General information

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.

Process Design

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 have 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 ~ 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 pressure 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.**

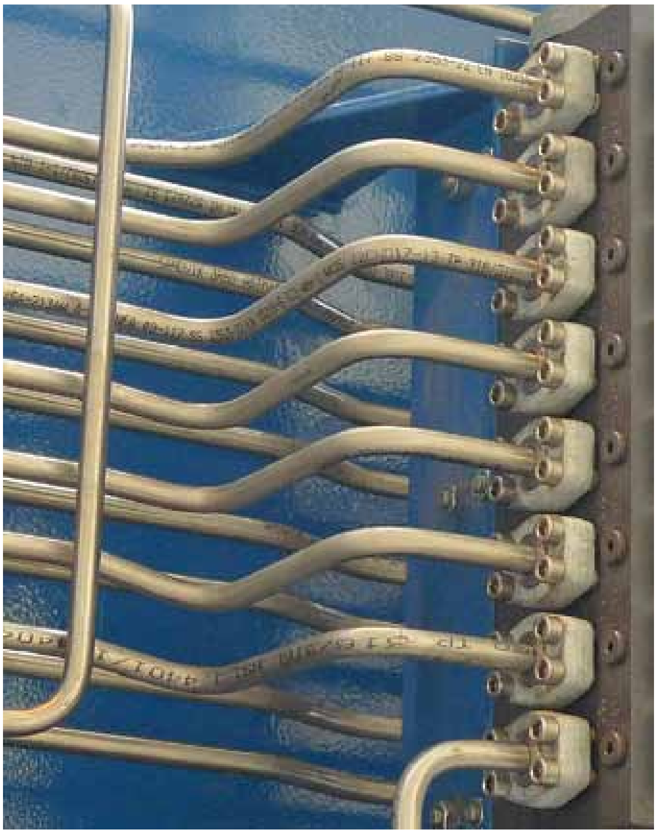
The oil flow rates at the recommended velocities are presented in **attachment 2.**

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.)	ASTM A312
Manufacturing Tolerances	ASTM A269	ASTM A999

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 235N) – 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.

Mechanical Design

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/stainless steel
- 210 bar, carbon steel/stainless steel
- 280 bar, carbon steel/stainless steel
- 350 bar, carbon steel/stainless steel
- 420 bar, carbon steel/stainless steel
- 690 bar, Duplex steel

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.

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.

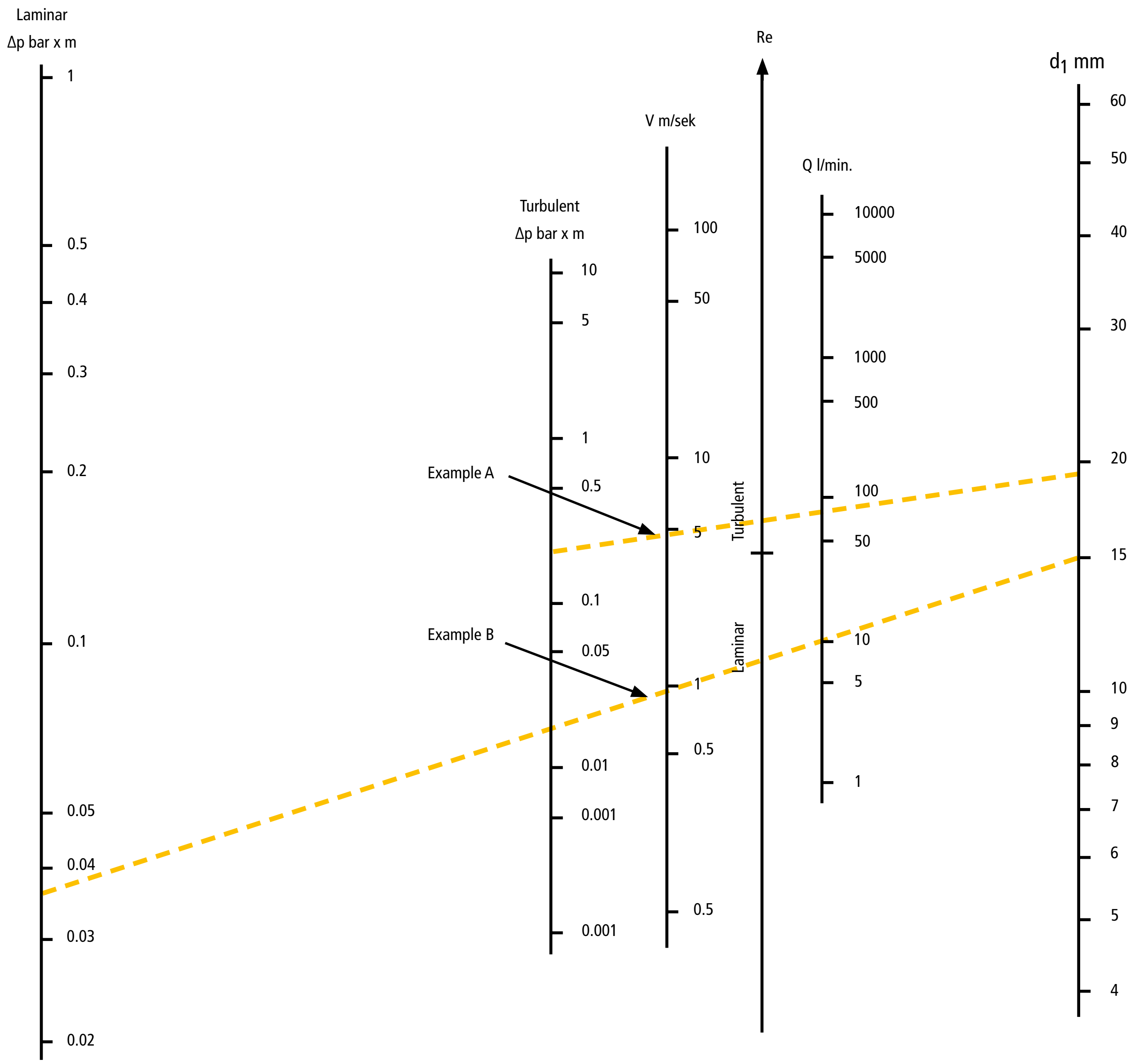
The pipe clamps should be made of both a muffling material and a which resists wear (when the pipe moves). Pipe clamps conforming to DIN 3015-1...3 should be utilised.

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

Attachments

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 throug 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 throug 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:

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

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

ν = the oil viscosity in cSt.

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

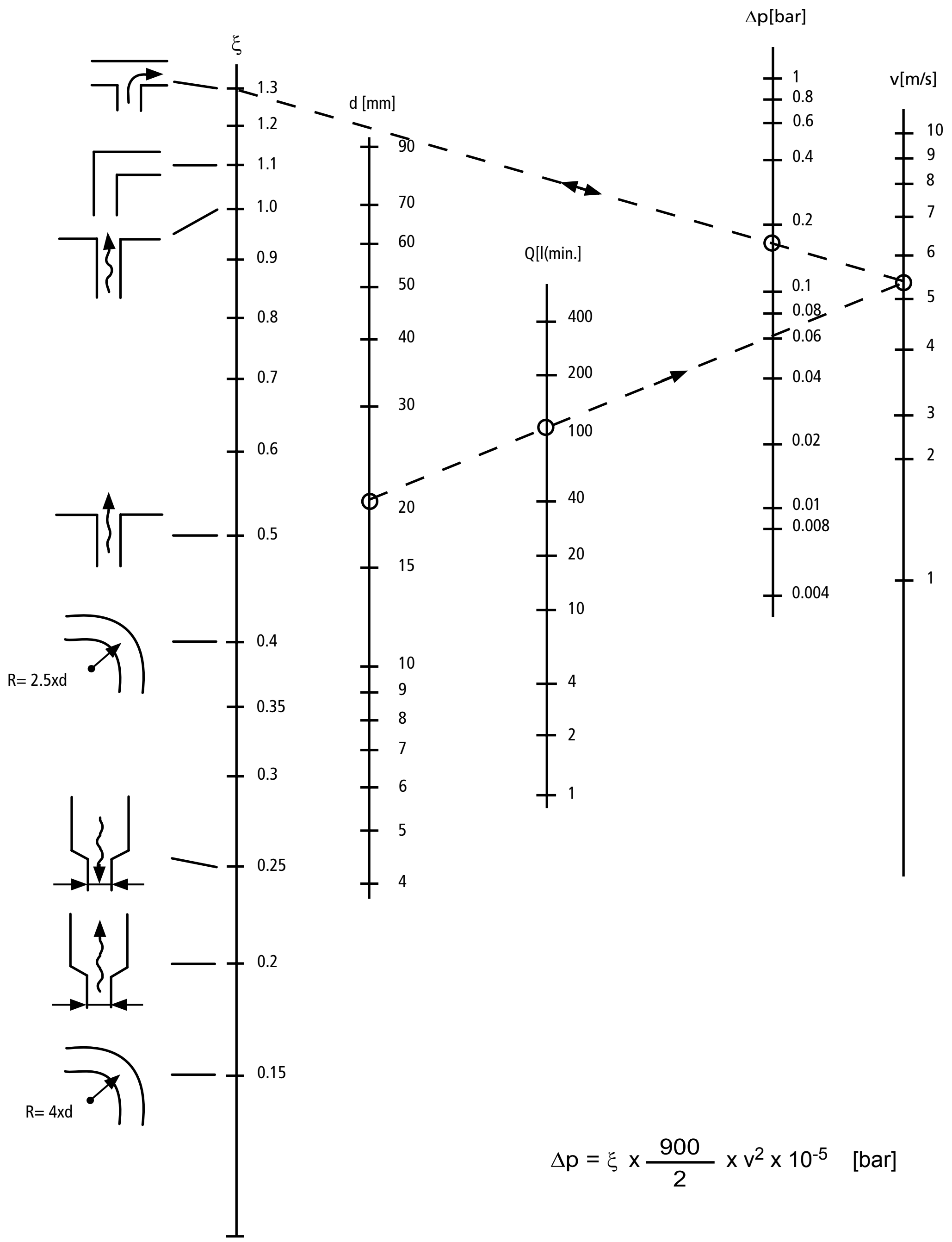
$$\Delta p \approx \sqrt{\frac{\varsigma}{\varsigma_{nomogr}}} \times \Delta p_{nomogr}$$

ς = the oil density in kg/m3.

Attachments

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

The nomographic chart apllies to turbulent flow and a density of the oil of 900 kg/m³.



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

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
ξ = 1.3
the pressure drop is Δp = 0.17 bar.

Attachments

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	4	2
6 x 1.5	1	2	1
8 x 1.0	2	9	5
8 x 1.5	2	6	4
8 x 2.0	1	3	2
8 x 2.5	1	2	1
10 x 1.0	4	15	9
10 x 1.5	3	12	7
10 x 2.0	2	9	5
10 x 2.5	2	6	4
12 x 1.5	5	19	11
12 x 2.0	4	15	9
12 x 2.5	3	12	7
14 x 1.5	7	29	17
14 x 2.0	6	24	14
15 x 1.5	9	34	20
15 x 2.0	7	29	17
16 x 1.5	10	40	24
16 x 2.0	9	34	20
16 x 2.5	7	29	17
16 x 3.0	6	24	14
18 x 1.5	14	53	32
18 x 2.0	12	46	28
20 x 2.0	16	60	36
20 x 2.5	14	53	32
20 x 3.0	12	46	28
20 x 4.0	9	34	20
22 x 1.5	22	85	51
22 x 2.0	20	76	46
22 x 2.5	18	68	41
25 x 2.0	27	104	63
25 x 2.5	25	94	57
25 x 3.0	22	85	51
25 x 4.0	18	68	41

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	136	81
28 x 2.5	32	125	75
28 x 3.0	30	114	68
30 x 2.0	41	159	96
30 x 3.0	35	136	81
30 x 4.0	30	114	68
35 x 2.0	59	226	136
35 x 3.0	52	198	119
38 x 2.5	67	257	154
38 x 3.0	63	241	145
38 x 4.0	55	212	127
38 x 5.0	48	185	111
42 x 2.0	88	340	204
42 x 3.0	79	305	183
42 x 4.0	71	272	163
50 x 3.0	119	456	274
50 x 5.0	98	377	226
56 x 8.5	93	358	215
60 x 3.0	179	687	412
60 x 5.0	153	589	353
65 x 8.5	141	543	326
66 x 8.5	147	565	339
73 x 3.0	275	1058	635
73 x 5.0	243	935	561
73 x 7.0	213	820	492
80 x 10	220	848	509
90 x 3.5	422	1622	973
90 x 5.0	392	1507	904
97 x 12	326	1255	753
115 x 4.0	701	2696	1618
115 x 15	442	17016	1021
130 x 15	612	2355	1413
140 x 4.5	1051	4041	2425
150 x 15	882	3391	2035
165 x 5.0	1471	5658	3395
220 x 6.0	2649	10189	6113
273 x 6.0	4173	16051	9630

Attachments

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	DIN/JIC –fittings		
6X1ST37.4NBK	6	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
73X3ST37.4NBK	635	5.18	37° Flare flange	2 1/2”	140F
90X3.5ST37.4NBK	973	7.47	37° Flare flange	3”	148F
100X4ST37.4NBK	1197	9.47	37° Flare flange	3 1/2”	156F
115X4ST37.4NBK	1618	11.0	37° Flare flange	4”	164F
140X4.5ST37.4NBK	2425	15.0	37° Flare flange	5”	180F
165XST37.4NBK	3395	18.7	37° Flare flange	6”	196F
220X6ST37.4NBK	6113	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	DIN/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

Attachments

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	DIN/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
73X5ST52.4NBK	935	8.38	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	4″	456
130X15ST52.4NBK	2356	42.5	Retain ring flange	4 1/2″	860
150X15ST52.4NBK	3393	49.9	Retain ring flange	5″	864
190X20ST52.4NBK	5301	83.8	Retain ring flange	6″	880
250X25ST52.4NBK	9425	138.7	Retain ring flange	10″	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	DIN/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	4″	456

*) v = 5 m/s

Attachments

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	DIN/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
73X7ST52.4NBK	820	11.39	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	4"	456
130X15ST52.4NBK	2356	42.5	Retain ring flange	4 1/2"	860
150X15ST52.4NBK	3393	49.9	Retain ring flange	5"	864
190X20ST52.4NBK	5301	83.8	Retain ring flange	6"	880
250X25ST52.4NBK	9425	138.7	Retain ring flange	10"	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	DIN/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	4"	456

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

*) v = 5 m/s

Attachments

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	DIN/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	4"	456
130X15ST52.4NBK	2356	42.5	Retain ring flange	4 1/2""	860
150X15ST52.4NBK	3393	49.9	Retain ring flange	5"	864
190X20ST52.4NBK	5301	83.8	Retain ring flange	6"	880
250X25ST52.4NBK	9425	138.7	Retain ring flange	10"	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	DIN/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

Attachments

Attachment 3. Recommended Connection Technology

420 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	DIN/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	4”	456

420 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	DIN/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

690 bar – Section Table - Duplex Steel Pipes SAF2205 UNS S31803

Pipe	Volume Flow* [l/min]	Weight [kg/m]	Connection Type	Flange Size	Flange Type
48.3X10.15SAF2205	185	9.55	Retain ring flange	1 1/2”	924/48.3
60.3X11.07SAF2205	340	13.44	Retain ring flange	2”	932/60.3
73X14.02SAF2205	472	20.50	Retain ring flange	2 1/2”	940/73
88.9X15.24SAF2205	797	27.68	Retain ring flange	3”	948/88.9

*) v = 5 m/s

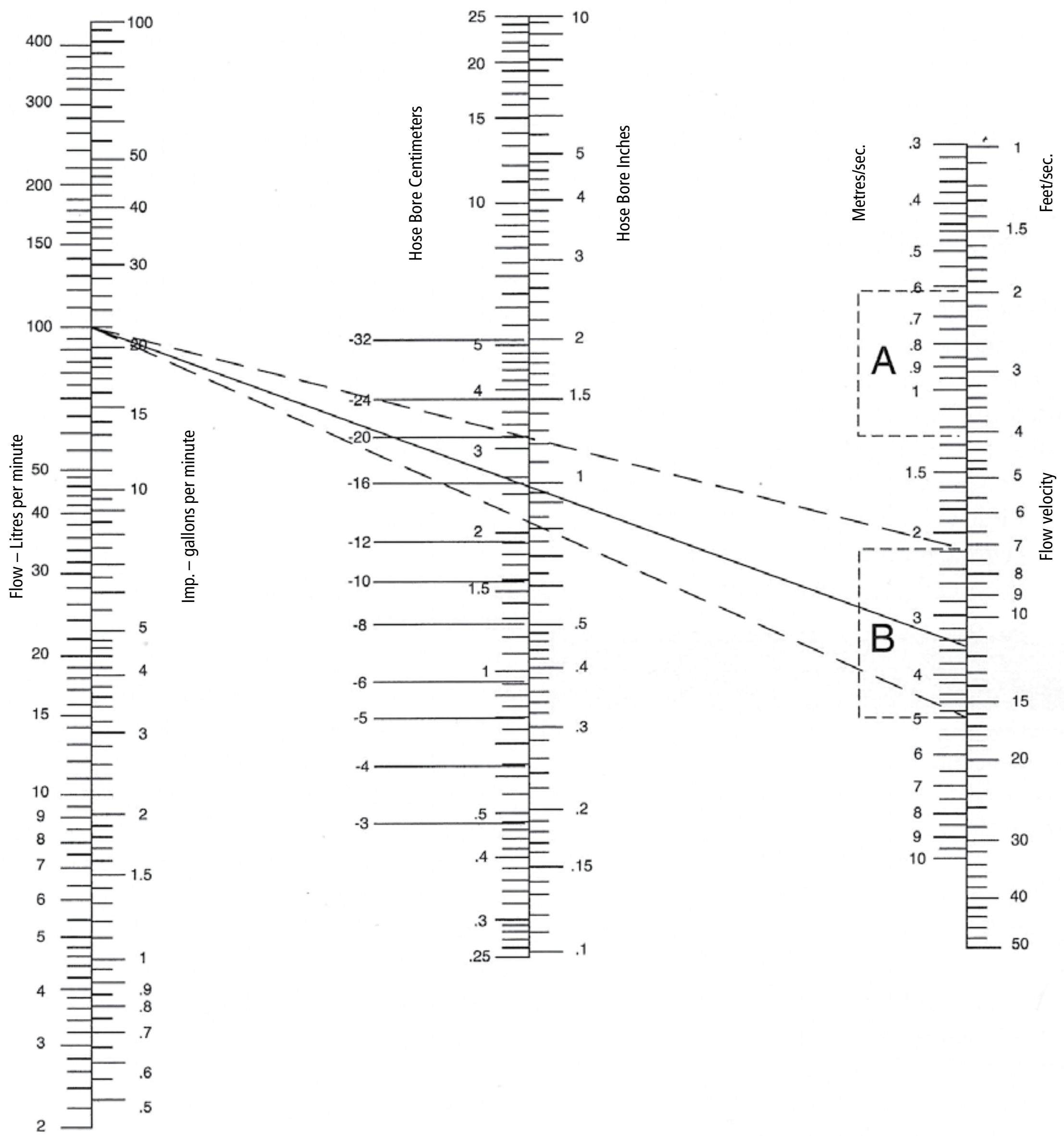
Attachments

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.



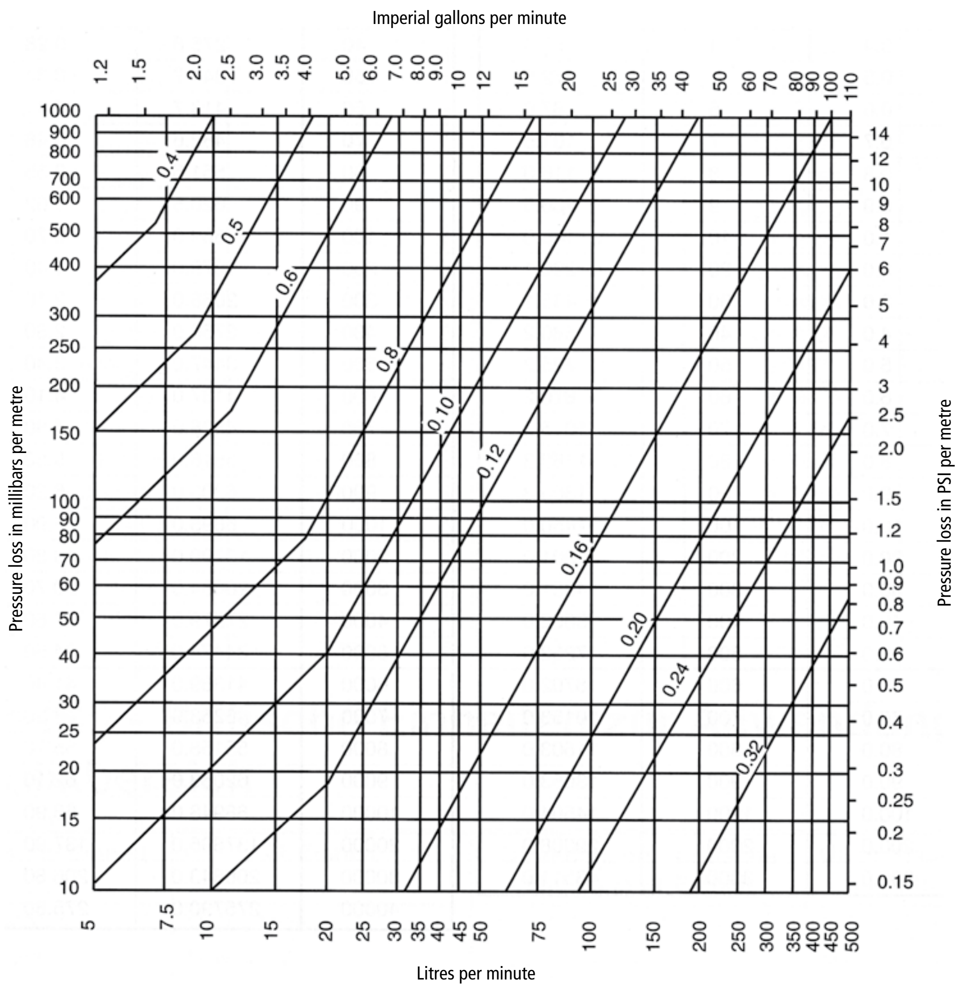
Note:
Flow velocities in range A are recommended for suction and return lines.
Flow velocities in range B are recommended for delivery lines.

Attachments

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.

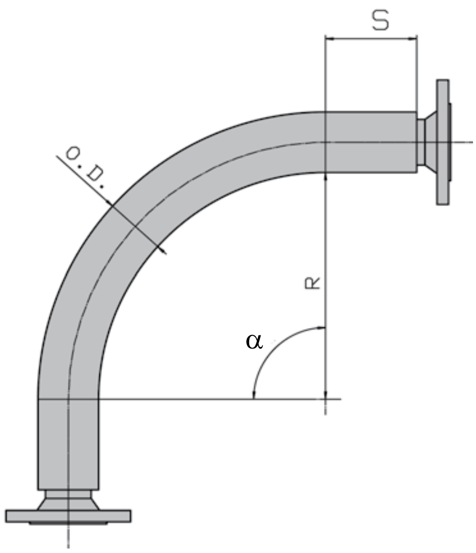
The following graph will help you to determine the amount of pressure drop.



Based on: fluid viscosity 20 cSt
specific gravity 0.875

Attachments

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

Attachments

Attachment 5. Spacing for Clamps

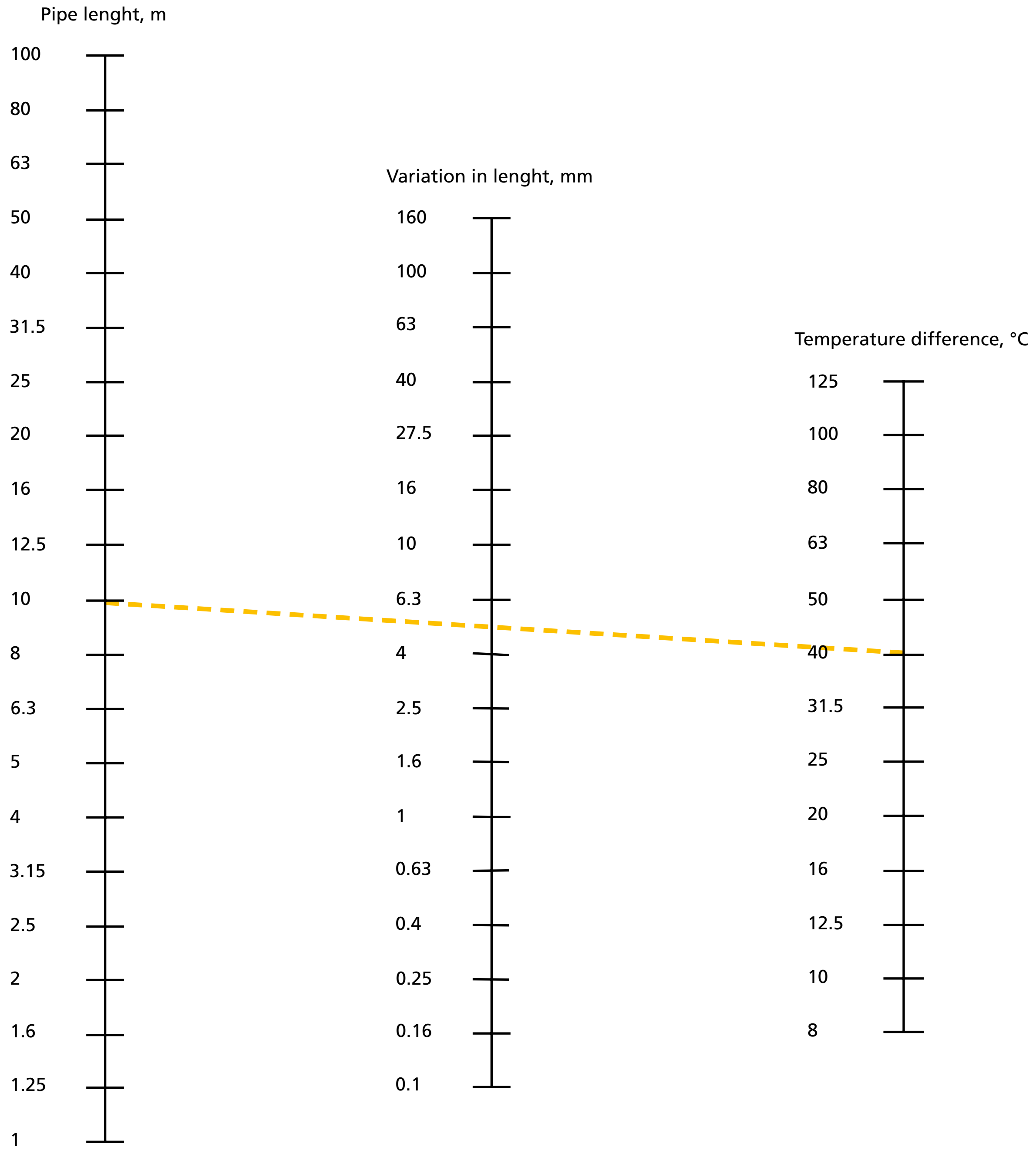
Max. distances between clamps for GS-pipes		
Pipe size [mm]	Marine hydraulics* [m]	Industrial hydraulics [m]
20 X 2	1.1	1.2
25 X 2.5	1.3	1.5
30 X 3	1.4	2.1
38 X 4	1.5	2.1
42 X 4	1.6	2.3
50 X 3	1.7	2.7
50 X 5	1.8	2.7
56 X 8.5	1.9	2.8
60 X 3	1.9	3.0
60 X 5	2.0	3.0
66 X 8.5	2.0	3.2
75 X 3	2.1	3.5
80 X 10	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).

Attachments

Attachment 6. Linear Expansion of Steel Pipes



Attachments

Attachment 7. Thread identification

Thread Identification			JIC		DIN	
O.D. [mm]	I.D. [mm]	Type of thread	Size	Pitch	Size	Pitch
7.95	6.78	5/16"UNF				
8.00	6.92	M8			04LL	1.0
9.73	8.57	1/8"BSP				
10.00	8.92	M10			06LL	1.0
10.27	8.77	1/8"NPT				
11.11	9.74	7/16"UNF	-04	20		
12.00	10.38	M12			08LL, 06L	1.0, 1.5
12.70	11.33	1/2"UNF	-05	20		
13.16	11.45	1/4"BSP				
13.57	11.31	1/4"NPT				
14.00	12.38	M14			08L, 06S	1.5
14.27	12.76	9/16"UNF	-06	18		
15.88	14.35	5/8"UNF				
16.00	14.38	M16			10L, 08S	1.5
16.66	14.95	3/8"BSP				
17.06	14.80	3/8"NPT				
18.00	16.38	M18			12L, 10S	1.5
19.05	17.33	3/4"UNF	-08	16		
20.00	18.38	M20			12S	1.5
20.96	18.63	1/2"BSP				
21.22	18.32	1/2"NPT				
22.00	20.38	M22			15L, 14S	1.5
22.23	20.26	7/8"UNF	-10	14		
22.91	20.59	5/8"BSP				
24.00	22.38	M24			16S	1.5
26.00	24.38	M26			18L	1.5
26.44	24.12	3/4"BSP				
26.57	23.67	3/4"NPT				
26.99	25.10	1 1/16"UN	-12	12		
27.00	24.83	M27				2.0
28.00	26.38	M28				2.0
30.00	27.83	M30			22L, 20S	2.0
30.16	28.20	1 3/16"UN				
30.20	27.88	7/8"BSP				
31.23	29.61	1"NPT				
33.25	30.29	1"BSP				
33.34	31.40	1 5/16"UN	-16	12		
36.00	33.83	M36			28L, 25S	2.0
41.28	39.30	1 5/8"UN	-20	12		
41.91	38.95	1 1/4"BSP				
41.99	38.95	1 1/4"NPT				
42.00	39.83	M42			30S	2.0
45.00	42.83	M45			35L	2.0
47.63	45.80	1 7/8"UN	-24	12		
47.80	44.85	1 1/2"BSP				
48.05	44.52	1 1/2"NPT				
52.00	49.83	M52			42L, 38S	2.0
59.60	56.66	2"BSP				
60.09	56.56	2"NPT				
63.50	60.80	2 1/2"UN				
65.71	62.75	2 1/4"BSP				
73.00	68.80	2 1/2"NPT				
75.18	72.23	2 1/2"BSP				
87.88	84.93	3"BSP				
89.00	85.00	3"NPT				
113.03	110.70	4"BSP				
114.35	110.38	4"NPT				

Cleanliness

Introduction – Cleanliness

The cleanliness of hydraulic piping systems is of utmost importance. Research shows that in average 80% of the operational problems of hydraulic systems are related to impurities in the system. An important cause of the impurties are the welds in a welded piping system (or when utilising welded flanges).

The oil purity is typically presented in accordance with the following standards: ISO 4406 or NAS 1638.

ISO 4406:1987 and ISO 4406:1999

Standards ISO 4406:1987 and ISO 4406:1999 define the oil purity class based on the cumulative particle count in three different particle size ranges (≥2 / ≥5 / ≥15 µm and ≥4 / ≥6 / ≥14 µm respectively). The purity class is defined for each size range based the number of particles which are of the specified size or larger. ISO 4406:1999 defines the oil purity on scale from 0-28 (:1987 is otherwise the same but class 0 is missing)

ISO 4406:1999-oil purity classes and particle count (no. of particles per 100 ml) for particle size ranges ≥4 / ≥6 / ≥14 µm

Particle count / 100 ml		ISO-class
>	≤	
130 000 000	250 000 000	28
64 000 000	130 000 000	27
32 000 000	64 000 000	26
16 000 000	32 000 000	25
8 000 000	16 000 000	24
4 000 000	8 000 000	23
2 000 000	4 000 000	22
1 000 000	2 000 000	21
500 000	1 000 000	20
250 000	500 000	19
130 000	250 000	18
64 000	130 000	17
32 000	64 000	16
16 000	32 000	15
8 000	16 000	14
4 000	8 000	13
2 000	4 000	12
1 000	2 000	11
500	1 000	10
250	500	9
130	250	8
64	130	7
32	64	6
16	32	5
8	16	4
4	8	3
2	4	2
1	2	1
0	1	0

example

ISO 4406:1999 15/13/10 is equal to :

- the no. of particles ≥4 µm corresponds to class 15 ie. 16,001–32,000 / 100 ml
- the no. of particles ≥6 µm corresponds to class 13 ie. 16,001–32,000 / 100 ml
- the no. of particles ≥14 µm corresponds to class 10 ie. 16,001–32,000 / 100 ml

Cleanliness

NAS 1638

The NAS 1638 standard utilises five (5) particle size ranges and thirteen (13) oil purity classes between 00–12. The oil purity (particle count) is measured and the oil purity class defined independently for all five size ranges. The NAS 1638 oil purity class is then given with a single figure which is the lowest (impurest) of the measured five size ranges. A more precise view of the purity is obtained if the NAS-class is provided separately for all five size ranges.

NAS 1638-oil purity classes (no. of particles per 100 ml)

Particle count / 100 ml					NAS-class
5–15 µm	15–25 µm	25–50 µm	50–100 µm	> 100 µm	
125	22	4	1	0	00
250	44	8	2	0	0
500	89	16	3	1	1
1 000	178	32	6	1	2
2 000	256	63	11	2	3
4 000	712	126	22	4	4
8 000	1 425	253	45	8	5
16 000	2 850	506	90	16	6
32 000	5 700	1 012	128	32	7
64 000	11 400	2 025	360	64	8
128 000	22 800	4 050	720	128	9
256 000	45 600	8 100	1 440	256	10
512 000	91 200	16 200	2 880	512	11
1 024 000	182 400	32 400	5 760	1 024	12

example

NAS 7 is equal to (for instance):

- the no. of particles 5–15 µm is 25,000/100 ml
- the no. of particles 15–25 µm is 1,400/100 ml
- the no. of particles 25–50 µm is 63/100 ml
- the no. of particles 50–100 µm is 45/100 ml
- the no. of particles > 100 µm is 4/100 ml

Cleanliness

SAE AS4059

The SAE AS4059-standard is based on the NAS 1638-standard. The SAE AS4059-standard utilises particle sizes defined in the ISO 11171-standard. The oil purity class is based on the cumulative particle count (in a similar fashion as in the ISO-4406 standard).

SAE AS4059 oil purity classes (no. of particles per 100 ml)

Particle count / 100 ml						AS4059-class
> 4 µm A	> 6 µm B	> 14 µm C	> 21 µm D	> 38 µm E	> 70 µm F	
195	76	14	3	1	0	000
390	152	27	5	1	0	00
780	304	54	10	2	0	0
1 560	609	109	20	4	1	1
3 120	1 220	217	39	7	1	2
6 250	2 430	432	76	13	2	3
12 500	4 860	864	152	26	4	4
25 000	9 730	1 730	306	53	8	5
50 000	19 500	3 460	612	106	16	6
100 000	38 900	6 920	1 220	212	32	7
200 000	77 900	13 900	2 450	424	64	8
400 000	156 000	27 700	4 900	848	128	9
800 000	311 000	55 400	9 800	1 700	256	10
1 600 000	623 000	111 000	19 600	3 390	512	11
3 200 000	1 250 000	222 000	39 200	6 780	1 020	12

example

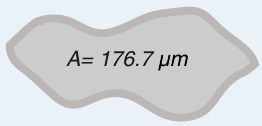
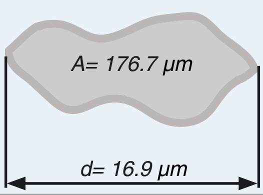
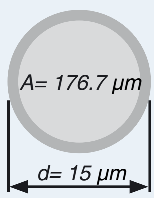
According to the SAE AS4506-standard the oil purity can be defined:

- with a single class; for instance 6 or 6B
- with a independent class for each size; for instance 6B/5C/4D/3E
- with the maximum oil purity class of a larger range; for instance 6 B-F

The oil purity is dependent on the application and equipment. All manufacturer's have their own recommendations for their own, specific equipment and machinery. The following table provides the general guidelines for various types of hydraulic systems as well as a comparison between the various standards.

	ISO 4406: 1987 (ACFTD) ≥2 / ≥5 / ≥15 µm	ISO 4406: 1999 ≥4 / ≥6 / ≥14 (c) µm	NAS 1638
Servosystems	(17)/13/10	18/13/10	NAS 4
Proportional systems	(18)/15/12	20/15/12	NAS 6
Other systems	(19)/16/13	22/16/13	NAS 7

According to the ISO 4402-standard the size of an ACFT-particle is defined in accordance with the maximum dimension of the particle. In the newer ISO 11171-standard the ISO MTD particle size is defined as the diameter of a circle with the same area (as the actual particle). The designation 'c' (certified) is utilised to identify the particle size.

Particle		
Standard	ACFTD ISO 4402 (1991)	ISO MTD ISO 11171 (1999)
Definition of particle size		
Particle size	16.9 µm	15 µm (c)