 2 1/2”x12
65,71	62,75	R 2 1/4”x11
73,00	68,80	NPTF 2 1/2”x8
75,18	72,23	R 2 1/2”x11
87,88	84,93	R 3”x11
89,00	85,00	NPTF 3”x8
113,03	110,07	R 4”x11
114,35	110,30	NPTF 4”x8

NOTE: NPTF thread have to be measured outside on the 4. thread from the end.

Tubes to ASTM A269 and DIN 2391.C/2445 Permissible Variations in Dimensions (Metric)					
Size O.D. in	Tolerance O.D.	Tolerance Wallthickness %	Ovality shall be double permissible variation in O.D when wallthickness is:	Permissible variation in cut length	
				Over	Under
Up to 1/2	±0.13 mm	±15	—	3.18 mm	0
1/2 to 1 1/2 excl.	±0.13 mm	±10	Less than 1.66 mm	3.18 mm	0
1 1/2 to 3 1/2 excl.	±0.25 mm	±10	Less than 2.41 mm	4.78 mm	0
3 1/2 to 5 1/2 excl.	±0.38 mm	±10	Less than 3.81 mm	4.78 mm	0
5 1/2 to 8 excl.	±0.76 mm	±10	—	4.78 mm	0
Calculation of the weight in kilos per metre of tubes and pipes		$\frac{(O.D - W.T) \times W.T}{1000} \times 24.61$ = kg/m		O.D= Outside dia. tube/pipe W.T= Wallthickness	

Pipes to ASTM A312 Permissible Variations in Dimensions (Metric)			
Nominal Diameter in.	Permissible Variation in Outside Diameter		Thickness
	Over	Under	
1/8 to 1 1/2 incl.	0.38 mm	0.79 mm	The minimum wall thickness at any point shall not be more than 12.5% under the nominal wall thickness specified.
Over 1 1/2 to 4 incl.	0.79 mm	0.79 mm	
Over 4 to 8 incl.	1.57 mm	0.79 mm	
Over 8 to 18 incl.	2.36 mm	0.79 mm	
Over 18 to 24 incl.	3.18 mm	0.79 mm	
Calculation of the weight in lbs per metre of tubes and pipes	(D - t) x 10.85 where		D= outside dia. in inches t= wallthickness in inches

A.P.I A.S.A.E. A.S.S.P.T.	American Petroleum Institute Taper Thread American Society of Agricultural Engineers American National Straight Pipe Thread
B.S.P. B.S.T.P. F.I.E.I. G.H.T.	British Standard Parallel Pipe Thread British Standard Taper Pipe Thread Farm and Industrial Equipment Institute Garden Hose Threads/F.P.T.- Female Pipe Thread
I.P.T. J.I.C. J.I.S.	American Iron Pipe Thread - Straight Joint Industry Conferance (SAE 37) Japaneese Industrial Standard
M. M.M.	Metric Thread Metric thread

N.P.S. N.P.S.M. N.P.T. N.P.T.F N.S.T.	American National Pipe Thread - Straight American National Pipe Thread - Straight Mechanical American National Pipe Thread - Taper American National Pipe Thread - Taper /Dry seal) American National Standard Thread - Straight
R. R.T. S.A.E.	Rörgjenger - BSP British Round Thread Society of Automative Engineers (45)
U.R.T. U.N.C. U.N.F.	Dennis Urban Round Thread Unified Coarse Thread Unified Fine Thread
VEE W.	Shelvoke Drewry “VEE” Round Thread Withworth Thread

GS-Hydro

Weight Comparison Class 1500 LB Rating

Size	GS-Hydro Retain Ring Flanges		Class 1500lb Flange		
	W.P.	GS-Hydro kg/set	ANSI kg/set	GRAYLOK kg/set	TAPELOK kg/set
1/2”	350 bar	0.34	3.80	6.00	1.80
3/4”	350 bar	0.42	5.10	5.80	2.80
1”	350 bar	0.50	7.50	5.80	3.70
1 1/4”	280 bar	0.78	8.70		4.80
1 1/2”	280 bar	1.28	11.9	7.40	8.30
2”	280 bar	1.78	21.8	9.20	14.7
2 1/2”	400 bar	4.50	30.0	15.6	16.6
3”	400 bar	9.10	39.8	14.7	19.2
4”	400 bar	13.4	59.6	21.0	28.0
5”	350 bar	20.4	111		38.0
6”	350 bar	44.6	137	51.0	45.0
8”	350 bar	61.0	234	81.0	92.0

1 set of flanges consist of 2 flanges without bolts.

Outside Dia. Comparison Class 1500 LB Rating

Size	GS-Hydro Retain Ring Flanges		Class 1500lb Flange		
	W.P.	GS-Hydro O.D. mm	ANSI O.D. mm	GRAYLOK O.D. mm	TAPELOK O.D. mm
1/2”	350 bar	54	120	133	89
3/4”	350 bar	65	130	133	95
1”	350 bar	70	149	199	105
1 1/4”	280 bar	79	159		116
1 1/2”	280 bar	94	178	203	138
2”	280 bar	102	216	229	167
2 1/2”	400 bar	120	244	257	195
3”	400 bar	145	267	267	195
4”	400 bar	180	311	305	233
5”	350 bar	245	375		260
6”	350 bar	300	394	445	289
8”	350 bar	385	483	507	385

Unit	Factor	Conversion Unit
Weight (basic unit kg)		
1 kg= 10^3 g = 10^{-3}Mg		
g= gram	0,035274	oz.= ounce
kg= kilogram	2,204622	lb.= pound
Lb.= pound	0,453592	kg= kilogram
Mg= megagram	1	t= ton
oz.= ounce	28,349525	g= gram
t= ton	0,984206	(Long) ton (UK)
t= ton	1,102311	(Short) ton (USA)
(Long) ton (UK)	1,016047	t= ton
(Short) ton (USA)	0,907185	t= ton
kg/m= kilogram/metre	0,672	lb./ft.= pound per foot
Power (basic unit W)		
1 W= 1 J/s= 1 Nm/s= 10^{-3} kW		
Btu/hr.= British thermal unit per hour	0,293071	W= watt
ft.-/lb./sec.= foot-pound force/second	1,35582	W= watt
hP= horsepower	0,7457	kW= kilowatt
kW= kilowatt	1,341022	hP= horsepower
kW= kilowatt	1,3596	PS= horsepower
PS= horsepower	0,7355	kW= kilowatt
W= watt	3,41342	Bru/hr.= British thermal unit per hour
W= watt	0,737561	ft.-lbt./sec.= foot-pound force per second
Pressure (basic unit Pa)		
1 Pa= 1 N/m^3= 1 kg/m * g^3		
bar	10^{-1}	MPa= mega-Pascal
bar	10^5	Pa= Pascal
bar	14,503768	psi= pound per square inch
in.-Hg= inch Hg	33,863788	mb= millibar
mb= millibar	0,029528	in. Hg= inch Hg
MPa= mega-Pascal	10	bar
Pa= Pascal	10^{-5}	bar
psi= pound/square inch	0,068948	bar

Maximum Ratings for ANSI B16.5 Flanges

Temp. in °C	Working Pressure in psig by Classes						
	150	300	400	600	900	1500	2500
+30–40	290	750	1000	1500	2250	3750	6250
95	260	750	1000	1500	2250	3750	6250
150	230	730	970	1455	2185	2640	6070
205	200	705	940	1410	2115	2530	5880
260	170	665	885	1330	1995	3225	5540
315	140	605	805	1210	1815	3025	5040
345	125	590	785	1175	1765	2940	4905
370	110	570	755	1135	1705	2840	4730
400	95	530	710	1065	1595	2660	4430
425	80	510	675	1015	1525	2540	4230
455	65	485	650	975	1460	2435	4060
480	50	450	600	900	1350	2245	3745
510	35	385	515	775	1160	1930	3220
540	20	365	485	725	1090	1820	3030
565		360	480	720	1080	1800	3000
595		325	430	645	965	1610	2685
620		275	365	550	825	1370	2285
650		205	725	410	620	1030	1715
675		180	245	365	545	910	1515
705		140	185	275	410	685	1145
730		105	140	205	310	515	860
760		75	100	150	225	380	630
790		60	80	115	175	290	485
815		40	55	85	125	205	345

TECHNICAL INFORMATION

Alphabetic Register

GS-Hydro

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