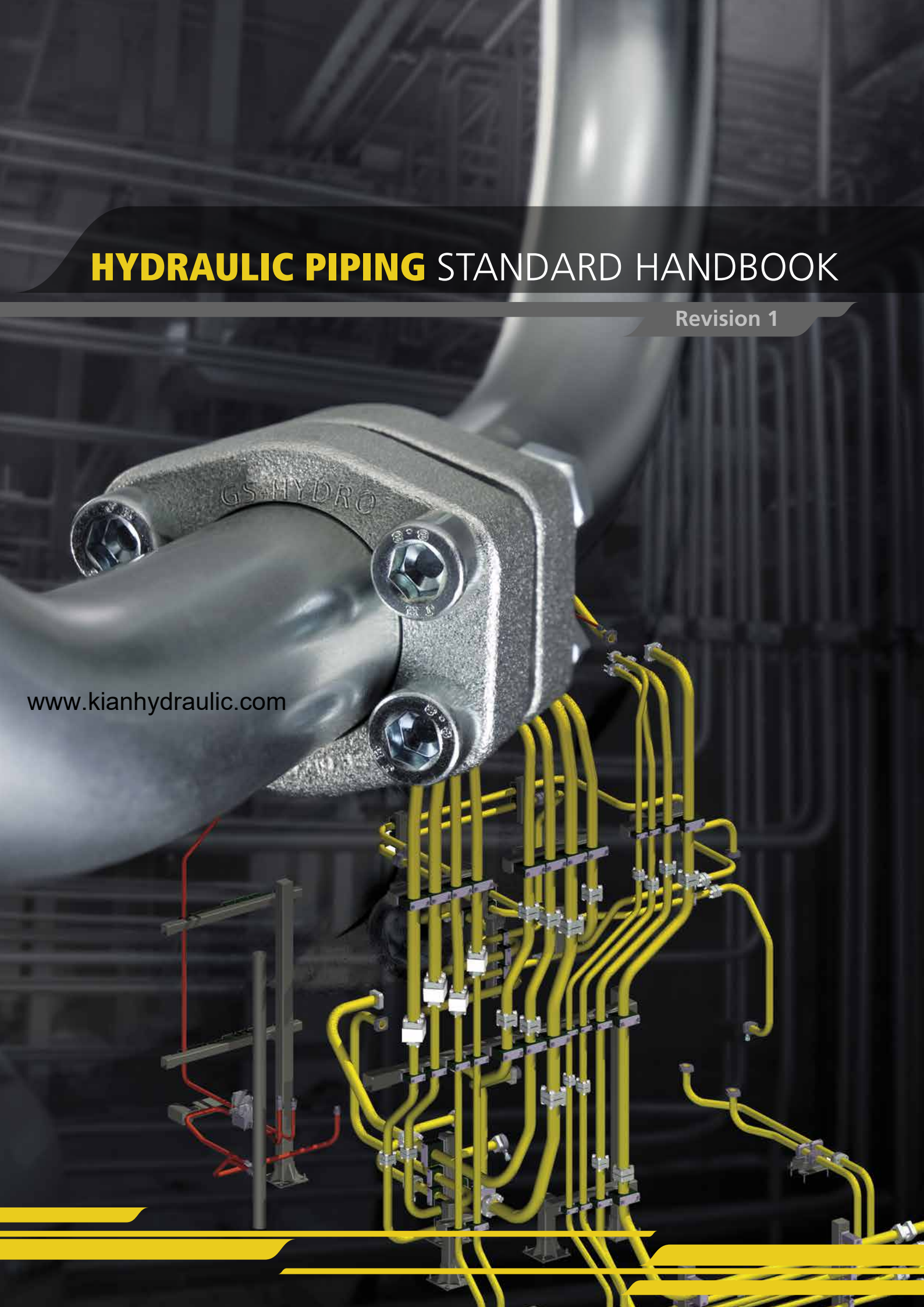
HYDRAULIC PIPING STANDARD HANDBOOK

Revision 1



www.kianhydraulic.com

Preface

We aim to fill a gap in technical literature. At this moment there are no hydraulic piping standards available which cover different pressure classes and piping materials as well as being generally suited for all applications. The authors of this Handbook have several decades of experience in hundreds of non-welded piping projects all over the world in segments such as offshore, marine, steel, mining and testing (just to mention a few).

Hydraulic Piping Standard Handbook is intended for professionals working within industries where hydraulic piping is used. This Handbook offers relevant information in one package for anyone installing or using non-welded hydraulic piping systems.

This Handbook gives easy-to-use guidelines and compiles all relevant information in one place instead of having to look it up from several different sources. One of the main advantages in this Handbook is the standardization of piping classes which enables the reduction of pipe sizes/wall thicknesses as well as components. This Handbook contains information and standards that assist in the engineering process of a non-welded piping system through non-welded hydraulic piping standards, recognized Marine Classification Societies' main rules, relevant technical guidelines and hydraulic symbols.

We appreciate your assistance in perfecting this Handbook. Please send any suggestions or possible corrections to info@gshydro.com. Please specify in the subject field "Hydraulic Piping Standard Handbook". Thank you!

Disclamer

In the professional judgment of GS-Hydro, the accuracy and level of detail of the information presented in this Handbook are suitable for use by professional users with the required expertise and experience. The information is believed to be correct at time of release of this edition of the Handbook. However, correct use of this Handbook and verification of relevant information for the job at hand is the responsibility of the user.

GS-Hydro is not responsible for any direct or indirect damage caused by possible mistakes or the wrong application of the information. The latest rules and instructions must always be checked to ensure the safety of the people, equipment and environment involved. GS-Hydro prohibits reproduction and distribution of this material for use by third parties or for commercial gain.

Content

Preface 3
Disclaimer 5
Content 7
How to Use this Handbook 8

1. Piping Standards 11
    Carbon Steel Piping: 16 bar - 420 bar 13
    Stainless Steel Piping, AISI: 16 bar - 420 bar 37
    Stainless Steel Piping, Ice Class -50°C: 16 bar - 420 bar 61

2. Relevant Rules and Guidelines from Classification Societies 85
    American Bureau of Shipping 87
    Det Norske Veritas 105
    Germanischer Lloyd 115
    Lloyd's Register 135

3. Flushing and Pressure Testing Procedure 153
    General Guidelines for Pressure Testing and Flushing of Hydraulic Systems . 154
    Pressure Testing 156
    Flushing 159
    Schematics Instructions 164

4. Useful Technical Information 167
    Piping System Design 168
        General 168
        Fluid (Oil) Velocities 170
        Pressure Loss 171
    Mechanical Design 171
        Pipe and Tube Materials 171
        Fitting and Flanges 172
        Hoses and Hose Couplings 173
        Pipe Supports 174
    Cleanliness 174
        ISO 4406:1987 and ISO 4406:1999 175
        NAS 1638 176
        SAE AS4059 176
    Attachments 177

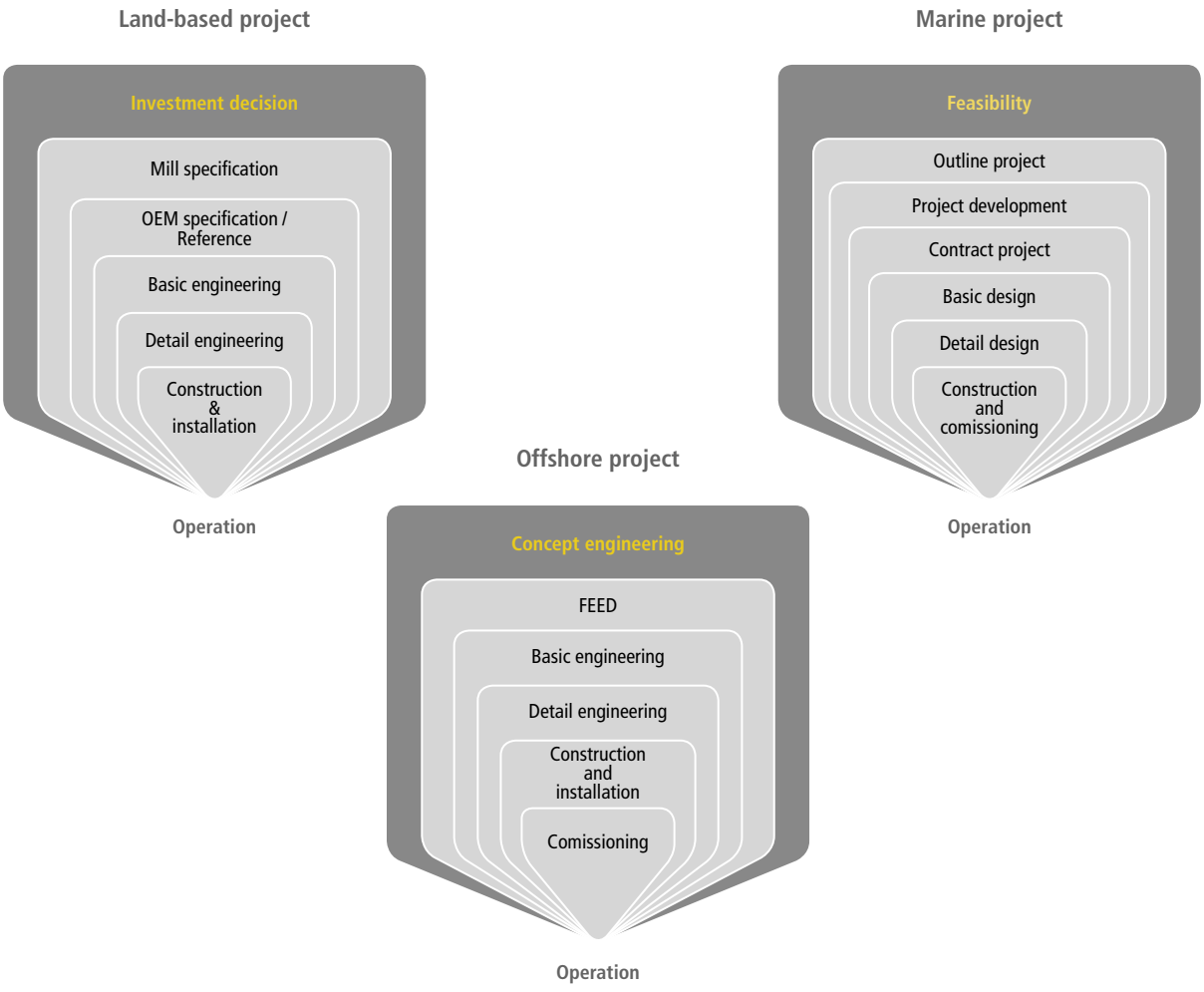
5. Hydraulic Symbols 189

How to use this handbook

Hydraulic Piping Standard Handbook is a compilation of standards and information which is useful when engineering hydraulic piping systems. This Handbook offers information and guidelines according to international standards and Classification Societies' rules which are meant to assist in the standardization of hydraulic piping as well as to act as the foundation for project detail engineering.

Understanding Projects

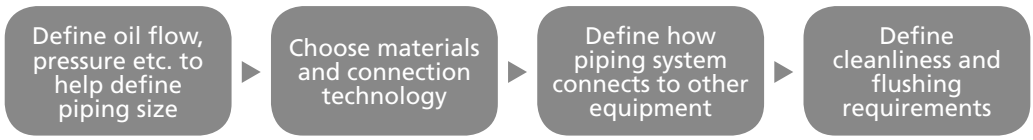
It is important to understand the basics of project business, in other words, the processes behind every project in the offshore, marine and land-based businesses. Below are presented three different project types in simplified steps.



From a hydraulic piping viewpoint the most important issue in every project is the basic engineering which involves making decisions on how the project will be executed later on (such as detail design, installation and commissioning). Even in a basic design stage, clear and exact decisions are critical for the success of the next project stage. If basic design is done in a very light or unclear manner there will be difficulties later on when these decisions and technical specifications need to be followed.

One of the main goals of this Handbook is to assist in the basic engineering or basic design. Very detailed information is needed to execute the basic engineering in a way that will create success in the later stages of detail engineering, installation and commission.

For the project input phase, basic engineering for hydraulic piping is based on the following simplified steps:



Next comes detail engineering which determines the detail level of final pipe routing, material, components etc.

The Hydraulic Piping Standard Handbook assists in the above mentioned engineering process by providing relevant information and standards for this project input phase. This is when the piping requirements are defined such as desired working pressure, maximum pressure, maximum flow rate, acceptable pressure drops and classification requirements.

Piping standards - Chapter 1

Piping standards are based on three different conditions:
- Normal dry indoor conditions (carbon steel)
- High humidity outdoor conditions (stainless steel)
- Ice conditions -50 °C (stainless steel)

Pipe sizes are standardized to reduce the numbers of pipe sizes. The tables give basic information for normal standard pipe sizes with flow and pressure. All pipe sizes have been matched with a recommended non-welded connection technology while fulfilling Classification Society Standards. The chosen seals, valves and hose-assemblies are the ones that are most commonly used. In high humidity outdoor conditions with high pressure (>315 bar) and large pipe sizes (>4") duplex or superduplex piping material can alternatively be used (this is intentionally not covered in this Handbook). Their use should be considered separately each time (take into consideration the application, material and manufacturing method).

Rules and guidelines for hydraulic piping from corresponding Classification Societies – Chapter 2

This presents a selection of the main rules from four Marine Classification Societies (American Bureau of Shipping, Det Norske Veritas, Germanischer Lloyd, Lloyd's Register). It gives a basic understanding of the main rules and guidelines for hydraulic piping which need to be considered in the piping project. The authors do not have any liability for context or possible changes to the rules so it is assumed that the reader always checks for the latest updates directly from the Classification Societies.

Flushing and pressure testing – Chapter 3

Flushing is a critical step in the hydraulic piping procedure as it ensures the cleanliness of the piping. Given the variety of hydraulic systems, it is important that the relevant professionals are present at a very early stage to set the right goals for the level of purity. The desired level of purity can be influenced e.g. by different types of valves (proportional or servo valves), pumps, cylinders, motors, and oil viscosity.

Useful technical information – Chapter 4

An overview of the most important issues involved in hydraulic piping design and installation.

Hydraulic symbols – Chapter 5

Basic symbols used in hydraulic engineering including those according to SMS and Cetop.

www.kianhydraulic.com

Piping Standards

Carbon Steel Piping: 16 bar - 420 bar 13
Stainless Steel Piping, AISI: 16 bar - 420 bar 37
Stainless Steel Piping, Ice Class –50°C : 16 bar – 420 bar 61

Carbon Steel Piping: 16 bar - 420 bar

Basic Connection Table 15
Carbon Steel 16 bar / 250 Psi 16
Carbon Steel 50 bar / 750 Psi 18
Carbon Steel 150 bar / 2250 Psi 20
Carbon Steel 210 bar / 3000 Psi 22
Carbon Steel 250 bar / 3600 Psi 24
Carbon Steel 280 bar / 4000 Psi 26
Carbon Steel 315 bar / 4500 Psi 28
Carbon Steel 350 bar / 5000 Psi 30
Carbon Steel 380 bar / 5500 Psi 32
Carbon Steel 420 bar / 6000 Psi 34

Basic Connection Table

EF = End forming
37 = 37°-Flaring
RR = Retain Ring Flange

PRESSURE [BAR]	⅛″	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″	8″	10″
420	EF	EF	37	37	37	37	RR	RR	RR							
380	EF	EF	37	37	37	37	RR	RR	RR	RR	RR	RR				
350	EF	EF	37	37	37	37	RR	RR	RR	RR	RR	RR	RR	RR		
315	EF	EF	EF	EF	37	37	RR	37	RR	RR	RR	RR	RR	RR	RR	
280	EF	EF	EF	EF	37	37	37	37	37	37	RR	RR	RR	RR	RR	RR
250	EF	EF	EF	EF	EF	37	37	37	37	37	RR	RR	RR	RR	RR	RR
210	EF	EF	EF	EF	EF	37	37	37	37	37	RR	RR	RR	RR	RR	RR
150	EF	EF	EF	EF	EF	37	37	37	37	37	37	RR	RR	RR	RR	RR
50	EF	EF	EF	EF	EF	37	37	37	37	37	37	37	37	37	37	37
16	EF	EF	EF	EF	EF	37	37	37	37	37	37	37	37	37	37	37

PIPE SIZE

Carbon Steel 16 bar / 250 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0,3 mm**	**16 bar / 250 Psi**	**GSCS01-01**	**1**
Pipe standard:	**E235N (St 37.4 NBK) to DIN 2391C (EN10305-4)**	Tensile strength min 340 N/mm²	Yield strength min 235 N/mm²	Elongation at break min. 25 %	
	E355N (St 52.4 NBK) to DIN 2391C (EN10305-4)	Tensile strength min 490 N/mm²	Yield strength min 355 N/mm²	Elongation at break min. 22 %	

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	**10**	**12**	**15**	**18**	**22**	**28**	**35**	**42**	**50**
Wall thickness [mm]	**1,5**	**1,5**	**2**	**2**	**2**	**2**	**3**	**3**	**3**
Material	**E235N**	**E235N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E235N**
Flow (v=3 m/s) [l/min]	**6,93**	**11,45**	**17,11**	**27,71**	**45,78**	**81,39**	**118,89**	**183,12**	**273,56**
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
NPS/ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	**60**	**73**	**90**	**115**	**140**	**165**	**220**	**273**
Wall thickness [mm]	**3**	**3**	**3,5**	**4**	**4,5**	**5**	**6**	**6**
Material	**E235N**	**E235N**	**E235N**	**E235N**	**E235N**	**E235N**	**E235N**	**E235N**
Flow (v=3 m/s) [l/min]	**412,03**	**634,3**	**973,91**	**1617,74**	**2424,85**	**3394,73**	**6113,2**	**9625,5**
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3	219,1	273
NPS/ASME B36.19M-2004	2"	2 1/2"	3"	4"	5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30	219,10	273,00

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–22 mm	Male stud	GE	10–22		1/4"– 3/4"	L-Series	ISO 8434-1 (DIN 2353)	C15S10 / 1.0718	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–22 mm – 37°-flaring O.D. 28–273 mm
	Straight union	G							
	Reducer straight union	GR							
	Union T	T							
	Union elbow	W							
	Union cross	K							
	Union Weld bulkhead	ESV							
	Union bulkhead	SV							
	Reducer	RED							
	Thread reducer	RI							
	Blanking plug	VSTI							
Pipe O.D. 28–42 mm	Flange connection	3xx/ODxWt	28–42	3/4"–1 1/4"	1/4"– 2"	SAE 3000 Psi	ISO 6162-1 (SAE J 518 Code 61)	P355N / S355J (EN10305-4)	
	Male thread flange	3xx014							
	Elbow block	3xx115							
	Tee block	3xx116							
	Reducer tee block	3xx/3xx/3xx116							
	Flange bend	3xx018							
	Bulkhead flange	3xx019							
	Reducer flange	RF3xx-3xx							
	Reducer block	RBE3xx-3xx							
	Blind flange	3xx125							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 50–273 mm	Flange connection	1xx/ODxWt	50–273	1 1/2 –10"	1 1/2"–2"	SAE 50 bar	ISO 6162-1 (SAE J 518 Code 61)	P355N / S355J (EN10305-4)	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–22 mm – 37°-flaring O.D. 28–273 mm
	Elbow block	1xx115							
	Tee block	1xx116							
	Reducer tee block	1xx/1xx/1xx116							
	Flange bend	1xx018							
	Bulkhead flange	1xx019							
	Reducer flange	RF1xx-1xx							
	Reducer block	RBE1xx-1xx							
	Blind flange	1xx125							
Bolt	Hexagon head bolt		28–273				DIN 912 / ASME B/8.2.2	8.8 electro galvanized	
Nut	Hexagon nut		28–273				DIN 934 / ASME B/8.2.2	8. electro galvanized	
Gasket			10–22					FPM (Viton®)	
			28–42				Bonded Seal	Steel and Perbunan	
			50–273				O-Ring	NBR	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S Series (Heavy)	DIN 3015	Polypropylene & St37	
Hose	1/4"–2"	G1 / GS1T		1/4"–2"			EN 853 1 SN / SAE 100 R1AT / ISO 1436-1 / SN	Synthetic rubber	
Hose fittings	1/4"–3/4"	G- / GSP-series P-series			1/4"–3/4"	L-series	ISO 12151-2	C15S10 / 1.0718	
	1"–2"					SAE 3000 Psi (SAE J 518 Code 61)	ISO 12151-3		

*) xx=components size code

08	12	16	20	24	32	40	48	56	64	80	96	note: 8"=228xx 10"=260xx
1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	3 3/4"	4"	5"	6"	

Branch connections

RUN SIZE	¼"	⅜"	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	4"	5"	6"	8"	10"
½"	T-DIN	T-DIN	T-DIN												
¾"	T-DIN	T-DIN	T-DIN	T-DIN											
1"	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN										
1¼"	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP									
1½"	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL								
2"	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL							
2½"	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL						
3"	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL					
4"	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
5"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL			
6"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL		
8"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL	
10"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	BL	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1

TE = Tee or Reduction Tee Flange

BL = Tee or Reduction Tee Block

BLBSP = Reduction Tee Block BSP

TBN = Reduction Tee Between BSP thread

Carbon Steel 50 bar / 750 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0,3 mm**	**50 bar / 750 Psi**	**GSCS01-02**	**1**
Pipe standard:	**E235N (St 37.4 NBK) to DIN 2391C (EN10305-4)**	Tensile strength min 340 N/mm²	Yield strength min 235 N/mm²	Elongation at break min. 25 %	
	E355N (St 52.4 NBK) to DIN 2391C (EN10305-4)	Tensile strength min 490 N/mm²	Yield strength min 355 N/mm²	Elongation at break min. 22 %	

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	**10**	**12**	**15**	**18**	**22**	**28**	**35**	**42**	**50**
Wall thickness [mm]	**1,5**	**1,5**	**2**	**2**	**2**	**2**	**3**	**3**	**3**
Material	**E235N**	**E235N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E235N**
Flow (v=5 m/s) [l/min]	**11,54**	**19,08**	**28,5**	**46,16**	**76,3**	**135,65**	**198,06**	**305,21**	**455,93**
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
NPS/ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	**60**	**73**	**90**	**115**	**140**	**165**	**220**
Wall thickness [mm]	**3**	**3**	**3,5**	**4**	**4,5**	**5**	**6**
Material	**E235N**	**E235N**	**E235N**	**E235N**	**E235N**	**E235N**	**E235N**
Flow (v=5 m/s) [l/min]	**686,72**	**1 057,16**	**1 622,36**	**2 646,08**	**4 041,42**	**5 657,89**	**10 188,67**
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3	219,1
NPS/ASME B36.19M-2004	2"	2 1/2"	3"	4"	5"	6"	8"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30	219,10

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–22 mm	Male stud	GE	10–22		1/4"–3/4"	L-Series	ISO 8434-1 (DIN 2353)	C15S10 / 1.0718	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–22 mm – 37°-flaring O.D. 28–220 mm
	Straight union	G							
	Reducer straight union	GR							
	Union T	T							
	Union elbow	W							
	Union cross	K							
	Union Weld bulkhead	ESV							
	Union bulkhead	SV							
	Reducer	RED							
	Thread reducer	RI							
	Blanking plug	VSTI							
Pipe O.D. 28–42 mm	Flange connection	3xx/ODxWt	28–42	3/4"–1 1/4"	1/4"–2"	SAE 3000 Psi	ISO 6162-1 (SAE J 518 Code 61)	P355N / S355J (EN10305-4)	
	Male thread flange	3xx014							
	Elbow block	3xx115							
	Tee block	3xx116							
	Reducer tee block	3xx/3xx/3xx116							
	Flange bend	3xx018							
	Bulkhead flange	3xx019							
	Reducer flange	RF3xx-3xx							
	Reducer block	RBE3xx-3xx							
	Blind flange	3xx125							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 50–220 mm	Flange connection	1xx/ODxWt	50–220	1 1/2–8″	1 1/2″–2″	SAE 50 bar	ISO 6162-1 (SAE J 518 Code 61)	P355N / S355J (EN10305-4)	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10 – 22 mm – 37°-flaring O.D. 28 – 220 mm
	Elbow block	1xx115							
	Tee block	1xx116							
	Reducer tee block	1xx/1xx/1xx116							
	Flange bend	1xx018							
	Bulkhead flange	1xx019							
	Reducer flange	RF1xx-1xx							
	Reducer block	RBE1xx-1xx							
	Blind flange	1xx125							
Bolt	Hexagon head bolt		28–220				DIN 912 / ASME B/8.2.2	8.8 electro galvanized	
Nut	Hexagon nut		28–220				DIN 934 / ASME B/8.2.2	8. electro galvanized	
Gasket			10–22					FPM (Viton®)	
			28–42				Bonded Seal	Steel and Perbunan	
			50–220				O-Ring	NBR	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–220			S Series (Heavy)	DIN 3015	Polypropylene & St37	
Hose	1/4″–2″	G1 / GS1T		1/4″–2″			EN 853 1 SN / SAE 100 R1AT / ISO 1436-1 / SN	Synthetic rubber	
Hose fittings	1/4″–3/4″	G- / GSP-series P-series			1/4″–3/4″	L-series	ISO 12151-2	C15S10 / 1.0718	
	1″–2″					SAE 3000 Psi (SAE J 518 Code 61)	ISO 12151-3		

*) xx=components size code

08	12	16	20	24	32	40	48	56	64	80	96	note: 8"=228xx
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	3 3/4″	4″	5″	6″	

Branch connections

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

RUN SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″	8″
½″	T-DIN	T-DIN	T-DIN											
¾″	T-DIN	T-DIN	T-DIN	T-DIN										
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN									
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP								
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL							
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL						
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL					
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL			
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL		
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL	
8″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL

BRANCH SIZE

Carbon Steel 150 bar / 2250 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0,3 mm**	**150 bar / 2250 Psi**	**GSCS01-03**	**1**
Pipe standard:	**E235N (St 37.4 NBK) to DIN 2391C (EN10305-4)**	Tensile strength min 340 N/mm²	Yield strength min 235 N/mm²	Elongation at break min. 25 %	
	E355N (St 52.4 NBK) to DIN 2391C (EN10305-4)	Tensile strength min 490 N/mm²	Yield strength min 355 N/mm²	Elongation at break min. 22 %	

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	**10**	**12**	**16**	**20**	**25**	**30**	**38**	**42**	**50**
Wall thickness [mm]	**1,5**	**1,5**	**2**	**2,5**	**2,5**	**3**	**4**	**4**	**5**
Material	**E235N**	**E235N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**
Flow (v=5 m/s) [l/min]	**11,54**	**19,08**	**33,91**	**52,99**	**94,2**	**135,65**	**211,95**	**272,24**	**376,8**
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
NPS/ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	**60**	**73**	**90**	**115**	**130**	**150**	**190**	**250**	**273**
Wall thickness [mm]	**5**	**5**	**5**	**15**	**15**	**15**	**20**	**25**	**25**
Material	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**
Flow (v=5 m/s) [l/min]	**589,05**	**995,49**	**1 507,96**	**1 701,49**	**2 355,00**	**3 391,20**	**5 298,75**	**9 420,00**	**11 711,18**
Nominal diameter	DN 50	DN 65	DN 80	DN 100		DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3		139,3	168,3	219,1	273
NPS/ASME B36.19M-2004	2"	2 1/2"	3"	4"		5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30		141,3	168,30	219,10	273,0

Item		**Type**	**Pipe Size [mm]**	**Pipe Size [in]**	**Thread size BSP [in]**	**Class**	**Standard**	**Material**	**Connection Technology**
Pipe O.D. 10–25 mm	Male stud	GE	10–25		3/8"–1"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	C15S10 / 1.0718	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–90 mm – Retain Ring O.D. 115–273 mm
	Straight union	G							
	Reducer straight union	GR							
	Union T	T							
	Union elbow	W							
	Union cross	K							
	Union Weld bulkhead	ESV							
	Union bulkhead	SV							
	Reducer	RED							
	Thread reducer	RI							
	Blanking plug	VSTI							
Pipe O.D. 30–90 mm	Flange connection	3xx/ODxWt	30–90	1"–3"	1"–2"	SAE 3000 Psi	ISO 6162-1 (SAE J 518 Code 61)	P355N / S355J (EN10305-4)	
	Male thread flange	3xx014							
	Elbow block	3xx115							
	Tee block	3xx116							
	Reducer tee block	3xx/3xx/3xx116							
	Flange bend	3xx018							
	Bulkhead flange	3xx019							
	Reducer flange	RF3xx-3xx							
	Reducer block	RBE3xx-3xx							
	Blind flange	3xx125							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 115 mm	Flange connection	4xx	115	4″	1 1/2″–2″	400-series (350-400 bar)	ISO 6164	P355N / S355J (EN10305-4)	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–90 mm – Retain Ring O.D. 115–273 mm
	Elbow block	4xx115							
	Tee block	4xx116							
	Reducer tee block	4xx/4xx/4xx116							
	Flange bend	4xx018							
	Bulkhead flange	4xx019							
	Reducer flange	RF4xx-4xx							
	Reducer block	RBE4xx-4xx							
	Blind flange	4xx125							
Pipe O.D. 130–250 mm	Flange connection	8xx	130–273	41/2″–10″		800-series (350-400 bar)			
	Elbow block	8xx115							
	Tee block	8xx116							
	Reducer tee block	8xx/8xx/8xx116							
	Flange bend	8xx018							
	Bulkhead flange	8xx019							
	Reducer flange	RF8xx-8xx							
	Reducer block	RBE8xx-8xx							
	Blind flange	8xx125							
Bolt	Hexagon head bolt		30–273				DIN 912 / ASME B/8.2.2	8.8 electro galvanized	
Nut	Hexagon nut		30–273				DIN 934 / ASME B/8.2.2	8. electro galvanized	
Gasket			10–25					FPM (Viton®)	
			30–273				Bonded Seal	Steel and Perbunan	
			10–273				DIN 3015	Polypropylene & St37	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S-Series (Heavy)	DIN 3015	Polypropylene & St37	
Hose	1/4″–1″	M3K GS2C		1/4″–1″			EN 857 1SC EN 857 2SC	Synthetic rubber	
	11/4″–2″	EFG3K GS4SH		11/4″–2″			EN 856 R12 / EN 856 4SH		
Hose fittings	1/4″–1″	G- / P-series			1/4″–1″	S-Series (Heavy)	ISO 12151-2	C15S10 / 1.0718	
	11/4″–2″	GSP / GSH / I-series				SAE 3000 Psi (SAE J 518 Code 61)	ISO 12151-3		

*) xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″	8″	10″
½″	T-DIN	T-DIN	T-DIN												
¾″	T-DIN	T-DIN	T-DIN	T-DIN											
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN										
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP									
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL								
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL							
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL						
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL					
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL			
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL		
8″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL	
10″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	BL	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1

TE = Tee or Reduction Tee Flange

BL = Tee or Reduction Tee Block

BLBSP = Reduction Tee Block BSP

TBN = Reduction Tee Between BSP thread

Carbon Steel 210 bar / 3000 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0,3 mm**	**210 bar / 3000 Psi**	**GSCS01-04**	**1**
Pipe standard:	**E235N (St 37.4 NBK) to DIN 2391C (EN10305-4)**	Tensile strength min 340 N/mm²	Yield strength min 235 N/mm²	Elongation at break min. 25 %	
	E355N (St 52.4 NBK) to DIN 2391C (EN10305-4)	Tensile strength min 490 N/mm²	Yield strength min 355 N/mm²	Elongation at break min. 22 %	

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	**10**	**12**	**16**	**20**	**25**	**30**	**38**	**42**	**50**
Wall thickness [mm]	**2**	**2**	**2**	**2,5**	**2,5**	**3**	**4**	**4**	**5**
Material	**E235N**	**E235N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**
Flow (v=5 m/s) [l/min]	**8,48**	**15,07**	**33,91**	**52,99**	**94,2**	**135,65**	**211,95**	**272,24**	**376,8**
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
NPS/ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	**60**	**73**	**97**	**115**	**130**	**150**	**190**	**250**	**273**
Wall thickness [mm]	**5**	**7**	**12**	**15**	**15**	**15**	**20**	**25**	**25**
Material	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**
Flow (v=5 m/s) [l/min]	**588,75**	**819,78**	**1 254,98**	**1 701,49**	**2 355,00**	**3 391,20**	**5 298,75**	**9 420,00**	**11 711,18**
Nominal diameter	DN 50	DN 65	DN 80	DN 100		DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3		139,3	168,3	219,1	273
NPS/ASME B36.19M-2004	2"	2 1/2"	3"	4"		5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30		141,3	168,30	219,10	273,0

Item		**Type**	**Pipe Size [mm]**	**Pipe Size [in]**	**Thread size BSP [in]**	**Class**	**Standard**	**Material**	**Connection Technology**
Pipe O.D. 10–25 mm	Male stud	GE	10–25		3/8"–1"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	C15S10 / 1.0718	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–73 mm – Retain Ring O.D. 97–250 mm
	Straight union	G							
	Reducer straight union	GR							
	Union T	T							
	Union elbow	W							
	Union cross	K							
	Union Weld bulkhead	ESV							
	Union bulkhead	SV							
	Reducer	RED							
	Thread reducer	RI							
	Blanking plug	VSTI							
Pipe O.D. 30–73 mm	Flange connection	3xx/ODxWt	30–73	1"–21/2"	1"–2"	SAE 3000 Psi	ISO 6162-1 (SAE J 518 Code 61)	P355N / S355J (EN10305-4)	
	Male thread flange	3xx014							
	Elbow block	3xx115							
	Tee block	3xx116							
	Reducer tee block	3xx/3xx/3xx116							
	Flange bend	3xx018							
	Bulkhead flange	3xx019							
	Reducer flange	RF3xx-3xx							
	Reducer block	RBE3xx-3xx							
	Blind flange	3xx125							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 97–115 mm	Flange connection	4xx	97–115	3–4″	1 1/2″–2″	400-series (350–400 bar)	ISO 6164	P355N / S355J (EN10305-4)	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–73 mm – Retain Ring O.D. 97–273 mm
	Elbow block	4xx115							
	Tee block	4xx116							
	Reducer tee block	4xx/4xx/4xx116							
	Flange bend	4xx018							
	Bulkhead flange	4xx019							
	Reducer flange	RF4xx-4xx							
	Reducer block	RBE4xx-4xx							
	Blind flange	4xx125							
Pipe O.D. 130–273 mm	Flange connection	8xx	130–273	41/2″ – 10″		800-series (350–400 bar)			
	Elbow block	8xx115							
	Tee block	8xx116							
	Reducer tee block	8xx/8xx/8xx116							
	Flange bend	8xx018							
	Bulkhead flange	8xx019							
	Reducer flange	RF8xx-8xx							
	Reducer block	RBE8xx-8xx							
	Blind flange	8xx125							
Bolt	Hexagon head bolt		30–273				DIN 912 / ASME B/8.2.2	8.8 electro galvanized	
Nut	Hexagon nut		30–273				DIN 934 / ASME B/8.2.2	8. electro galvanized	
Gasket			10–25					FPM (Viton®)	
			30–273				Bonded Seal	Steel and Perbunan	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S-Series (Heavy)	DIN 3015	Polypropylene & St37	
Hose	1/4″–1″	M3K GS2C		1/4″–1″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	11/4″–2″	EFG3K GS4SH		11/4″–2″			EN 856 R12 SAE 100R12 EN856 4SH		
Hose fittings	1/4″–1″	G- / P-series			1/4″–1″	S-Series (Heavy)	ISO 12151-2	C15S10 / 1.0718	
	11/4″–2″	GSP / GSH / I-series				SAE 3000 Psi (SAE J 518 Code 61)	ISO 12151-3		

*) xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″	8″	10″
½″	T-DIN	T-DIN	T-DIN												
¾″	T-DIN	T-DIN	T-DIN	T-DIN											
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN										
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP									
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL								
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL							
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL						
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL					
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL			
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL		
8″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL	
10″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	BL	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1

TE = Tee or Reduction Tee Flange

BL = Tee or Reduction Tee Block

BLBSP = Reduction Tee Block BSP

TBN = Reduction Tee Between BSP thread

Carbon Steel 250 bar / 3600 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0,3 mm**	**250 bar / 3600 Psi**	**GSCS01-05**	**1**
Pipe standard:	**E235N (St 37.4 NBK) to DIN 2391C (EN10305-4)**	Tensile strength min 340 N/mm²	Yield strength min 235 N/mm²	Elongation at break min. 25 %	
	E355N (St 52.4 NBK) to DIN 2391C (EN10305-4)	Tensile strength min 490 N/mm²	Yield strength min 355 N/mm²	Elongation at break min. 22 %	

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	**10**	**12**	**16**	**20**	**25**	**30**	**38**	**42**	**50**
Wall thickness [mm]	**2**	**2**	**2**	**2,5**	**2,5**	**3**	**4**	**4**	**5**
Material	**E235N**	**E235N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**
Flow (v=5 m/s) [l/min]	**8,48**	**15,07**	**33,91**	**52,99**	**94,2**	**135,65**	**211,95**	**272,24**	**376,8**
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
NPS/ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	**60**	**73**	**97**	**115**	**130**	**150**	**190**	**250**	**273**
Wall thickness [mm]	**6**	**7**	**12**	**15**	**15**	**15**	**20**	**25**	**25**
Material	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**
Flow (v=5 m/s) [l/min]	**542,50**	**819,78**	**1 254,98**	**1 701,49**	**2 355,00**	**3 391,20**	**5 298,75**	**9 420,00**	**11 711,18**
Nominal diameter	DN 50	DN 65	DN 80	DN 100		DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3		139,3	168,3	219,1	273
NPS/ASME B36.19M-2004	2"	2 1/2"	3"	4"		5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30		141,3	168,30	219,10	273,0

Item		**Type**	**Pipe Size [mm]**	**Pipe Size [in]**	**Thread size BSP [in]**	**Class**	**Standard**	**Material**	**Connection Technology**
Pipe O.D. 10–25 mm	Male stud	GE	10–25		3/8"–1"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	C15S10 / 1.0718	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–73 mm – Retain Ring O.D. 97–273 mm
	Straight union	G							
	Reducer straight union	GR							
	Union T	T							
	Union elbow	W							
	Union cross	K							
	Union Weld bulkhead	ESV							
	Union bulkhead	SV							
	Reducer	RED							
	Thread reducer	RI							
	Blanking plug	VSTI							
Pipe O.D. 30–73 mm	Flange connection	6xx/ODxWt	30–73	1"–21/2"	1"–2"	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	P355N / S355J (EN10305-4)	
	Male thread flange	6xx014							
	Elbow block	6xx115							
	Tee block	6xx116							
	Reducer tee block	6xx/6xx/6xx116							
	Flange bend	6xx018							
	Bulkhead flange	6xx019							
	Reducer flange	RF6xx-6xx							
	Reducer block	RBE6xx-6xx							
	Blind flange	6xx125							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 97–115 mm	Flange connection	4xx	97–115	3–4″	1 1/2″–2″	400-series (350–400 bar)	ISO 6164	P355N / S355J (EN10305-4)	Notes: All piping connections with non-welded technology Acceptable technology: –Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–73 mm – Retain Ring O.D. 97–273 mm
	Elbow block	4xx115							
	Tee block	4xx116							
	Reducer tee block	4xx/4xx/4xx116							
	Flange bend	4xx018							
	Bulkhead flange	4xx019							
	Reducer flange	RF4xx-4xx							
	Reducer block	RBE4xx-4xx							
	Blind flange	4xx125							
Pipe O.D. 130–273 mm	Flange connection	8xx	130–273	41/2″ – 10″		800-series (350–400 bar)			
	Elbow block	8xx115							
	Tee block	8xx116							
	Reducer tee block	8xx/8xx/8xx116							
	Flange bend	8xx018							
	Bulkhead flange	8xx019							
	Reducer flange	RF8xx-8xx							
	Reducer block	RBE8xx-8xx							
	Blind flange	8xx125							
Bolt	Hexagon head bolt		30–273				DIN 912 / ASME B/8.2.2	8.8 electro galvanized	
Nut	Hexagon nut		30–273				DIN 934 / ASME B/8.2.2	8. electro galvanized	
Gasket			10–25					FPM (Viton®)	
			30–273				Bonded Seal	Steel and Perbunan	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S-Series (Heavy)	DIN 3015	Polypropylene & St37	
Hose	1/4″–1″	M4K GS2C		1/4″–1″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	11/4″–2″	EFG5SK GS5SH		11/4″–2″			EN 856 R12 SAE 100R12 ISO 3862-12 EN856 4SH		
Hose fittings	1/4″–1″	G- / P-series			1/4″–1″	S-Series (Heavy)	ISO 12151-2	C15S10 / 1.0718	
	11/4″–2″	GSH-series I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE \ BRANCH SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″	8″	10″
½″	T-DIN	T-DIN	T-DIN												
¾″	T-DIN	T-DIN	T-DIN	T-DIN											
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN										
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP									
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL								
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL							
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL						
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL					
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL			
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL		
8″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL	
10″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	BL	TE / BL	TE / BL	TE / BL

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Carbon Steel 280 bar / 4000 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0,3 mm**	**280 bar / 4000 Psi**	**GSCS01-06**	**1**
Pipe standard:	**E235N (St 37.4 NBK) to DIN 2391C (EN10305-4)**	Tensile strength min 340 N/mm²	Yield strength min 235 N/mm²	Elongation at break min. 25 %	
	E355N (St 52.4 NBK) to DIN 2391C (EN10305-4)	Tensile strength min 490 N/mm²	Yield strength min 355 N/mm²	Elongation at break min. 22 %	

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	**10**	**12**	**16**	**20**	**25**	**30**	**38**	**46**	**50**
Wall thickness [mm]	**2**	**2**	**2**	**3**	**3**	**4**	**4**	**8**	**5**
Material	**E235N**	**E235N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**
Flow (v=5 m/s) [l/min]	**8,48**	**15,07**	**33,91**	**46,16**	**85,02**	**113,98**	**211,95**	**211,95**	**376,8**
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
NPS/ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	**60**	**73**	**97**	**115**	**130**	**150**	**190**	**250**	**273**
Wall thickness [mm]	**6**	**7**	**12**	**15**	**15**	**15**	**20**	**25**	**25**
Material	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**
Flow (v=5 m/s) [l/min]	**542,50**	**819,78**	**1 254,98**	**1 701,49**	**2 355,00**	**3 391,20**	**5 298,75**	**9 420,00**	**11 711,18**
Nominal diameter	DN 50	DN 65	DN 80	DN 100		DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3		139,3	168,3	219,1	273
NPS/ASME B36.19M-2004	2"	2 1/2"	3"	4"		5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30		141,3	168,30	219,10	273,0

Item		**Type**	**Pipe Size [mm]**	**Pipe Size [in]**	**Thread size BSP [in]**	**Class**	**Standard**	**Material**	**Connection Technology**
Pipe O.D. 10–20 mm	Male stud	GE	10–20		3/8"–3/4"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	C15S10 / 1.0718	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–20 mm – 37°-flaring O.D. 25–73 mm – Retain Ring O.D. 97–273 mm
	Straight union	G							
	Reducer straight union	GR							
	Union T	T							
	Union elbow	W							
	Union cross	K							
	Union Weld bulkhead	ESV							
	Union bulkhead	SV							
	Reducer	RED							
	Thread reducer	RI							
	Blanking plug	VSTI							
Pipe O.D. 25–73 mm	Flange connection	6xx/ODxWt	25–73	3/4"–2 1/2"	1/2"–2"	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	P355N / S355J (EN10305-4)	
	Male thread flange	6xx014							
	Elbow block	6xx115							
	Tee block	6xx116							
	Reducer tee block	6xx/6xx/6xx116							
	Flange bend	6xx018							
	Bulkhead flange	6xx019							
	Reducer flange	RF6xx-6xx							
	Reducer block	RBE6xx-6xx							
	Blind flange	6xx125							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 97–115 mm	Flange connection	4xx	97–115	3–4″	1 1/2″–2″	400-series (350-400 bar)	ISO 6164	P355N / S355J (EN10305-4)	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–20 mm – 37°-flaring O.D. 25–73 mm – Retain Ring O.D. 97–273 mm
	Elbow block	4xx115							
	Tee block	4xx116							
	Reducer tee block	4xx/4xx/4xx116							
	Flange bend	4xx018							
	Bulkhead flange	4xx019							
	Reducer flange	RF4xx-4xx							
	Reducer block	RBE4xx-4xx							
	Blind flange	4xx125							
Pipe O.D. 130–273 mm	Flange connection	8xx	130–273	41/2″ – 10″		800-series (350-400 bar)			
	Elbow block	8xx115							
	Tee block	8xx116							
	Reducer tee block	8xx/8xx/8xx116							
	Flange bend	8xx018							
	Bulkhead flange	8xx019							
	Reducer flange	RF8xx-8xx							
	Reducer block	RBE8xx-8xx							
	Blind flange	8xx125							
Bolt	Hexagon head bolt		25–273				DIN 912 / ASME B/8.2.2	8.8 electro galvanized	
Nut	Hexagon nut		25–273				DIN 934 / ASME B/8.2.2	8. electro galvanized	
Gasket			10–20					FPM (Viton®)	
			25–273				Bonded Seal	Steel and Perbunan	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S-Series (Heavy)	DIN 3015	Polypropylene & St37	
Hose	1/4″–3/4″	M4K GS2C		1/4″–3/4″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	1″–2″	EFG5SK GSR13		1″–2″			EN 856 R13 SAE 100R13 ISO 3862-1 R13		
Hose fittings	1/4″–3/4″	G- / P-series			1/4″–3/4″	S-Series (Heavy)	ISO 12151-2	C15S10 / 1.0718	
	1″–2″	GSH-series I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE \ BRANCH SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″	8″	10″
½″	T-DIN	T-DIN	T-DIN												
¾″	T-DIN	T-DIN	T-DIN	T-DIN											
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN										
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP									
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL								
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL							
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL						
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL					
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL			
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL		
8″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL	
10″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	BL	TE / BL	TE / BL	TE / BL

T-DIN = Tee Fitting ISO 8434-1

TE = Tee or Reduction Tee Flange

BL = Tee or Reduction Tee Block

BLBSP = Reduction Tee Block BSP

TBN = Reduction Tee Between BSP thread

Carbon Steel 315 bar / 4500 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0,3 mm**	**315 bar / 4500 Psi**	**GSCS01-07**	**1**
Pipe standard:	**E235N (St 37.4 NBK) to DIN 2391C (EN10305-4)**	Tensile strength min 340 N/mm²	Yield strength min 235 N/mm²	Elongation at break min. 25 %	
	E355N (St 52.4 NBK) to DIN 2391C (EN10305-4)	Tensile strength min 490 N/mm²	Yield strength min 355 N/mm²	Elongation at break min. 22 %	

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	**10**	**12**	**16**	**20**	**25**	**30**	**38**	**46**	**50**
Wall thickness [mm]	**2**	**2,5**	**2**	**2,5**	**3**	**4**	**5**	**8**	**6**
Material	**E235N**	**E235N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**
Flow (v=5 m/s) [l/min]	**8,48**	**11,54**	**33,93**	**53,01**	**94,25**	**114,04**	**184,63**	**211,95**	**340,06**
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
NPS/ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	13,7	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	**66**	**80**	**97**	**115**	**141**	**168**	**190**
Wall thickness [mm]	**8,5**	**10**	**12**	**15**	**20**	**25**	**20**
Material	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**
Flow (v=5 m/s) [l/min]	**564,44**	**847,80**	**1 254,98**	**1 701,49**	**2 358,00**	**3 280,00**	**5 298,75**
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3	219,1
NPS/ASME B36.19M-2004	2"	2 1/2"	3"	4"	5"	6"	8"
O.D. [mm]	60,30	73,00	88,90		141,3	168,30	219,10

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–20 mm	Male stud	GE	10–20		3/8"–3/4"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	C15S10 / 1.0718	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–20 mm – 37°-flaring O.D. 25, 30, 38 and 50 mm – Retain Ring O.D. 46, 66–190 mm
	Straight union	G							
	Reducer straight union	GR							
	Union T	T							
	Union elbow	W							
	Union cross	K							
	Union Weld bulkhead	ESV							
	Union bulkhead	SV							
	Reducer	RED							
	Thread reducer	RI							
	Blanking plug	VSTI							
Pipe O.D. 25, 30, 38 and 50 mm	Flange connection	6xx/ODxWt	25, 30, 38 and 50	3/4" –1 1/2"	1,2"–2"	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	P355N / S355J (EN10305-4)	
	Male thread flange	6xx014							
	Elbow block	6xx115							
	Tee block	6xx116							
	Reducer tee block	6xx/6xx/6xx116							
	Flange bend	6xx018							
	Bulkhead flange	6xx019							
	Reducer flange	RF6xx-6xx							
	Reducer block	RBE6xx-6xx							
	Blind flange	6xx125							
Pipe O.D. 46 & 66 mm	Flange connection	6xx	46 and 66	11/4" and 2"	1 1/2"–2"				
	Elbow block	6xx115							
	Tee block	6xx116							
	Reducer tee block	6xx/6xx/6xx116							
	Flange bend	6xx018							
	Bulkhead flange	6xx019							
	Reducer flange	RF6xx-6xx							
	Reducer block	RBE6xx-6xx							
	Blind flange	6xx125							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 80–115 mm	Flange connection	4xx	80–115	21/2–4″		400-series (350-400 bar)	ISO 6164	P355N / S355J (EN10305-4)	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–20 mm – 37°-flaring O.D. 25, 30, 38 and 50 mm – Retain Ring O.D. 46, 66–190 mm
	Elbow block	4xx115							
	Tee block	4xx116							
	Reducer tee block	4xx/4xx/4xx116							
	Flange bend	4xx018							
	Bulkhead flange	4xx019							
	Reducer flange	RF4xx-4xx							
	Reducer block	RBE4xx-4xx							
	Blind flange	4xx125							
Pipe O.D. 141–190 mm	Flange connection	8xx	141–190	4″–8″		800-series (350–400 bar)			
	Elbow block	8xx115							
	Tee block	8xx116							
	Reducer tee block	8xx/8xx/8xx116							
	Flange bend	8xx018							
	Bulkhead flange	8xx019							
	Reducer flange	RF8xx-8xx							
	Reducer block	RBE8xx-8xx							
	Blind flange	8xx125							
Bolt	Hexagon head bolt		25–190				DIN 912 / ASME B/8.2.2	8.8 electro galvanized	
Nut	Hexagon nut		25–190				DIN 934 / ASME B/8.2.2	8. electro galvanized	
Gasket			10–20					FPM (Viton®)	
			25–190				Bonded Seal	Steel and Perbunan	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–190			S-Series (Heavy)	DIN 3015	Polypropylene & St37	
Hose	1/4″–3/4″	M5K GS2C		1/4″–3/4″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	1″–2″	EFG5SK GSR13		1″–2″			EN 856 R13 SAE 100R13 ISO 3862-1 R13		
Hose fittings	1/4″–3/4″	G- / P-series			1/4″–3/4″	S-Series (Heavy)	ISO 12151-2	C15S10 / 1.0718	
	1″–2″	GSH-series I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″	8″
½″	T-DIN	T-DIN	T-DIN											
¾″	T-DIN	T-DIN	T-DIN	T-DIN										
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN									
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP								
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL							
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL						
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL					
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL			
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL		
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL	
8″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Carbon Steel 350 bar / 5000 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0,3 mm**	**350 bar / 5000 Psi**	**GSCS01-08**	**1**
Pipe standard:	**E235N (St 37.4 NBK) to DIN 2391C (EN10305-4)**	Tensile strength min 340 N/mm²	Yield strength min 235 N/mm²	Elongation at break min. 25 %	
	E355N (St 52.4 NBK) to DIN 2391C (EN10305-4)	Tensile strength min 490 N/mm²	Yield strength min 355 N/mm²	Elongation at break min. 22 %	

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	**10**	**12**	**16**	**20**	**25**	**30**	**38**	**46**	**56**
Wall thickness [mm]	**2**	**2,5**	**2,5**	**3**	**4**	**4**	**5**	**8**	**8,5**
Material	**E235N**	**E235N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**
Flow (v=5 m/s) [l/min]	**8,48**	**11,54**	**28,51**	**46,18**	**68,09**	**114,04**	**184,63**	**212,06**	**358,2**
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
NPS/ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	**66**	**80**	**97**	**115**	**141**	**168**
Wall thickness	**8,5**	**10**	**12**	**15**	**20**	**25**
Material	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**
Flow (v=5 m/s) [l/min]	**564,44**	**847,80**	**1 254,98**	**1 701,49**	**2 358,00**	**3 280,00**
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3
NPS/ASME B36.19M-2004	2"	2 1/2"	3"	4"	5"	6"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,3

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–12 mm	Male stud	GE	10–12		3/8″	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	C15S10 / 1.0718	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–38 mm – Retain Ring O.D. 46–168,3 mm
	Straight union	G							
	Reducer straight union	GR							
	Union T	T							
	Union elbow	W							
	Union cross	K							
	Union Weld bulkhead	ESV							
	Union bulkhead	SV							
	Reducer	RED							
	Thread reducer	RI							
	Blanking plug	VSTI							
Pipe O.D. 16–38 mm	Flange connection	6xx/ODxWt	16–38	3/8″–1 1/4″	1/2″–2″	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	P355N / S355J (EN10305-4)	
	Male thread flange	6xx014							
	Elbow block	6xx115							
	Tee block	6xx116							
	Reducer tee block	6xx/6xx/6xx116							
	Flange bend	6xx018							
	Bulkhead flange	6xx019							
	Reducer flange	RF6xx-6xx							
	Reducer block	RBE6xx-6xx							
	Blind flange	6xx125							
Pipe O.D. 46–66 mm	Flange connection	6xx	46–66	1 1/4″ and 2″					
	Elbow block	6xx115							
	Tee block	6xx116							
	Reducer tee block	6xx/6xx/6xx116							
	Flange bend	6xx018							
	Bulkhead flange	6xx019							
	Reducer flange	RF6xx-6xx							
	Reducer block	RBE6xx-6xx							
	Blind flange	6xx125							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 80–115 mm	Flange connection	4xx	80–115	2 1/2–4″		400-series (350–400 bar)	ISO 6164	P355N / S355J (EN10305-4)	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–38 mm – Retain Ring O.D. 46–168,3 mm
	Elbow block	4xx115							
	Tee block	4xx116							
	Reducer tee block	4xx/4xx/4xx116							
	Flange bend	4xx018							
	Bulkhead flange	4xx019							
	Reducer flange	RF4xx-4xx							
	Reducer block	RBE4xx-4xx							
	Blind flange	4xx125							
Pipe O.D. 141–168,3 mm	Flange connection	8xx	141 – 168,3	5″–6″		800-series (350–400 bar)			
	Elbow block	8xx115							
	Tee block	8xx116							
	Reducer tee block	8xx/8xx/8xx116							
	Flange bend	8xx018							
	Bulkhead flange	8xx019							
	Reducer flange	RF8xx-8xx							
	Reducer block	RBE8xx-8xx							
	Blind flange	8xx125							
Bolt	Hexagon head bolt		16–168,3				DIN 912 / ASME B/8.2.2	8.8 electro galvanized	
Nut	Hexagon nut		16–168,3				DIN 934 / ASME B/8.2.2	8. electro galvanized	
Gasket			10–12					FPM (Viton®)	
			16–42				Bonded Seal	Steel and Perbunan	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–168,3			S-Series (Heavy)	DIN 3015	Polypropylene & St37	
Hose	1/4″–1/2″	M5K GS2C		1/4″–1/2″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	5/8″–2″	EFG5SK GSR13		5/8″–2″			EN 856 R13 SAE 100R13 ISO 3862-1 R13		
Hose fittings	1/4″–1/2″	G- / P-series			1/4″–1/2″	S-Series (Heavy)	ISO 12151-2	C15S10 / 1.0718	
	5/8″–2″	GSH-series I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″
½″	T-DIN	T-DIN	T-DIN										
¾″	T-DIN	T-DIN	T-DIN	T-DIN									
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN								
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP							
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL						
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL					
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL				
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL			
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL		
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL	
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Carbon Steel 380 bar / 5500 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0,3 mm**	**380 bar / 5500 Psi**	**GSCS01-09**	**1**
Pipe standard:	**E235N (St 37.4 NBK) to DIN 2391C (EN10305-4)**	Tensile strength min 340 N/mm²	Yield strength min 235 N/mm²	Elongation at break min. 25 %	
	E355N (St 52.4 NBK) to DIN 2391C (EN10305-4)	Tensile strength min 490 N/mm²	Yield strength min 355 N/mm²	Elongation at break min. 22 %	

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	**10**	**12**	**16**	**20**	**25**	**30**	**38**	**46**	**56**
Wall thickness [mm]	**2**	**2,5**	**2,5**	**3**	**4**	**4**	**5**	**8**	**8,5**
Material	**E235N**	**E235N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**
Flow (v=5 m/s) [l/min]	**8,48**	**11,54**	**28,51**	**46,18**	**68,09**	**114,04**	**184,63**	**212,06**	**358,2**
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
NPS/ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	**66**	**80**	**97**	**115**
Wall thickness	**8,5**	**10**	**12**	**15**
Material	**E355N**	**E355N**	**E355N**	**E355N**
Flow (v=5 m/s) [l/min]	**564,44**	**847,80**	**1 254,98**	**1 701,49**
Nominal diameter	DN 50	DN 65	DN 80	DN 100
O.D. [mm]	60,3	76,1	88,9	114,3
NPS/ASME B36.19M-2004	2"	2 1/2"	3"	4"
O.D. [mm]	60,30	73,00	88,90	114,30

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–12 mm	Male stud	GE	10–12		3/8″	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	C15S10 / 1.0718	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–38 mm – Retain Ring O.D. 46–115
	Straight union	G							
	Reducer straight union	GR							
	Union T	T							
	Union elbow	W							
	Union cross	K							
	Union Weld bulkhead	ESV							
	Union bulkhead	SV							
	Reducer	RED							
	Thread reducer	RI							
	Blanking plug	VSTI							
Pipe O.D. 16–38 mm	Flange connection	6xx/ODxWt	16–38	3/8″–1 1/4″	1/2″–2″	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	P355N / S355J (EN10305-4)	
	Male thread flange	6xx014							
	Elbow block	6xx115							
	Tee block	6xx116							
	Reducer tee block	6xx/6xx/6xx116							
	Flange bend	6xx018							
	Bulkhead flange	6xx019							
	Reducer flange	RF6xx-6xx							
	Reducer block	RBE6xx-6xx							
	Blind flange	6xx125							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 46–66 mm	Flange connection	6xx	46–66	1 1/4″ and 2″		SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	P355N / S355J (EN10305-4)	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–38 mm – Retain Ring O.D. 46–115 mm
	Elbow block	6xx115							
	Tee block	6xx116							
	Reducer tee block	6xx/6xx/6xx116							
	Flange bend	6xx018							
	Bulkhead flange	6xx019							
	Reducer flange	RF6xx-6xx							
	Reducer block	RBE6xx-6xx							
	Blind flange	6xx125							
Pipe O.D. 80–115 mm	Flange connection	4xx	80–115	2 1/2–4″		400-series (350–400 bar)	ISO 6164		
	Elbow block	4xx115							
	Tee block	4xx116							
	Reducer tee block	4xx/4xx/4xx116							
	Flange bend	4xx018							
	Bulkhead flange	4xx019							
	Reducer flange	RF4xx-4xx							
	Reducer block	RBE4xx-4xx							
	Blind flange	4xx125							
Bolt	Hexagon head bolt		16–115				DIN 912 / ASME B/8.2.2	8.8 electro galvanized	
Nut	Hexagon nut		16–115				DIN 934 / ASME B/8.2.2	8. electro galvanized	
Gasket			10–12					FPM (Viton®)	
			16–115				Bonded Seal	Steel and Perbunan	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–115			S-Series (Heavy)	DIN 3015	Polypropylene & St37	
Hose	1/4″	M6K GS2C		1/4″			EN 857 2SC ISO 11237	Synthetic rubber	
	3/8″–2″	EFG6K GSR15		3/8″–2″			EN 856 R15 SAE 100R15 ISO 3862-1 R15		
Hose fittings	1/4″	G- / P-series			1/4″	S-Series (Heavy)	ISO 12151-2	C15S10 / 1.0718	
	3/8″–2″	GSH-series I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″
½″	T-DIN	T-DIN	T-DIN								
¾″	T-DIN	T-DIN	T-DIN	T-DIN							
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN						
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP					
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL				
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL			
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL		
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL	
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Carbon Steel 420 bar / 6000 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0,3 mm**	**380 bar / 5500 Psi**	**GSCS01-09**	**1**
Pipe standard:	**E235N (St 37.4 NBK) to DIN 2391C (EN10305-4)**	Tensile strength min 340 N/mm²	Yield strength min 235 N/mm²	Elongation at break min. 25 %	
	E355N (St 52.4 NBK) to DIN 2391C (EN10305-4)	Tensile strength min 490 N/mm²	Yield strength min 355 N/mm²	Elongation at break min. 22 %	

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	**10**	**12**	**16**	**20**	**25**	**30**	**38**	**46**	**56**
Wall thickness [mm]	**2**	**2,5**	**2,5**	**3**	**4**	**4**	**5**	**8**	**8,5**
Material	**E235N**	**E235N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**	**E355N**
Flow (v=5 m/s) [l/min]	**8,48**	**11,54**	**28,51**	**46,18**	**68,09**	**114,04**	**184,63**	**212,06**	**358,2**
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
NPS/ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	**60**
Wall thickness	**10**
Material	**E355N**
Flow (v=5 m/s) [l/min]	**376,8**
Nominal diameter	DN 50
O.D. [mm]	60,3
NPS/ASME B36.19M-2004	2"
O.D. [mm]	60,30

Item		**Type**	**Pipe Size [mm]**	**Pipe Size [in]**	**Thread size BSP [in]**	**Class**	**Standard**	**Material**	**Connection Technology**
Pipe O.D. 10–12 mm	Male stud	GE	10–12		3/8"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	C15S10 / 1.0718	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–38 mm – Retain Ring O.D. 46–115
	Straight union	G							
	Reducer straight union	GR							
	Union T	T							
	Union elbow	W							
	Union cross	K							
	Union Weld bulkhead	ESV							
	Union bulkhead	SV							
	Reducer	RED							
	Thread reducer	RI							
	Blanking plug	VSTI							
Pipe O.D. 16–38 mm	Flange connection	6xx/ODxWt	16–38	3/8"–1 1/4"	1/2"–1 1/4"	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	P355N / S355J (EN10305-4)	
	Male thread flange	6xx014							
	Elbow block	6xx115							
	Tee block	6xx116							
	Reducer tee block	6xx/6xx/6xx116							
	Flange bend	6xx018							
	Bulkhead flange	6xx019							
	Reducer flange	RF6xx-6xx							
	Reducer block	RBE6xx-6xx							
	Blind flange	6xx125							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 46–66 mm	Flange connection	6xx	46–60	1 1/4" and 2"		SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	P355N / S355J (EN10305-4)	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–38 mm – Retain Ring O.D. 46–60 mm
	Elbow block	6xx115							
	Tee block	6xx116							
	Reducer tee block	6xx/6xx/6xx116							
	Flange bend	6xx018							
	Bulkhead flange	6xx019							
	Reducer flange	RF6xx-6xx							
	Reducer block	RBE6xx-6xx							
	Blind flange	6xx125							
Bolt	Hexagon head bolt		16–60				DIN 912 / ASME B/8.2.2	8.8 electro galvanized	
Nut	Hexagon nut		16–60				DIN 934 / ASME B/8.2.2	8. electro galvanized	
Gasket			10–12					FPM (Viton®)	
			16–60				Bonded Seal	Steel and Perbunan	
Pipework fastening	SPALxxxxPP-DPAL-AS		10–115			S-Series (Heavy)	DIN 3015	Polypropylene & St37	
Hose	1/4"	M6K GS2C		1/4"			EN 857 2SC ISO 11237	Synthetic rubber	
	3/8"–2"	EFG6K GSR15		3/8"–2"			EN 856 R15 SAE 100R15 ISO 3862-1 R15		
Hose fittings	1/4"	G- / P-series			1/4"	S-Series (Heavy)	ISO 12151-2	C15S10 / 1.0718	
	3/8"–2"	GSH-series I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"	4 1/2"	5"	6"	8"	8"	10"

Branch connections

RUN SIZE	¼"	⅜"	½"	¾"	1"	1¼"	1½"	2"
½"	T-DIN	T-DIN	T-DIN					
¾"	T-DIN	T-DIN	T-DIN	T-DIN				
1"	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN			
1¼"	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP		
1½"	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	
2"	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

www.kianhydraulic.com

Stainless Steel Piping, AISI: 16 bar - 420 bar

Basic Connection Table 39
Stainless Steel AISI 16 bar / 250 Psi 40
Stainless Steel AISI 50 bar / 750 Psi 42
Stainless Steel AISI 150 bar / 2250 Psi 44
Stainless Steel AISI 210 bar / 3000 Psi 46
Stainless Steel AISI 250 bar / 3600 Psi 48
Stainless Steel AISI 280 bar / 3600 Psi 50
Stainless Steel AISI 315 bar / 4500 Psi 52
Stainless Steel AISI 350 bar / 5000 Psi 54
Stainless Steel AISI 380 bar / 5500 Psi 56
Stainless Steel AISI 420 bar / 6000 Psi 58

Basic Connection Table

EF = End forming
37 = 37°-Flaring
RR = Retain Ring Flange

PRESSURE [BAR]	⅛″	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″	8″	10″
420	EF	EF	37	37	37	37	RR	RR	RR							
380	EF	EF	37	37	37	37	RR	RR	RR	RR	RR	RR				
350	EF	EF	37	37	37	37	RR	RR	RR	RR	RR	RR	RR	RR		
315	EF	EF	EF	EF	37	37	RR	37	RR	RR	RR	RR	RR	RR	RR	
280	EF	EF	EF	EF	37	37	37	37	37	37	RR	RR	RR	RR	RR	RR
250	EF	EF	EF	EF	EF	37	37	37	37	37	RR	RR	RR	RR	RR	RR
210	EF	EF	EF	EF	EF	37	37	37	37	37	RR	RR	RR	RR	RR	RR
150	EF	EF	EF	EF	EF	37	37	37	37	37	37	RR	RR	RR	RR	RR
50	EF	EF	EF	EF	EF	37	37	37	37	37	37	37	37	37	37	37
16	EF	EF	EF	EF	EF	37	37	37	37	37	37	37	37	37	37	37

PIPE SIZE

Stainless Steel AISI 16 bar / 250 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0,3 mm**	**16 bar / 250 Psi**	**GSSS02-01**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	15	18	22	28	35	42	50
Wall thickness [mm]	1,5	1,5	2	2	2	2	3	3	3
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=3 m/s) [l/min]	6,93	11,45	17,11	27,71	45,78	81,39	118,89	183,12	273,56
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60	73,05	88,9	114,3	141,3	168,28	219,08	273,05
Wall thickness [mm]	3	3,05	3,05	3,05	3,4	3,4	3,76	4,19
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=3 m/s) [l/min]	412,03	634,30	973,91	1 617,74	2 424,85	3 394,73	6 113,20	9 625,50
Nominal Diameter [mm]	50	65	80	100	125	150	200	250
Nominal Diameter [in]	2	2 1/2	3	4	5	6	8	10
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3	219,1	273
ASME B36.19M-2004	2"	2 1/2"	3"	4"	5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30	219,10	273,00

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–22 mm	Male stud	GE -316	10–22		1/4"–3/4"	L-Series	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–22 mm – 37°-flaring O.D. 28–273 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 28–42 mm	Flange connection	3xx/ODxWtSS	28–42	3/4"–1 1/4"	1/4"–2"	SAE 3000 Psi	ISO 6162-1 (SAE J 518 Code 61)	AISI316 / AISI316L	
	Male thread flange	3xx014SS							
	Elbow block	3xx115SS							
	Tee block	3xx116SS							
	Reducer tee block	3xx/3xx/3xx116SS							
	Flange bend	3xx018SS							
	Bulkhead flange	3xx019SS							
	Reducer flange	RF3xx-3xxSS							
	Reducer block	RBE3xx-3xxSS							
	Blind flange	3xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 50–273 mm	Flange connection	1xx/ODxWtxxSS	50–273	1 1/2"–10"	1 1/2"–2"	SAE 50 bar	ISO 6162-1 (SAE J 518 Code 61)	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–22 mm – 37°-flaring O.D. 28–273 mm
	Elbow block	1xx115SS							
	Tee block	1xx116SS							
	Reducer tee block	1xx/1xx/1xx116SS							
	Flange bend	1xx018SS							
	Bulkhead flange	1xx019SS							
	Reducer flange	RF1xx-1xxSS							
	Reducer block	RBE1xx-1xxSS							
	Blind flange	1xx125SS							
Bolt	Hexagon head bolt		28–273				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		28–273				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–22					FPM (Viton®)	
			28–42				Bonded Seal	Stainless Steel and Perbunan	
			50–273				O-Ring	NBR	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S Series (Heavy)	DIN 3015	Polypropylene & St37	
Hose	1/4"–2"	G1 / GS1T		1/4" – 2"			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
Hose fittings	1/4"–3/4"	G- / GSP-series P-series			1/4"–3/4"	L-series	ISO 12151-2	AISI316 / AISI316TI / W1.4571	
	1"–2"					SAE 3000 Psi (SAE J 518 Code 61)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	64	80	96	note: 8"=228xx 10"=260xx
1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	3 3/4"	4"	5"	6"	

Branch connections

RUN SIZE	¼"	⅜"	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	4"	5"	6"	8"	10"
½"	T-DIN	T-DIN	T-DIN												
¾"	T-DIN	T-DIN	T-DIN	T-DIN											
1"	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN										
1¼"	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP									
1½"	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL								
2"	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL							
2½"	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL						
3"	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL					
4"	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
5"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL			
6"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL		
8"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL	
10"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	BL	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel AISI 50 bar / 750 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0 mm**	**50 bar / 750 Psi**	**GSSS02-02**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	15	18	22	28	35	42	50
Wall thickness [mm]	1,5	1,5	2	2	2	2	3	3	3
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	11,54	19,08	28,5	46,16	76,3	135,65	198,06	305,21	455,93
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60	73,05	88,9	114,3	141,3	168,28	219,08	273,05
Wall thickness [mm]	3	3,05	3,05	3,05	3,4	3,4	3,76	4,19
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	412,03	634,30	973,91	1 617,74	2 424,85	3 394,73	6 113,20	9 625,50
Nominal Diameter [mm]	50	65	80	100	125	150	200	250
Nominal Diameter [in]	2	2 1/2	3	4	5	6	8	10
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3	219,1	273
ASME B36.19M-2004	2"	2 1/2"	3"	4"	5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30	219,10	273,00

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–22 mm	Male stud	GE -316	10–22		1/4"–3/4"	L-Series	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–22 mm – 37°-flaring O.D. 28–273 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 28–42 mm	Flange connection	3xx/ODxWtSS	28–42	3/4"–1 1/4"	1"– 1 1/4"	SAE 3000 Psi	ISO 6162-1 (SAE J 518 Code 61)	AISI316 / AISI316L	
	Male thread flange	3xx014SS							
	Elbow block	3xx115SS							
	Tee block	3xx116SS							
	Reducer tee block	3xx/3xx/3xx116SS							
	Flange bend	3xx018SS							
	Bulkhead flange	3xx019SS							
	Reducer flange	RF3xx-3xxSS							
	Reducer block	RBE3xx-3xxSS							
	Blind flange	3xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 50–273 mm	Flange connection	1xx/ODxWtxxSS	50–273	1 1/2"–8"	1 1/2"–2"	SAE 50 bar	ISO 6162-1 (SAE J 518 Code 61)	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–22 mm – 37°-flaring O.D. 28–273 mm
	Elbow block	1xx115SS							
	Tee block	1xx116SS							
	Reducer tee block	1xx/1xx/1xx116SS							
	Flange bend	1xx018SS							
	Bulkhead flange	1xx019SS							
	Reducer flange	RF1xx-1xxSS							
	Reducer block	RBE1xx-1xxSS							
	Blind flange	1xx125SS							
Bolt	Hexagon head bolt		28–273				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		28–273				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–22					FPM (Viton®)	
			28–42				Bonded Seal	Stainless Steel and Perbunan	
			50–273				O-Ring	NBR	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S Series (Heavy)	DIN 3015	Polypropylene & St37	
Hose	1/4"–2"	G1 / GS1T		1/4"–2"			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
Hose fittings	1/4"–3/4"	G- / GSP-series P-series			1/4"–3/4"	L-series	ISO 12151-2	AISI316 / AISI316TI / W1.4571	
	1"–2"					SAE 3000 Psi (SAE J 518 Code 61)	ISO 12151-3		

*) xx=components size code

08	12	16	20	24	32	40	48	56	64	80	96	note: 8"=228xx 10"=260xx
1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	3 3/4"	4"	5"	6"	

Branch connections

RUN SIZE \ BRANCH SIZE	¼"	⅜"	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	4"	5"	6"	8"	10"
½"	T-DIN	T-DIN	T-DIN												
¾"	T-DIN	T-DIN	T-DIN	T-DIN											
1"	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN										
1¼"	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP									
1½"	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL								
2"	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL							
2½"	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL						
3"	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL					
4"	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
5"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL			
6"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL		
8"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL	
10"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	BL	TE / BL	TE / BL	TE / BL

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel AISI 150 bar / 2250 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0 mm**	**150 bar / 2250 Psi**	**GSSS02-03**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	16	20	25	30	38	42	50
Wall thickness [mm]	1,5	1,5	2	2,5	2,5	3	4	4	5
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	11,54	19,08	33,91	52,99	94,2	135,65	211,95	272,24	376,8
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60	73,05	88,9	114,3	141,3	168,28	219,08	273,05
Wall thickness [mm]	5	7,01	7,67	13,49	15,88	14,27	18,26	25,4
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	588,75	821,02	1 274,55	1 796,55	2 827,20	4 601,00	7 852,75	11 638,43
Nominal Diameter [mm]	50	65	80	100	125	150	200	250
Nominal Diameter [in]	2	2 1/2	3	4	5	6	8	10
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3	219,1	273
ASME B36.19M-2004	2"	2 1/2"	3"	4"	5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30	219,10	273,0

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–25 mm	Male stud	GE -316	10–25		3/8"–1"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–88,9 mm – Retain Ring O.D. 114,3–273 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 30–88,9 mm	Flange connection	3xx/ODxWtSS	30–88,9	1"–3"	1"–2"	SAE 3000 Psi	ISO 6162-1 (SAE J 518 Code 61)	AISI316 / AISI316L	
	Male thread flange	3xx014SS							
	Elbow block	3xx115SS							
	Tee block	3xx116SS							
	Reducer tee block	3xx/3xx/3xx116SS							
	Flange bend	3xx018SS							
	Bulkhead flange	3xx019SS							
	Reducer flange	RF3xx-3xxSS							
	Reducer block	RBE3xx-3xxSS							
	Blind flange	3xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 114,3 mm	Flange connection	4xxSS	114,3	4″	1 1/2″–2″	400-series (350–400 bar)	ISO 6164	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–88,9 mm – Retain Ring O.D. 114,3–273 mm
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							
Pipe O.D. 141,3–273 mm	Flange connection	8xxSS	141,3–273	4 1/2″–10″		800-series (350–400 bar)			
	Elbow block	8xx115SS							
	Tee block	8xx116SS							
	Reducer tee block	8xx/8xx/8xx116SS							
	Flange bend	8xx018SS							
	Bulkhead flange	8xx019SS							
	Reducer flange	RF8xx-8xxSS							
	Reducer block	RBE8xx-8xxSS							
	Blind flange	8xx125SS							
Bolt	Hexagon head bolt		30–273				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		30–273				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–25					FPM (Viton®)	
			30–273				Bonded Seal	Stainless Steel and Perbunan	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4″–1″	M3K GS2C		1/4″ –1″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	1 1/4″–2″	EFG3K GS4SH		1 1/4″–2″					
Hose fittings	1/4″–3/4″	G- / P-series			1/4″–3/4″	S Series (Heavy)	ISO 12151-2	AISI316 / AISI316TI / W1.4571	
	1″–2″	GSP / GSH / I-series				SAE 3000 Psi (SAE J 518 Code 61)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″	8″	10″
½″	T-DIN	T-DIN	T-DIN												
¾″	T-DIN	T-DIN	T-DIN	T-DIN											
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN										
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP									
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL								
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL							
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL						
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL					
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL			
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL		
8″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL	
10″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	BL	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel AISI 210 bar / 3000 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0 mm**	**210 bar / 3000 Psi**	**GSSS02-04**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	16	20	25	30	38	42	50
Wall thickness [mm]	2	2	2	2,5	2,5	3	4	4	5
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	8,48	15,07	33,91	52,99	94,2	135,65	211,95	272,24	376,8
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60	73,05	88,9	114,3	141,3	168,28	219,08	273,05
Wall thickness [mm]	5	7,01	7,67	13,49	15,88	14,27	18,26	25,4
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	588,75	821,02	1 274,55	1 796,55	2 827,20	4 601,00	7 852,75	11 638,43
Nominal Diameter [mm]	50	65	80	100	125	150	200	250
Nominal Diameter [in]	2	2 1/2	3	4	5	6	8	10
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3	219,1	273
ASME B36.19M-2004	2"	2 1/2"	3"	4"	5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30	219,10	273,0

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–25 mm	Male stud	GE -316	10–25		3/8"–1"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–88,9 mm – Retain Ring O.D. 114,3–273 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 30–88,9 mm	Flange connection	3xx/ODxWtSS	30–88,9	1"–2 1/2"	1"–2"	SAE 3000 Psi	ISO 6162-1 (SAE J 518 Code 61)	AISI316 / AISI316L	
	Male thread flange	3xx014SS							
	Elbow block	3xx115SS							
	Tee block	3xx116SS							
	Reducer tee block	3xx/3xx/3xx116SS							
	Flange bend	3xx018SS							
	Bulkhead flange	3xx019SS							
	Reducer flange	RF3xx-3xxSS							
	Reducer block	RBE3xx-3xxSS							
	Blind flange	3xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 114,3 mm	Flange connection	4xxSS	114,3	3–4″	1 1/2″–2″	400-series (350–400 bar)	ISO 6164	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–88,9 mm – Retain Ring O.D. 114,3–273 mm
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							
Pipe O.D. 141,3–273 mm	Flange connection	8xxSS	141,3–273	4 1/2″–10″		800-series (350–400 bar)			
	Elbow block	8xx115SS							
	Tee block	8xx116SS							
	Reducer tee block	8xx/8xx/8xx116SS							
	Flange bend	8xx018SS							
	Bulkhead flange	8xx019SS							
	Reducer flange	RF8xx-8xxSS							
	Reducer block	RBE8xx-8xxSS							
	Blind flange	8xx125SS							
Bolt	Hexagon head bolt		30–273				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		30–273				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–25					FPM (Viton®)	
			30–273				Bonded Seal	Stainless Steel and Perbunan	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4″–1″	M3K GS2C		1/4″ –1″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	1 1/4″–2″	EFG3K GS4SH		1 1/4″–2″					
Hose fittings	1/4″–1″	G- / P-series			1/4″–1″	S Series (Heavy)	ISO 12151-2	AISI316 / AISI316TI / W1.4570	
	11/4″–2″	GSP / GSH / I-series				SAE 3000 Psi (SAE J 518 Code 61)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″	8″	10″
½″	T-DIN	T-DIN	T-DIN												
¾″	T-DIN	T-DIN	T-DIN	T-DIN											
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN										
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP									
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL								
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL							
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL						
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL					
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL			
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL		
8″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL	
10″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	BL	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel AISI 250 bar / 3600 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0 mm**	**250 bar / 3600 Psi**	**GSSS02-05**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	16	20	25	30	38	42	50
Wall thickness [mm]	2	2	2	2,5	2,5	3	4	4	5
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	8,48	15,07	33,91	52,99	94,2	135,65	211,95	272,24	376,8
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60	73,05	88,9	114,3	141,3	168,28	219,08	273,05
Wall thickness [mm]	6	7,01	11,13	13,49	15,88	18,26	23,01	25,58
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	542,59	821,02	1 046,36	1 796,55	2 827,20	4 090,51	7 056,74	10 981,86
Nominal Diameter [mm]	50	65	80	100	125	150	200	250
Nominal Diameter [in]	2	2 1/2	3	4	5	6	8	10
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3	219,1	273
ASME B36.19M-2004	2"	2 1/2"	3"	4"	5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30	219,10	273,0

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–25 mm	Male stud	GE -316	10–25		3/8"–1"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–73 mm – Retain Ring O.D. 88,9–273 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 30–73 mm	Flange connection	6xx/ODxWtSS	30–73	1"–2 1/2"	1"–2"	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	AISI316 / AISI316L	
	Male thread flange	6xx014SS							
	Elbow block	6xx115SS							
	Tee block	6xx116SS							
	Reducer tee block	6xx/6xx/6xx116SS							
	Flange bend	6xx018SS							
	Bulkhead flange	6xx019SS							
	Reducer flange	RF6xx-6xxSS							
	Reducer block	RBE6xx-6xxSS							
	Blind flange	6xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 88,9–114,3 mm	Flange connection	4xxSS	88,9–114,3	3–4″	1 1/2″–2″	400-series (350–400 bar)	ISO 6164	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–73 mm – Retain Ring O.D. 88,9–273 mm
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							
Pipe O.D. 141,3–273 mm	Flange connection	8xxSS	141,3–273	4 1/2″–10″		800-series (350–400 bar)			
	Elbow block	8xx115SS							
	Tee block	8xx116SS							
	Reducer tee block	8xx/8xx/8xx116SS							
	Flange bend	8xx018SS							
	Bulkhead flange	8xx019SS							
	Reducer flange	RF8xx-8xxSS							
	Reducer block	RBE8xx-8xxSS							
	Blind flange	8xx125SS							
Bolt	Hexagon head bolt		30–273				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		30–273				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–25					FPM (Viton®)	
			30–273				Bonded Seal	Stainless Steel and Perbunan	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4″–1″	M4K GS2C		1/4″–1″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	11/4″–2″	EFG5K GS5SH		1 1/4″–2″					
Hose fittings	1/4″–1″	G- / P-series			1/4″–1″	S Series (Heavy)	ISO 12151-2	AISI316 / AISI316TI / W1.4570	
	11/4″–2″	GSH / I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″	8″	10″
½″	T-DIN	T-DIN	T-DIN												
¾″	T-DIN	T-DIN	T-DIN	T-DIN											
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN										
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP									
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL								
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL							
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL						
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL					
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL			
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL		
8″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL	
10″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	BL	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel AISI 280 bar / 4000 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0 mm**	**280 bar / 4000 Psi**	**GSSS02-06**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	16	20	25	30	38	42	50
Wall thickness [mm]	2	2	2	3	3	4	4	4	5
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	8,48	15,07	33,91	46,16	85,02	113,98	211,95	272,24	376,8
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60	73,05	88,9	114,3	141,3	168,28	219,08	273,05
Wall thickness [mm]	6	7,01	11,13	13,49	15,88	18,26	23,01	28,58
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	542,59	821,02	1 046,36	1 796,55	2 827,20	1 090,51	7 056,74	10 981,86
Nominal Diameter [mm]	50	65	80	100	125	150	200	250
Nominal Diameter [in]	2	2 1/2	3	4	5	6	8	10
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3	219,1	273
ASME B36.19M-2004	2"	2 1/2"	3"	4"	5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30	219,10	273,0

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–20 mm	Male stud	GE -316	10–20		3/8"–3/4"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–20 mm – 37°-flaring O.D. 25–73 mm – Retain Ring O.D. 88,9–273 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 25–60 mm	Flange connection	6xx/ODxWtSS	25–60	3/4"–2"	1/2"–2"	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	AISI316 / AISI316L	
	Male thread flange	6xx014SS							
	Elbow block	6xx115SS							
	Tee block	6xx116SS							
	Reducer tee block	6xx/6xx/6xx116SS							
	Flange bend	6xx018SS							
	Bulkhead flange	6xx019SS							
	Reducer flange	RF6xx-6xxSS							
	Reducer block	RBE6xx-6xxSS							
	Blind flange	6xx125SS							
Pipe O.D. 73 mm	Flange connection	4xx/ODxWtSS	73	21/2"		400-series (350–400 bar)	ISO 6164		
	Male thread flange	4xx014SS							
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 88,9–114,3 mm	Flange connection	4xxSS	88,9–114,3	3–4″	1 1/2″–2″	400-series (350–400 bar)	ISO 6164	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–20 mm – 37°-flaring O.D. 25–73 mm – Retain Ring O.D. 88,9–273 mm
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							
Pipe O.D. 141,3–273 mm	Flange connection	8xxSS	141,3–273	4 1/2″–10″		800-series (350–400 bar)			
	Elbow block	8xx115SS							
	Tee block	8xx116SS							
	Reducer tee block	8xx/8xx/8xx116SS							
	Flange bend	8xx018SS							
	Bulkhead flange	8xx019SS							
	Reducer flange	RF8xx-8xxSS							
	Reducer block	RBE8xx-8xxSS							
	Blind flange	8xx125SS							
Bolt	Hexagon head bolt		25–273				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		25–273				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–20					FPM (Viton®)	
			25–273				Bonded Seal	Stainless Steel and Perbunan	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4″–3/4″	M4K GS2C		1/4″–3/4″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	1″–2″	EFG5SK GSR13		1″–2″			EN 856 R13 SAE 100R13 ISO 3862-1 R13		
Hose fittings	1/4″–3/4″	G- / P-series			1/4″–3/4″	S Series (Heavy)	ISO 12151-2	AISI316 / AISI316TI / W1.4570	
	1″–2″	GSH / I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″	8″	10″
½″	T-DIN	T-DIN	T-DIN												
¾″	T-DIN	T-DIN	T-DIN	T-DIN											
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN										
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP									
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL								
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL							
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL						
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL					
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL			
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL		
8″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL	
10″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	BL	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel AISI 315 bar / 4500 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0 mm**	**315 bar / 4500 Psi**	**GSSS02-07**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	16	20	25	30	38	42,16	50
Wall thickness [mm]	2	2,5	2	2,5	3	4	5	6,35	6
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	8,48	11,54	33,93	53,01	94,25	114,04	184,63	204,49	340,06
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60,3	73,05	88,9	114,3	141,3	168,28
Wall thickness [mm]	8,74	9,53	11,13	13,49	19,05	21,95
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	431,8	686,72	1 046,36	1 796,55	2 509,40	3 645,12
Nominal Diameter [mm]	50	65	80	100	125	150
Nominal Diameter [in]	2	21/2	3	4	5	6
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3
ASME B36.19M-2004	2"	21/2"	3"	4"	5"	6"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30

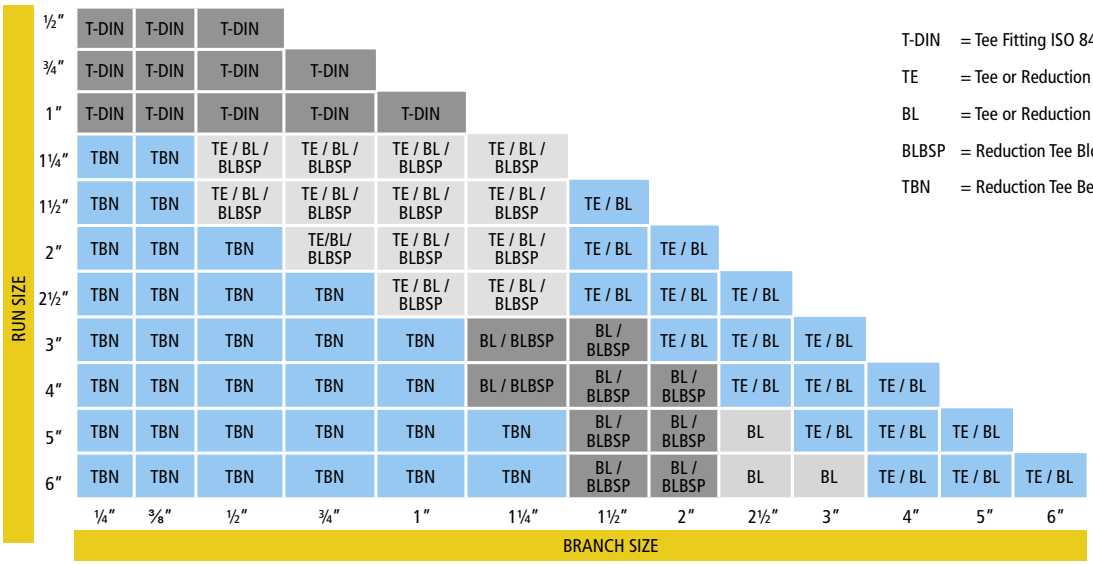
Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–20 mm	Male stud	GE -316	10–20		3/8"–3/4"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–20 mm – 37°-flaring O.D. 25–60,3 mm – Retain Ring O.D. 73,05–168,3 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 25–60,3 mm	Flange connection	6xx/ODxWtSS	25–60,3	3/4"–2"	1/2"–2"	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)		
	Male thread flange	6xx014SS							
	Elbow block	6xx115SS							
	Tee block	6xx116SS							
	Reducer tee block	6xx/6xx/6xx116SS							
	Flange bend	6xx018SS							
	Bulkhead flange	6xx019SS							
	Reducer flange	RF6xx-6xxSS							
	Reducer block	RBE6xx-6xxSS							
	Blind flange	6xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 73,05–114,3 mm	Flange connection	4xxSS	73,05–114,3	2 1/2″		400-series (350–400 bar)	ISO 6164		Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–20 mm – 37°-flaring O.D. 25–60,3 mm – Retain Ring O.D. 73,05–168,3 mm
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							
Pipe O.D. 141,3–168,3 mm	Flange connection	8xxSS	141,3–168,3	5″– 6″		800-series (350–400 bar)			
	Elbow block	8xx115SS							
	Tee block	8xx116SS							
	Reducer tee block	8xx/8xx/8xx116SS							
	Flange bend	8xx018SS							
	Bulkhead flange	8xx019SS							
	Reducer flange	RF8xx-8xxSS							
	Reducer block	RBE8xx-8xxSS							
	Blind flange	8xx125SS							
Bolt	Hexagon head bolt		25–168,3				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		25–168,3				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–20					FPM (Viton®)	
			25–168,3				Bonded Seal	Stainless Steel and Perbunan	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–168,3			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4″–3/4″	M4K GS2C		1/4″–3/4″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	1″–2″	EFG5K GS5SH		1″ –2″			EN 856 R13 SAE 100R13 ISO 3862-1 R13		
Hose fittings	1/4″–3/4″	G- / P-series			1/4″–3/4″	S Series (Heavy)	ISO 12151-2	AISI316 / AISI316TI / W1.4570	
	1″–2″	GSH / I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections



T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel AISI 350 bar / 5000 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0 mm**	**350 bar / 5000 Psi**	**GSSS02-08**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	16	20	25	30	38	42,16	48,26
Wall thickness [mm]	2	2,5	2,5	3	4	4	5	6,35	7,14
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	8,48	11,54	28,51	46,18	68,09	114,04	184,63	204,49	272,14
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60,3	73,05	88,9	114,3	141,3	168,28
Wall thickness [mm]	8,72	14,02	15,24	17,12	19,05	21,95
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	432,02	477,34	804,14	1 510,23	2 509,40	3 645,12
Nominal Diameter [mm]	50	65	80	100	125	150
Nominal Diameter [in]	2	21/2	3	4	5	6
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3
ASME B36.19M-2004	2"	21/2"	3"	4"	5"	6"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–12 mm	Male stud	GE -316	10–12		3/8"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–60,3 mm – Retain Ring O.D. 73–168,3 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 16–60,3 mm	Flange connection	6xx/ODxWtSS	16–60,3	3/8"–2"	1/2"–2"	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	AISI316 / AISI316L	
	Male thread flange	6xx014SS							
	Elbow block	6xx115SS							
	Tee block	6xx116SS							
	Reducer tee block	6xx/6xx/6xx116SS							
	Flange bend	6xx018SS							
	Bulkhead flange	6xx019SS							
	Reducer flange	RF6xx-6xxSS							
	Reducer block	RBE6xx-6xxSS							
	Blind flange	6xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 73–114,3 mm	Flange connection	4xxSS	73–114,3 mm	2 1/2–4″	1 1/2″–2″	400-series (350–400 bar)	ISO 6164	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–60,3 mm – Retain Ring O.D. 73–168,3 mm
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							
Pipe O.D. 141,3–168,3 mm	Flange connection	8xxSS	141,3–168,3	5″– 6″		800-series (350–400 bar)			
	Elbow block	8xx115SS							
	Tee block	8xx116SS							
	Reducer tee block	8xx/8xx/8xx116SS							
	Flange bend	8xx018SS							
	Bulkhead flange	8xx019SS							
	Reducer flange	RF8xx-8xxSS							
	Reducer block	RBE8xx-8xxSS							
	Blind flange	8xx125SS							
Bolt	Hexagon head bolt		16–168,3				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		16–168,3				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–12					FPM (Viton®)	
			16–168,3				Bonded Seal	Stainless Steel and Perbunan	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–168,3			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4″–1/2″	M4K GS2C		1/4″–1/2″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	5/8″–2″	EFG5K GSR13		5/8″–2″			EN 856 R13 SAE 100R13 ISO 3862-1 R13		
Hose fittings	1/4″– 1/2″	G- / P-series			1/4″–1/2″	S Series (Heavy)	ISO 12151-2	AISI316 / AISI316TI / W1.4570	
	5/8″–2″	GSH / I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE \ BRANCH SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″
½″	T-DIN	T-DIN	T-DIN										
¾″	T-DIN	T-DIN	T-DIN	T-DIN									
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN								
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP							
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL						
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL					
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL				
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL			
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL		
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL	
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel AISI 380 bar / 5500 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0 mm**	**380 bar / 5500 Psi**	**GSSS02-09**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	16	20	25	30	38	42,16	48,26
Wall thickness [mm]	2	2,5	2,5	3	4	4	5	9,7	10,16
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	8,48	11,54	28,51	46,18	68,09	114,04	184,63	122,05	183,93
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60,3	73,05	88,9	114,3
Wall thickness [mm]	11,07	14,02	15,24	17,12
Material	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	343,11	477,34	804,14	1 510,23
Nominal Diameter [mm]	50	65	80	100
Nominal Diameter [in]	2	21/2	3	4
Nominal diameter	DN 50	DN 65	DN 80	DN 100
O.D. [mm]	60,3	76,1	88,9	114,3
ASME B36.19M-2004	2"	21/2"	3"	4"
O.D. [mm]	60,30	73,00	88,90	114,30

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–12 mm	Male stud	GE -316	10–12		3/8"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–38 mm – Retain Ring O.D. 42–114,3 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 16–38 mm	Flange connection	6xx/ODxWtSS	16–38	3/8"–1 1/4"	1/2"–1"	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	AISI316 / AISI316L	
	Male thread flange	6xx014SS							
	Elbow block	6xx115SS							
	Tee block	6xx116SS							
	Reducer tee block	6xx/6xx/6xx116SS							
	Flange bend	6xx018SS							
	Bulkhead flange	6xx019SS							
	Reducer flange	RF6xx-6xxSS							
	Reducer block	RBE6xx-6xxSS							
	Blind flange	6xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 42,16–60,3 mm	Flange connection	6xxSS	42,16–60,3	1 1/4–2″	1 1/4″–2″	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–38 mm – Retain Ring O.D. 42–114,3 mm
	Elbow block	6xx115SS							
	Tee block	6xx116SS							
	Reducer tee block	6xx/6xx/6xx116SS							
	Flange bend	6xx018SS							
	Bulkhead flange	6xx019SS							
	Reducer flange	RF6xx-6xxSS							
	Reducer block	RBE6xx-6xxSS							
	Blind flange	6xx125SS							
Pipe O.D. 73–114,3 mm	Flange connection	4xxSS	73–114,3	2 1/2″–4″		400-series (350–400 bar)	ISO 6164		
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							
Bolt	Hexagon head bolt		16–114,3				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		16–114,3				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–12					FPM (Viton®)	
			16–114,3				Bonded Seal	Stainless Steel and Perbunan	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–114,3			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4″–1/2″	M4K GS2C		1/4″–1/2″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	5/8″–2″	EFG6K GSR15		5/8″–2″			EN 856 R13 SAE 100R13 ISO 3862-1 R13		
Hose fittings	1/4″– 1/2″	G- / P-series			1/4″–1/2″	S Series (Heavy)	ISO 12151-2	AISI316 / AISI316TI / W1.4570	
	5/8″–2″	GSH / I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″
½″	T-DIN	T-DIN	T-DIN								
¾″	T-DIN	T-DIN	T-DIN	T-DIN							
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN						
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP					
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL				
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL			
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL		
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL	
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel AISI 420 bar / 6000 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 20 + 60 °C**	**0 mm**	**420 bar / 6000 Psi**	**GSSS02-10**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	16	20	25	33,4		42,16	48,26
Wall thickness [mm]	1,5	2	2,5	3	4	6,35		9,7	10,16
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L		AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	11,55	15,08	28,51	46,18	68,09	100,96		122,05	183,93
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20			DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9			42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1''		11/4"	11/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60,3	73,05	88,9
Wall thickness [mm]	11,07	14,02	15,24
Material	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	343,11	477,34	804,14
Nominal Diameter [mm]	50	65	80
Nominal Diameter [in]	2	21/2	3
Nominal diameter	DN 50	DN 65	DN 80
O.D. [mm]	60,3	76,1	88,9
ASME B36.19M-2004	2"	21/2"	3"
O.D. [mm]	60,30	73,00	88,90

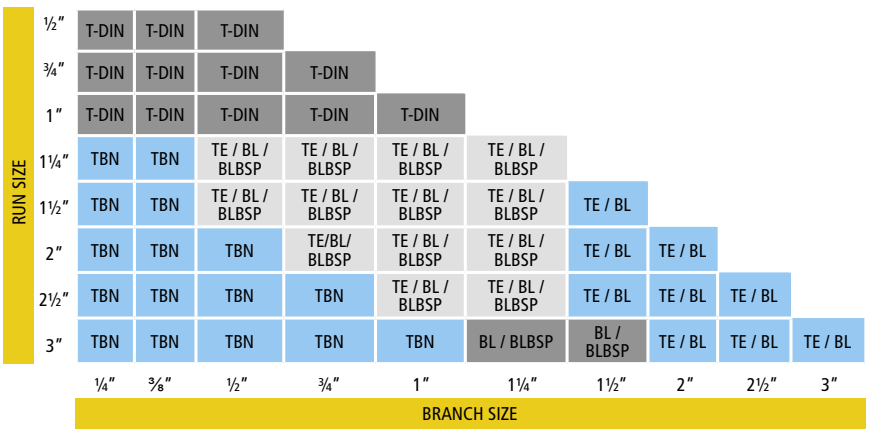
Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–12 mm	Male stud	GE -316	10–12		3/8"–1"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–33,4 mm – Retain Ring O.D. 42,1–88,9 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 16–33,4 mm	Flange connection	6xx/ODxWtSS	16–33,4	3/8"–1"	1/2"–2"	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)		
	Male thread flange	6xx014SS							
	Elbow block	6xx115SS							
	Tee block	6xx116SS							
	Reducer tee block	6xx/6xx/6xx116SS							
	Flange bend	6xx018SS							
	Bulkhead flange	6xx019SS							
	Reducer flange	RF6xx-6xxSS							
	Reducer block	RBE6xx-6xxSS							
	Blind flange	6xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 42,16–60,3 mm	Flange connection	6xxSS	42,16–60,3	1 1/4–2″	1 1/4″–2″	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 61)	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–33,4 mm – Retain Ring O.D. 42,1–88,9 mm
	Elbow block	6xx115SS							
	Tee block	6xx116SS							
	Reducer tee block	6xx/6xx/6xx116SS							
	Flange bend	6xx018SS							
	Bulkhead flange	6xx019SS							
	Reducer flange	RF6xx-6xxSS							
	Reducer block	RBE6xx-6xxSS							
	Blind flange	6xx125SS							
Pipe O.D. 73–88,9 mm	Flange connection	4xxSS	73–88,9	2 1/2″–3″		400-series (350–400 bar)	ISO 6164		
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							
Bolt	Hexagon head bolt		16–88,9				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		16–60,3				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–12					FPM (Viton®)	
			16–88,9				Bonded Seal	Stainless Steel and Perbunan	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–114,3			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4″	M4K GS2C		1/4″			EN 857 2SC ISO 11237	Synthetic rubber	
	3/8″–2″	EFG6K GSR15		3/8″–2″			EN 856 R15 SAE 100R15 ISO 3862-1 R15		
Hose fittings	1/4″– 1/2″	G- / P-series			1/4″–1/2″	S Series (Heavy)	ISO 12151-2	AISI316 / AISI316TI / W1.4570	
	3/8″–2″	GSH / I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections



T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel Piping, Ice Class –50°C : 16 bar – 420 bar

Basic Connection Table 63
Stainless Steel, Ice Class -50 °C 16 bar / 250 Psi 64
Stainless Steel, Ice Class -50 °C 50 bar / 750 Psi 66
Stainless Steel, Ice Class -50 °C 150 bar / 2250 Psi 68
Stainless Steel, Ice Class -50 °C 210 bar / 3000 Psi 70
Stainless Steel, Ice Class -50 °C 250 bar / 3600 Psi 72
Stainless Steel, Ice Class -50 °C 280 bar / 4000 Psi 74
Stainless Steel, Ice Class -50 °C 315 bar / 4500 Psi 76
Stainless Steel, Ice Class -50 °C 350 bar / 5000 Psi 78
Stainless Steel, Ice Class -50 °C 380 bar / 5500 Psi 80
Stainless Steel, Ice Class -50 °C 420 bar / 6000 Psi 82

Basic Connection Table

EF = End forming
37 = 37°-Flaring
RR = Retain Ring Flange

PRESSURE [BAR]	⅛″	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″	8″	10″
420	EF	EF	37	37	37	37	RR	RR	RR							
380	EF	EF	37	37	37	37	RR	RR	RR	RR	RR	RR				
350	EF	EF	37	37	37	37	RR	RR	RR	RR	RR	RR	RR	RR		
315	EF	EF	EF	EF	37	37	RR	37	RR	RR	RR	RR	RR	RR	RR	
280	EF	EF	EF	EF	37	37	37	37	37	37	RR	RR	RR	RR	RR	RR
250	EF	EF	EF	EF	EF	37	37	37	37	37	RR	RR	RR	RR	RR	RR
210	EF	EF	EF	EF	EF	37	37	37	37	37	RR	RR	RR	RR	RR	RR
150	EF	EF	EF	EF	EF	37	37	37	37	37	37	RR	RR	RR	RR	RR
50	EF	EF	EF	EF	EF	37	37	37	37	37	37	37	37	37	37	37
16	EF	EF	EF	EF	EF	37	37	37	37	37	37	37	37	37	37	37

PIPE SIZE

Stainless Steel, Ice Class -50 °C 16 bar / 250 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 50 + 60 °C**	**0,0 mm**	**16 bar / 250 Psi**	**GSSS02-01**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	15	18	22	28	35	42	50
Wall thickness [mm]	1,5	1,5	2	2	2	2	3	3	3
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=3 m/s) [l/min]	6,93	11,45	17,11	27,71	45,78	81,39	118,89	183,12	273,56
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60	73,05	88,9	114,3	141,3	168,28	219,08	273,05
Wall thickness [mm]	3	3,05	3,05	3,05	3,4	3,4	3,76	4,19
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=3 m/s) [l/min]	412,03	634,30	973,91	1 617,74	2 424,85	3 394,73	6 113,20	9 625,50
Nominal Diameter [mm]	50	65	80	100	125	150	200	250
Nominal Diameter [in]	2	2 1/2	3	4	5	6	8	10
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3	219,1	273
ASME B36.19M-2004	2"	2 1/2"	3"	4"	5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30	219,10	273,00

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–22 mm	Male stud	GE -316	10–22		1/4"–3/4"	L-Series	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–22 mm – 37°-flaring O.D. 28–273 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 28–42 mm	Flange connection	3xx/ODxWtSS	28–42	3/4"–1 1/4"	1/4"–2"	SAE 3000 Psi	ISO 6162-1 (SAE J 518 Code 61)	AISI316 / AISI316L	
	Male thread flange	3xx014SS							
	Elbow block	3xx115SS							
	Tee block	3xx116SS							
	Reducer tee block	3xx/3xx/3xx116SS							
	Flange bend	3xx018SS							
	Bulkhead flange	3xx019SS							
	Reducer flange	RF3xx-3xxSS							
	Reducer block	RBE3xx-3xxSS							
	Blind flange	3xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 50–273 mm	Flange connection	1xx/ODxWtxxSS	50–273	1 1/2"–10"	1 1/2"–2"	SAE 50 bar	ISO 6162-1 (SAE J 518 Code 61)	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–22 mm – 37°-flaring O.D. 28–273 mm
	Elbow block	1xx115SS							
	Tee block	1xx116SS							
	Reducer tee block	1xx/1xx/1xx116SS							
	Flange bend	1xx018SS							
	Bulkhead flange	1xx019SS							
	Reducer flange	RF1xx-1xxSS							
	Reducer block	RBE1xx-1xxSS							
	Blind flange	1xx125SS							
Bolt	Hexagon head bolt		28–273				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		28–273				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–22					FPM (Viton®)	
			28–42				Bonded Seal	Stainless Steel and FPM (Viton®)	
			50–273				O-Ring	FPM (Viton®)	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4"–2"	G1 / GS1T		1/4"–2"			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
Hose fittings	1/4"–3/4"	G- / GSP-series P-series			1/4"–3/4"	L-series	ISO 12151-2	AISI316 / AISI316TI / W1.4571	
	1"–2"					SAE 3000 Psi (SAE J 518 Code 61)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	64	80	96	note: 8"=228xx 10"=260xx
1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	3 3/4"	4"	5"	6"	

Branch connections

RUN SIZE \ BRANCH SIZE	¼"	⅜"	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	4"	5"	6"	8"	10"
½"	T-DIN	T-DIN	T-DIN												
¾"	T-DIN	T-DIN	T-DIN	T-DIN											
1"	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN										
1¼"	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP									
1½"	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL								
2"	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL							
2½"	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL						
3"	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL					
4"	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
5"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL			
6"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL		
8"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL	
10"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	BL	TE / BL	TE / BL	TE / BL

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel, Ice Class -50 °C 50 bar / 750 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 50 + 60 °C**	**0 mm**	**50 bar / 750 Psi**	**GSSS02-02**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	15	18	22	28	35	42	50
Wall thickness [mm]	1,5	1,5	2	2	2	2	3	3	3
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	11,54	19,08	28,5	46,16	76,3	135,65	198,06	305,21	455,93
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60	73,05	88,9	114,3	141,3	168,28	219,08	273,05
Wall thickness [mm]	3	3,05	3,05	3,05	3,4	3,4	3,76	4,19
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	412,03	634,30	973,91	1 617,74	2 424,85	3 394,73	6 113,20	9 625,50
Nominal Diameter [mm]	50	65	80	100	125	150	200	250
Nominal Diameter [in]	2	2 1/2	3	4	5	6	8	10
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3	219,1	273
ASME B36.19M-2004	2"	2 1/2"	3"	4"	5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30	219,10	273,00

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–22 mm	Male stud	GE -316	10–22		1/4"–3/4"	L-Series	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–22 mm – 37°-flaring O.D. 28–273 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 28–42 mm	Flange connection	3xx/ODxWtSS	28–42	3/4"–1 1/4"	1"– 1 1/4"	SAE 3000 Psi	ISO 6162-1 (SAE J 518 Code 61)	AISI316 / AISI316L	
	Male thread flange	3xx014SS							
	Elbow block	3xx115SS							
	Tee block	3xx116SS							
	Reducer tee block	3xx/3xx/3xx116SS							
	Flange bend	3xx018SS							
	Bulkhead flange	3xx019SS							
	Reducer flange	RF3xx-3xxSS							
	Reducer block	RBE3xx-3xxSS							
	Blind flange	3xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 50–273 mm	Flange connection	1xx/ODxWtxxSS	50–273	1 1/2"–8"	1 1/2"–2"	SAE 50 bar	ISO 6162-1 (SAE J 518 Code 61)	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–22 mm – 37°-flaring O.D. 28–273 mm
	Elbow block	1xx115SS							
	Tee block	1xx116SS							
	Reducer tee block	1xx/1xx/1xx116SS							
	Flange bend	1xx018SS							
	Bulkhead flange	1xx019SS							
	Reducer flange	RF1xx-1xxSS							
	Reducer block	RBE1xx-1xxSS							
	Blind flange	1xx125SS							
Bolt	Hexagon head bolt		28–273				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		28–273				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–22					FPM (Viton®)	
			28–42				Bonded Seal	Stainless Steel and FPM (Viton®)	
			50–273				O-Ring	FPM (Viton®)	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4"–2"	G1 / GS1T		1/4"–2"			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
Hose fittings	1/4"–3/4"	G- / GSP-series P-series			1/4"–3/4"	L-series	ISO 12151-2	AISI316 / AISI316TI / W1.4571	
	1"–2"					SAE 3000 Psi (SAE J 518 Code 61)	ISO 12151-3		

*) xx=components size code

08	12	16	20	24	32	40	48	56	64	80	96	note: 8"=228xx 10"=260xx
1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	3 3/4"	4"	5"	6"	

Branch connections

RUN SIZE \ BRANCH SIZE	¼"	⅜"	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	4"	5"	6"	8"	10"
½"	T-DIN	T-DIN	T-DIN												
¾"	T-DIN	T-DIN	T-DIN	T-DIN											
1"	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN										
1¼"	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP									
1½"	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL								
2"	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL							
2½"	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL						
3"	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL					
4"	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
5"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL			
6"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL		
8"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL	
10"	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	BL	TE / BL	TE / BL	TE / BL

T-DIN = Tee Fitting ISO 8434-1

TE = Tee or Reduction Tee Flange

BL = Tee or Reduction Tee Block

BLBSP = Reduction Tee Block BSP

TBN = Reduction Tee Between BSP thread

Stainless Steel, Ice Class -50 °C 150 bar / 2250 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 50 + 60 °C**	**0 mm**	**150 bar / 2250 Psi**	**GSSS02-03**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	16	20	25	30	38	42	50
Wall thickness [mm]	1,5	1,5	2	2,5	2,5	3	4	4	5
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	11,54	19,08	33,91	52,99	94,2	135,65	211,95	272,24	376,8
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60	73,05	88,9	114,3	141,3	168,28	219,08	273,05
Wall thickness [mm]	5	7,01	7,67	13,49	15,88	14,27	18,26	25,4
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	588,75	821,02	1 274,55	1 796,55	2 827,20	4 601,00	7 852,75	11 638,43
Nominal Diameter [mm]	50	65	80	100	125	150	200	250
Nominal Diameter [in]	2	2 1/2	3	4	5	6	8	10
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3	219,1	273
ASME B36.19M-2004	2"	2 1/2"	3"	4"	5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30	219,10	273,0

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–25 mm	Male stud	GE -316	10–25		3/8"–1"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–88,9 mm – Retain Ring O.D. 114,3–273 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 30–88,9 mm	Flange connection	3xx/ODxWtSS	30–88,9	1"–3"	1"–2"	SAE 3000 Psi	ISO 6162-1 (SAE J 518 Code 61)	AISI316 / AISI316L	
	Male thread flange	3xx014SS							
	Elbow block	3xx115SS							
	Tee block	3xx116SS							
	Reducer tee block	3xx/3xx/3xx116SS							
	Flange bend	3xx018SS							
	Bulkhead flange	3xx019SS							
	Reducer flange	RF3xx-3xxSS							
	Reducer block	RBE3xx-3xxSS							
	Blind flange	3xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 114,3 mm	Flange connection	4xxSS	114,3	4″	1 1/2″–2″	400-series (350–400 bar)	ISO 6164	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–88,9 mm – Retain Ring O.D. 114,3–273 mm
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							
Pipe O.D. 141,3–273 mm	Flange connection	8xxSS	141,3–273	4 1/2″–10″		800-series (350–400 bar)			
	Elbow block	8xx115SS							
	Tee block	8xx116SS							
	Reducer tee block	8xx/8xx/8xx116SS							
	Flange bend	8xx018SS							
	Bulkhead flange	8xx019SS							
	Reducer flange	RF8xx-8xxSS							
	Reducer block	RBE8xx-8xxSS							
	Blind flange	8xx125SS							
Bolt	Hexagon head bolt		30–273				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		30–273				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–25					FPM (Viton®)	
			30–273				Bonded Seal	Stainless Steel and FPM (Viton®)	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4″–1″	M3K GS2C		1/4″ –1″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	1 1/4″–2″	EFG3K GS4SH		1 1/4″–2″					
Hose fittings	1/4″–3/4″	G- / P-series			1/4″–3/4″	S Series (Heavy)	ISO 12151-2	AISI316 / AISI316TI / W1.4571	
	1″–2″	GSP / GSH / I-series				SAE 3000 Psi (SAE J 518 Code 61)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″	8″	10″
½″	T-DIN	T-DIN	T-DIN												
¾″	T-DIN	T-DIN	T-DIN	T-DIN											
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN										
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP									
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL								
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL							
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL						
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL					
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL			
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL		
8″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL	
10″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	BL	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel, Ice Class -50 °C 210 bar / 3000 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 50 + 60 °C**	**0 mm**	**210 bar / 3000 Psi**	**GSSS02-04**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	16	20	25	30	38	42	50
Wall thickness [mm]	2	2	2	2,5	2,5	3	4	4	5
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	8,48	15,07	33,91	52,99	94,2	135,65	211,95	272,24	376,8
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60	73,05	88,9	114,3	141,3	168,28	219,08	273,05
Wall thickness [mm]	5	7,01	7,67	13,49	15,88	14,27	18,26	25,4
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	588,75	821,02	1 274,55	1 796,55	2 827,20	4 601,00	7 852,75	11 638,43
Nominal Diameter [mm]	50	65	80	100	125	150	200	250
Nominal Diameter [in]	2	2 1/2	3	4	5	6	8	10
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3	219,1	273
ASME B36.19M-2004	2"	2 1/2"	3"	4"	5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30	219,10	273,0

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–25 mm	Male stud	GE -316	10–25		3/8"–1"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–88,9 mm – Retain Ring O.D. 114,3–273 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 30–88,9 mm	Flange connection	3xx/ODxWtSS	30–88,9	1"–3"	1"–2"	SAE 3000 Psi	ISO 6162-1 (SAE J 518 Code 61)	AISI316 / AISI316L	
	Male thread flange	3xx014SS							
	Elbow block	3xx115SS							
	Tee block	3xx116SS							
	Reducer tee block	3xx/3xx/3xx116SS							
	Flange bend	3xx018SS							
	Bulkhead flange	3xx019SS							
	Reducer flange	RF3xx-3xxSS							
	Reducer block	RBE3xx-3xxSS							
	Blind flange	3xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 114,3 mm	Flange connection	4xxSS	114,3	4″	1 1/2″–2″	400-series (350–400 bar)	ISO 6164	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–88,9 mm – Retain Ring O.D. 114,3–273 mm
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							
Pipe O.D. 141,3–273 mm	Flange connection	8xxSS	141,3–273	4 1/2″–10″		800-series (350–400 bar)			
	Elbow block	8xx115SS							
	Tee block	8xx116SS							
	Reducer tee block	8xx/8xx/8xx116SS							
	Flange bend	8xx018SS							
	Bulkhead flange	8xx019SS							
	Reducer flange	RF8xx-8xxSS							
	Reducer block	RBE8xx-8xxSS							
	Blind flange	8xx125SS							
Bolt	Hexagon head bolt		30–273				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		30–273				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–25					FPM (Viton®)	
			30–273				Bonded Seal	Stainless Steel and FPM (Viton®)	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4″–1″	M3K GS2C		1/4″–1″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	1 1/4″–2″	EFG3K GS4SH		1 1/4″–2″					
Hose fittings	1/4″–1″	G- / P-series			1/4″–1″	S Series (Heavy)	ISO 12151-2	AISI316 / AISI316TI / W1.4570	
	11/4″–2″	GSP / GSH / I-series				SAE 3000 Psi (SAE J 518 Code 61)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″	8″	10″
½″	T-DIN	T-DIN	T-DIN												
¾″	T-DIN	T-DIN	T-DIN	T-DIN											
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN										
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP									
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL								
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL							
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL						
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL					
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL			
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL		
8″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL	
10″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	BL	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel, Ice Class -50 °C 250 bar / 3600 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 50 + 60 °C**	**0 mm**	**250 bar / 3600 Psi**	**GSSS02-05**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	16	20	25	30	38	42	50
Wall thickness [mm]	2	2	2	2,5	2,5	3	4	4	5
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	8,48	15,07	33,91	52,99	94,2	135,65	211,95	272,24	376,8
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60	73,05	88,9	114,3	141,3	168,28	219,08	273,05
Wall thickness [mm]	6	7,01	11,13	13,49	15,88	18,26	23,01	25,58
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	542,59	821,02	1 046,36	1 796,55	2 827,20	4 090,51	7 056,74	10 981,86
Nominal Diameter [mm]	50	65	80	100	125	150	200	250
Nominal Diameter [in]	2	2 1/2	3	4	5	6	8	10
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3	219,1	273
ASME B36.19M-2004	2"	2 1/2"	3"	4"	5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30	219,10	273,0

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–25 mm	Male stud	GE -316	10–25		3/8"–1"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–73 mm – Retain Ring O.D. 88,9–273 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 30–73 mm	Flange connection	6xx/ODxWtSS	30–73	1"–2 1/2"	1"–2"	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	AISI316 / AISI316L	
	Male thread flange	6xx014SS							
	Elbow block	6xx115SS							
	Tee block	6xx116SS							
	Reducer tee block	6xx/6xx/6xx116SS							
	Flange bend	6xx018SS							
	Bulkhead flange	6xx019SS							
	Reducer flange	RF6xx-6xxSS							
	Reducer block	RBE6xx-6xxSS							
	Blind flange	6xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 88,9–114,3 mm	Flange connection	4xxSS	88,9–114,3	3–4″	1 1/2″–2″	400-series (350–400 bar)	ISO 6164	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–25 mm – 37°-flaring O.D. 30–73 mm – Retain Ring O.D. 88,9–273 mm
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							
Pipe O.D. 141,3–273 mm	Flange connection	8xxSS	141,3–273	4 1/2″–10″		800-series (350–400 bar)			
	Elbow block	8xx115SS							
	Tee block	8xx116SS							
	Reducer tee block	8xx/8xx/8xx116SS							
	Flange bend	8xx018SS							
	Bulkhead flange	8xx019SS							
	Reducer flange	RF8xx-8xxSS							
	Reducer block	RBE8xx-8xxSS							
	Blind flange	8xx125SS							
Bolt	Hexagon head bolt		30–273				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		30–273				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–25					FPM (Viton®)	
			30–273				Bonded Seal	Stainless Steel and FPM (Viton®)	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4″–1″	M4K GS2C		1/4″–1″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	11/4″–2″	EFG5K GS5SH		1 1/4″–2″					
Hose fittings	1/4″–1″	G- / P-series			1/4″–1″	S Series (Heavy)	ISO 12151-2	AISI316 / AISI316TI / W1.4570	
	11/4″–2″	GSH / I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″	8″	10″
½″	T-DIN	T-DIN	T-DIN												
¾″	T-DIN	T-DIN	T-DIN	T-DIN											
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN										
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP									
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL								
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL							
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL						
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL					
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL				
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL			
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL		
8″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	TE / BL	TE / BL	TE / BL	
10″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	BL	BL	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel, Ice Class -50 °C 280 bar / 4000 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 50 + 60 °C**	**0 mm**	**280 bar / 4000 Psi**	**GSSS02-06**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	16	20	25	30	38	42	50
Wall thickness [mm]	2	2	2	3	3	4	4	4	5
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	8,48	15,07	33,91	46,16	85,02	113,98	211,95	272,24	376,8
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60	73,05	88,9	114,3	141,3	168,28	219,08	273,05
Wall thickness [mm]	6	7,01	11,13	13,49	15,88	18,26	23,01	28,58
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	542,59	821,02	1 046,36	1 796,55	2 827,20	1 090,51	7 056,74	10 981,86
Nominal Diameter [mm]	50	65	80	100	125	150	200	250
Nominal Diameter [in]	2	2 1/2	3	4	5	6	8	10
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150	DN 200	DN 250
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3	219,1	273
ASME B36.19M-2004	2"	2 1/2"	3"	4"	5"	6"	8"	10"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30	219,10	273,0

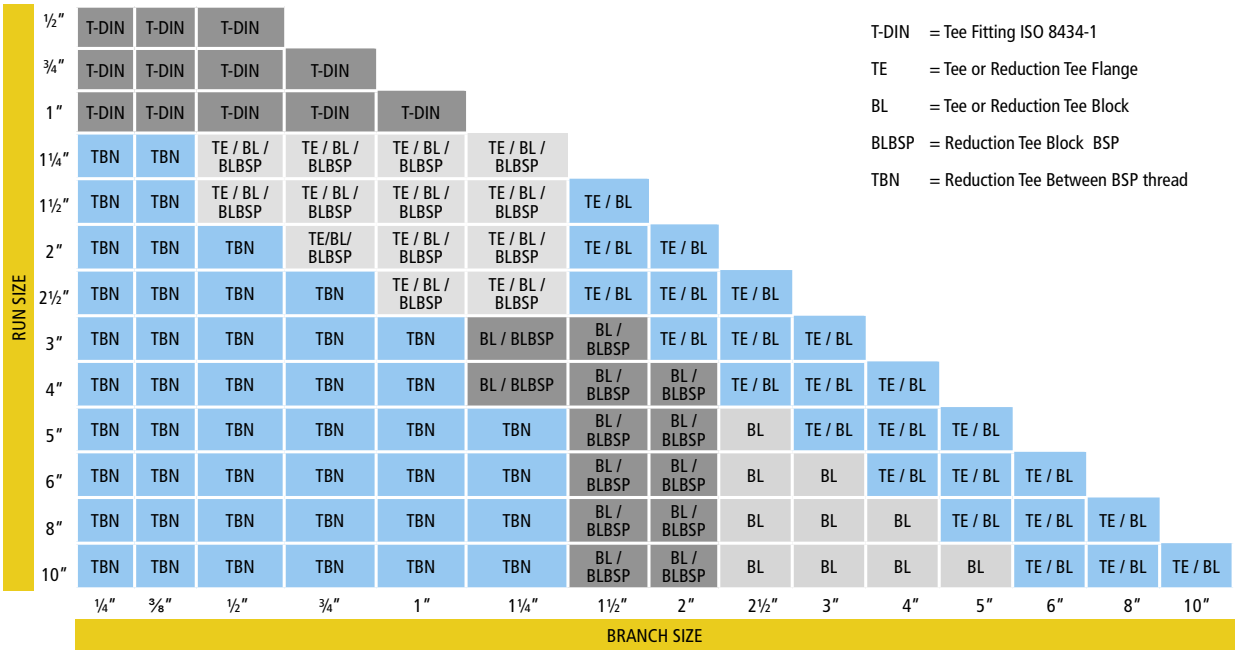
Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–20 mm	Male stud	GE -316	10–20		3/8"–3/4"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–20 mm – 37°-flaring O.D. 25–73 mm – Retain Ring O.D. 88,9–273 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 25–60 mm	Flange connection	6xx/ODxWtSS	25–60	3/4"–2"	1/2"–2"	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	AISI316 / AISI316L	
	Male thread flange	6xx014SS							
	Elbow block	6xx115SS							
	Tee block	6xx116SS							
	Reducer tee block	6xx/6xx/6xx116SS							
	Flange bend	6xx018SS							
	Bulkhead flange	6xx019SS							
	Reducer flange	RF6xx-6xxSS							
	Reducer block	RBE6xx-6xxSS							
	Blind flange	6xx125SS							
Pipe O.D. 73 mm	Flange connection	4xx/ODxWtSS	73	2 1/2"		400-series (350–400 bar)	ISO 6164		
	Male thread flange	4xx014SS							
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 88,9–114,3 mm	Flange connection	4xxSS	88,9–114,3	3–4″	1 1/2″–2″	400-series (350–400 bar)	ISO 6164	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–20 mm – 37°-flaring O.D. 25–73 mm – Retain Ring O.D. 88,9–273 mm
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							
Pipe O.D. 141,3–273 mm	Flange connection	8xxSS	141,3–273	4 1/2″–10″		800-series (350–400 bar)			
	Elbow block	8xx115SS							
	Tee block	8xx116SS							
	Reducer tee block	8xx/8xx/8xx116SS							
	Flange bend	8xx018SS							
	Bulkhead flange	8xx019SS							
	Reducer flange	RF8xx-8xxSS							
	Reducer block	RBE8xx-8xxSS							
	Blind flange	8xx125SS							
Bolt	Hexagon head bolt		25–273				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		25–273				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–20					FPM (Viton®)	
			25–273				Bonded Seal	Stainless Steel and FPM (Viton®)	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–273			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4″–3/4″	M4K GS2C		1/4″–3/4″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	1″–2″	EFG5SK GSR13		1″–2″			EN 856 R13 SAE 100R13 ISO 3862-1 R13		
Hose fittings	1/4″–3/4″	G- / P-series			1/4″–3/4″	S Series (Heavy)	ISO 12151-2	AISI316 / AISI316TI / W1.4570	
	1″–2″	GSH / I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections



Stainless Steel, Ice Class -50 °C 315 bar / 4500 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 50 + 60 °C**	**0 mm**	**315 bar / 4500 Psi**	**GSSS02-07**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	16	20	25	30	38	42,16	50
Wall thickness [mm]	2	2,5	2	2,5	3	4	5	6,35	6
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	8,48	11,54	33,93	53,01	94,25	114,04	184,63	204,49	340,06
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60,3	73,05	88,9	114,3	141,3	168,28
Wall thickness [mm]	8,74	9,53	11,13	13,49	19,05	21,95
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	431,8	686,72	1 046,36	1 796,55	2 509,40	3 645,12
Nominal Diameter [mm]	50	65	80	100	125	150
Nominal Diameter [in]	2	21/2	3	4	5	6
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3
ASME B36.19M-2004	2"	21/2"	3"	4"	5"	6"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–20 mm	Male stud	GE -316	10–20		3/8"–3/4"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–20 mm – 37°-flaring O.D. 25–73 mm – Retain Ring O.D. 88,9–168,3 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 25–60,3 mm	Flange connection	6xx/ODxWtSS	25–60,3	3/4"–2"	1/2"–2"	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)		
	Male thread flange	6xx014SS							
	Elbow block	6xx115SS							
	Tee block	6xx116SS							
	Reducer tee block	6xx/6xx/6xx116SS							
	Flange bend	6xx018SS							
	Bulkhead flange	6xx019SS							
	Reducer flange	RF6xx-6xxSS							
	Reducer block	RBE6xx-6xxSS							
	Blind flange	6xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 73,05–114,3 mm	Flange connection	4xxSS	73,05–114,3	3″–4″		400-series (350–400 bar)	ISO 6164		Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–20 mm – 37°-flaring O.D. 25–60,3 mm – Retain Ring O.D. 73,05–168,3 mm
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							
Pipe O.D. 141,3–168,3 mm	Flange connection	8xxSS	141,3–168,3	5″– 6″		800-series (350–400 bar)			
	Elbow block	8xx115SS							
	Tee block	8xx116SS							
	Reducer tee block	8xx/8xx/8xx116SS							
	Flange bend	8xx018SS							
	Bulkhead flange	8xx019SS							
	Reducer flange	RF8xx-8xxSS							
	Reducer block	RBE8xx-8xxSS							
	Blind flange	8xx125SS							
Bolt	Hexagon head bolt		25–168,3				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		25–168,3				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–20					FPM (Viton®)	
			25–168,3				Bonded Seal	Stainless Steel and FPM (Viton®)	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–168,3			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4″–3/4″	M4K GS2C		1/4″–3/4″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	1″–2″	EFG5K GS5SH		1″–2″			EN 856 R13 SAE 100R13 ISO 3862-1 R13		
Hose fittings	1/4″–3/4″	G- / P-series			1/4″–3/4″	S Series (Heavy)	ISO 12151-2	AISI316 / AISI316TI / W1.4570	
	1″–2″	GSH / I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″
½″	T-DIN	T-DIN	T-DIN										
¾″	T-DIN	T-DIN	T-DIN	T-DIN									
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN								
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP							
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL						
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL					
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL				
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL			
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL		
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL	
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel, Ice Class -50 °C 350 bar / 5000 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 50 + 60 °C**	**0 mm**	**350 bar / 5000 Psi**	**GSSS02-08**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	16	20	25	30	38	42,16	48,26
Wall thickness [mm]	2	2,5	2,5	3	4	4	5	6,35	7,14
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	8,48	11,54	28,51	46,18	68,09	114,04	184,63	204,49	272,14
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60,3	73,05	88,9	114,3	141,3	168,28
Wall thickness [mm]	8,72	14,02	15,24	17,12	19,05	21,95
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	432,02	477,34	804,14	1 510,23	2 509,40	3 645,12
Nominal Diameter [mm]	50	65	80	100	125	150
Nominal Diameter [in]	2	21/2	3	4	5	6
Nominal diameter	DN 50	DN 65	DN 80	DN 100	DN 125	DN 150
O.D. [mm]	60,3	76,1	88,9	114,3	139,3	168,3
ASME B36.19M-2004	2"	21/2"	3"	4"	5"	6"
O.D. [mm]	60,30	73,00	88,90	114,30	141,3	168,30

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–12 mm	Male stud	GE -316	10–12		3/8"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–60,3 mm – Retain Ring O.D. 73–168,3 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 16–60,3 mm	Flange connection	6xx/ODxWtSS	16–60,3	3/8"–2"	1/2"–2"	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	AISI316 / AISI316L	
	Male thread flange	6xx014SS							
	Elbow block	6xx115SS							
	Tee block	6xx116SS							
	Reducer tee block	6xx/6xx/6xx116SS							
	Flange bend	6xx018SS							
	Bulkhead flange	6xx019SS							
	Reducer flange	RF6xx-6xxSS							
	Reducer block	RBE6xx-6xxSS							
	Blind flange	6xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 73–114,3 mm	Flange connection	4xxSS	73–114,3 mm	2 1/2–4″	1 1/2″–2″	400-series (350–400 bar)	ISO 6164	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–60,3 mm – Retain Ring O.D. 73–168,3 mm
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							
Pipe O.D. 141,3–168,3 mm	Flange connection	8xxSS	141,3–168,3	5″– 6″		800-series (350–400 bar)			
	Elbow block	8xx115SS							
	Tee block	8xx116SS							
	Reducer tee block	8xx/8xx/8xx116SS							
	Flange bend	8xx018SS							
	Bulkhead flange	8xx019SS							
	Reducer flange	RF8xx-8xxSS							
	Reducer block	RBE8xx-8xxSS							
	Blind flange	8xx125SS							
Bolt	Hexagon head bolt		16–168,3				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		16–168,3				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–12					FPM (Viton®)	
			16–168,3				Bonded Seal	Stainless Steel and FPM (Viton®)	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–168,3			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4″–1/2″	M4K GS2C		1/4″–1/2″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	5/8″–2″	EFG5K GSR13		5/8″–2″			EN 856 R13 SAE 100R13 ISO 3862-1 R13		
Hose fittings	1/4″– 1/2″	G- / P-series			1/4″–1/2″	S Series (Heavy)	ISO 12151-2	AISI316 / AISI316TI / W1.4570	
	5/8″–2″	GSH / I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE \ BRANCH SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″	5″	6″
½″	T-DIN	T-DIN	T-DIN										
¾″	T-DIN	T-DIN	T-DIN	T-DIN									
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN								
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP							
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL						
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL					
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL				
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL			
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL		
5″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	TE / BL	TE / BL	TE / BL	
6″	TBN	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL	BL	TE / BL	TE / BL	TE / BL

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel, Ice Class -50 °C 380 bar / 5500 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 50 + 60 °C**	**0 mm**	**380 bar / 5500 Psi**	**GSSS02-09**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	16	20	25	30	38	42,16	48,26
Wall thickness [mm]	2	2,5	2,5	3	4	4	5	9,7	10,16
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	8,48	11,54	28,51	46,18	68,09	114,04	184,63	122,05	183,93
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20	DN 25		DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9	33,7		42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1"		1 1/4"	1 1/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60,3	73,05	88,9	114,3
Wall thickness [mm]	11,07	14,02	15,24	17,12
Material	AISI316L	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	343,11	477,34	804,14	1 510,23
Nominal Diameter [mm]	50	65	80	100
Nominal Diameter [in]	2	21/2	3	4
Nominal diameter	DN 50	DN 65	DN 80	DN 100
O.D. [mm]	60,3	76,1	88,9	114,3
ASME B36.19M-2004	2"	21/2"	3"	4"
O.D. [mm]	60,30	73,00	88,90	114,30

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–12 mm	Male stud	GE -316	10–12		3/8"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–38 mm – Retain Ring O.D. 42–114,3 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 16–38 mm	Flange connection	6xx/ODxWtSS	16–38	3/8"–1 1/4"	1/2"–1"	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	AISI316 / AISI316L	
	Male thread flange	6xx014SS							
	Elbow block	6xx115SS							
	Tee block	6xx116SS							
	Reducer tee block	6xx/6xx/6xx116SS							
	Flange bend	6xx018SS							
	Bulkhead flange	6xx019SS							
	Reducer flange	RF6xx-6xxSS							
	Reducer block	RBE6xx-6xxSS							
	Blind flange	6xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 42,16–60,3 mm	Flange connection	6xxSS	42,16–60,3	1 1/4–2″	1 1/4″–2″	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–38 mm – Retain Ring O.D. 42–114,3 mm
	Elbow block	6xx115SS							
	Tee block	6xx116SS							
	Reducer tee block	6xx/6xx/6xx116SS							
	Flange bend	6xx018SS							
	Bulkhead flange	6xx019SS							
	Reducer flange	RF6xx-6xxSS							
	Reducer block	RBE6xx-6xxSS							
	Blind flange	6xx125SS							
Pipe O.D. 73–114,3 mm	Flange connection	4xxSS	73–114,3	2 1/2″–4″		400-series (350–400 bar)	ISO 6164		
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							
Bolt	Hexagon head bolt		16–114,3				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		16–114,3				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–12					FPM (Viton®)	
			16–114,3				Bonded Seal	Stainless Steel and FPM (Viton®)	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–114,3			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4″–1/2″	M4K GS2C		1/4″–1/2″			EN 857 2SC SAE 100R19 ISO 11237 R19	Synthetic rubber	
	5/8″–2″	EFG6K GSR15		5/8″–2″			EN 856 R13 SAE 100R13 ISO 3862-1 R13		
Hose fittings	1/4″– 1/2″	G- / P-series			1/4″–1/2″	S Series (Heavy)	ISO 12151-2	AISI316 / AISI316TI / W1.4570	
	5/8″–2″	GSH / I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″	4″
½″	T-DIN	T-DIN	T-DIN								
¾″	T-DIN	T-DIN	T-DIN	T-DIN							
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN						
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP					
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL				
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL			
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL		
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL	
4″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL

BRANCH SIZE

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Stainless Steel, Ice Class -50 °C 420 bar / 6000 Psi

TECHNICAL SPECIFICATION					
Service / Fluid	Temp. Range	Corrosion Allowance	Class / Pressure (Bar/Psi)	Standard	Revision
Hydraulic	**- 50 + 60 °C**	**0 mm**	**420 bar / 6000 Psi**	**GSSS02-10**	**1**
Pipe standard:	**ASTM A269 / A213 - Grade TP316L** (metric sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %
	ASTM A312 / A530 - Grade TP316L (imperial sizes)	Tensile strength min 485 N/mm²	Proof strength $R_{p0,2}$ min 170 N/mm²		Elongation at break min. 35 %

Pipe calculation according to DNV – Bended Pipes. High dynamic systems demand separate calculations.

Outside diameter [mm]	10	12	16	20	25	33,4		42,16	48,26
Wall thickness [mm]	1,5	2	2,5	3	4	6,35		9,7	10,16
Material	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L	AISI316L		AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	11,55	15,08	28,51	46,18	68,09	100,96		122,05	183,93
Nominal Diameter [mm]	6	8	10	15	20	25		32	40
Nominal Diameter [in]	1/8	1/4	3/8	1/2	3/4	1		1 1/4	1 1/2
Nominal diameter	DN 6	DN 8	DN 12	DN 15	DN 20			DN 32	DN 40
O.D. [mm]	10,3	13,7	17,1	21,3	26,9			42,4	48,3
ASME B36.19M-2004	1/8"	1/4"	3/8"	1/2"	3/4"	1''		11/4"	11/2"
O.D. [mm]	10,3	13,7	17,1	21,3	26,67	33,40		42,16	48,26

Outside diameter [mm]	60,3	73,05	88,9
Wall thickness [mm]	11,07	14,02	15,24
Material	AISI316L	AISI316L	AISI316L
Flow (v=5 m/s) [l/min]	343,11	477,34	804,14
Nominal Diameter [mm]	50	65	80
Nominal Diameter [in]	2	21/2	3
Nominal diameter	DN 50	DN 65	DN 80
O.D. [mm]	60,3	76,1	88,9
ASME B36.19M-2004	2"	21/2"	3"
O.D. [mm]	60,30	73,00	88,90

Item		Type	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 10–12 mm	Male stud	GE -316	10–12		3/8"–1"	S-Series (Heavy)	ISO 8434-1 (DIN 2353)	AISI316 / AISI-316TI / W1.4401/ W1.4571	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–33,4 mm – Retain Ring O.D. 42,1–88,9 mm
	Straight union	G -316							
	Reducer straight union	GR -316							
	Union T	T -316							
	Union elbow	W -316							
	Union cross	K -316							
	Union Weld bulkhead	ESV -316							
	Union bulkhead	SV -316							
	Reducer	RED -316							
	Thread reducer	RI -316							
	Blanking plug	VSTI -316							
Pipe O.D. 16–33,4 mm	Flange connection	6xx/ODxWtSS	16–33,4	3/8"–1"	1/2"–2"	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 62)		
	Male thread flange	6xx014SS							
	Elbow block	6xx115SS							
	Tee block	6xx116SS							
	Reducer tee block	6xx/6xx/6xx116SS							
	Flange bend	6xx018SS							
	Bulkhead flange	6xx019SS							
	Reducer flange	RF6xx-6xxSS							
	Reducer block	RBE6xx-6xxSS							
	Blind flange	6xx125SS							

Item		Tag	Pipe Size [mm]	Pipe Size [in]	Thread size BSP [in]	Class	Standard	Material	Connection Technology
Pipe O.D. 42,16–60,3 mm	Flange connection	6xxSS	42,16–60,3	1 1/4–2″	1 1/4″–2″	SAE 6000 Psi	ISO 6162-2 (SAE J 518 Code 61)	AISI316 / AISI316L	Notes: All piping connections with non-welded technology Acceptable technology: – Tube endforming O.D. 10–12 mm – 37°-flaring O.D. 16–33,4 mm – Retain Ring O.D. 42,1–88,9 mm
	Elbow block	6xx115SS							
	Tee block	6xx116SS							
	Reducer tee block	6xx/6xx/6xx116SS							
	Flange bend	6xx018SS							
	Bulkhead flange	6xx019SS							
	Reducer flange	RF6xx-6xxSS							
	Reducer block	RBE6xx-6xxSS							
	Blind flange	6xx125SS							
Pipe O.D. 73–88,9 mm	Flange connection	4xxSS	73–88,9	2 1/2″–3″		400-series (350–400 bar)	ISO 6164		
	Elbow block	4xx115SS							
	Tee block	4xx116SS							
	Reducer tee block	4xx/4xx/4xx116SS							
	Flange bend	4xx018SS							
	Bulkhead flange	4xx019SS							
	Reducer flange	RF4xx-4xxSS							
	Reducer block	RBE4xx-4xxSS							
	Blind flange	4xx125SS							
Bolt	Hexagon head bolt		16–88,9				DIN 912 / ASME B/8.2.2	A4-80	
Nut	Hexagon nut		16–60,3				DIN 934 / ASME B/8.2.2	A4-80	
Gasket			10–12					FPM (Viton®)	
			16–88,9				Bonded Seal	Stainless Steel and FPM (Viton®)	
Pipework fastening	Clamp	SPALxxxxPP-DPAL-AS	10–114,3			S Series (Heavy)	DIN 3015	Polypropylene & AISI316	
Hose	1/4″	M4K GS2C		1/4″			EN 857 2SC ISO 11237	Synthetic rubber	
	3/8″–2″	EFG6K GSR15		3/8″–2″			EN 856 R15 SAE 100R15 ISO 3862-1 R15		
Hose fittings	1/4″– 1/2″	G- / P-series			1/4″–1/2″	S Series (Heavy)	ISO 12151-2	AISI316 / AISI316TI / W1.4570	
	3/8″–2″	GSH / I-series				SAE 6000 Psi (SAE J 518 Code 62)	ISO 12151-3		

*) SS=Stainless Steel
xx=components size code

08	12	16	20	24	32	40	48	56	60	64	80	88	96	160
1/2″	3/4″	1″	1 1/4″	1 1/2″	2″	2 1/2″	3″	4″	4 1/2″	5″	6″	8″	8″	10″

Branch connections

RUN SIZE \ BRANCH SIZE	¼″	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″
½″	T-DIN	T-DIN	T-DIN							
¾″	T-DIN	T-DIN	T-DIN	T-DIN						
1″	T-DIN	T-DIN	T-DIN	T-DIN	T-DIN					
1¼″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP				
1½″	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL			
2″	TBN	TBN	TBN	TE/BL/ BLBSP	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL		
2½″	TBN	TBN	TBN	TBN	TE / BL / BLBSP	TE / BL / BLBSP	TE / BL	TE / BL	TE / BL	
3″	TBN	TBN	TBN	TBN	TBN	BL / BLBSP	BL / BLBSP	TE / BL	TE / BL	TE / BL

T-DIN = Tee Fitting ISO 8434-1
TE = Tee or Reduction Tee Flange
BL = Tee or Reduction Tee Block
BLBSP = Reduction Tee Block BSP
TBN = Reduction Tee Between BSP thread

Relevant Rules and Guidelines from Classification Societies

American Bureau of Shipping 87
Det Norske Veritas 105
Germanischer Lloyd 115
Lloyd's Register 135

American Bureau of Shipping (ABS)

Rules for Materials and Welding 2013

Part 2 – Chapter 3 – Section 12

3 General

3.3 Grades 4 and 5

Grades 4 and 5 cover seamless carbon-steel pipe for high-temperature service. Pipe ordered to these grades is of a nominal (average) wall thickness and is to be suitable for bending, flanging and similar forming operations. Grade 4 rather than Grade 5 pipe should be used for close-coiling, cold-bending or forge-welding; this provision is not intended to prohibit the cold-bending of Grade 5 pipe.

3.5 Grade 6

Grade 6 covers seamless carbon-molybdenum alloy-steel pipe for high-temperature service. Pipe ordered to this grade is of a nominal (average) wall thickness and is to be suitable for bending, flanging (vanstoning) and similar forming operations, and for fusion-welding.

3.11 ASTM Designations (2006)

The various grades are in substantial agreement with ASTM, as follows:

ABS Grade	ASTM Designation
5	A106, Grade B
6	A335, Grade P1

35 Pipe Testing and Inspection

35.1 Group I Piping (2008)

Pipes intended for use in Group I piping systems (Class I and Class II, see 4-6-1/3, Rules for Building and Classing Steel Vessels) are to be tested, preferably at the mill, to the satisfaction of the Surveyor. The material surfaces will be examined by the Surveyor when specially requested by the purchaser. See also 4-6-7/3.5.1 of the Rules for Building and Classing Steel Vessels.

Rules for Building and Classing Steel vessels Part 4 Vessel Systems and Machinery

Part 4 – Chapter 5 – Section 1

1 General

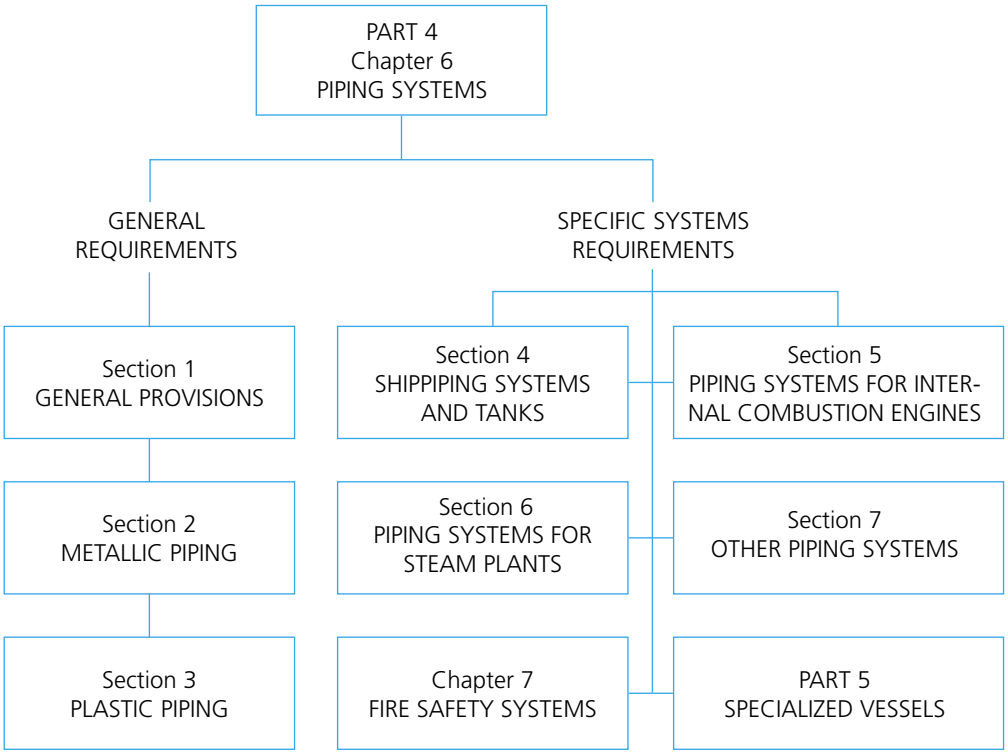
1.1 Application

The provisions of Part 4, Chapter 6, Section 1 (referred to as Section 4-6-1) apply to all piping systems. These include piping systems covered in Section 4-6-2 through Section 4-6-7, as well as to piping systems in Part 4, Chapter 7 “Fire Safety Systems”, and to piping systems of specialized types of vessels in the applicable sections of Part 5C.

1.3 Organization of Piping Systems Requirements

4-6-1/Figure 1 shows the organization of the provisions for piping systems. These requirements are divided into:

FIGURE 1 Organization of the Provisions for Piping Systems



ii) Specific systems requirements, which include:

• Other piping systems, such as hydraulic piping system, oxygen-acetylene piping system, etc.

3 Definitions

3.1 Piping

The term Piping refers to assemblies of piping components and pipe supports.

3.3 Piping System

Piping System is a network of piping and any associated pumps, designed and assembled to serve a specific purpose. Piping systems interface with, but exclude, major equipment, such as boilers, pressure vessels, tanks, diesel engines, turbines, etc.

3.5 Piping Components

Piping Components include pipes, tubes, valves, fittings, flanges, gaskets, bolting, hoses, expansion joints, sight flow glasses, filters, strainers, accumulators, instruments connected to pipes, etc.

3.7 Pipes

Pipes are pressure-tight cylinders used to contain and convey fluids. Where the word 'pipe' is used in this section, it means pipes conforming to materials and dimensions as indicated in Section 2-3-12, Section 2-3-13, Section 2-3-16 and Section 2-3-17, or equivalent national standards such as ASTM, BS, DIN, JIS, etc.

3.9 Pipe Schedule

Pipe Schedules are designations of pipe wall thicknesses as given in American National Standard Institute, ANSI B36.10. Standard and extra heavy (extra strong) pipes, where used in these sections, refer to Schedule 40 and Schedule 80, up to maximum wall thicknesses of 9.5 mm (0.375 in.) and 12.5 mm (0.5 in.), respectively. For a listing of commercial pipe sizes and wall thicknesses, see 4-6-2/Table 8.

3.11 Tubes

Tubes are generally small-diameter thin-wall pipes conforming to an appropriate national standard. Tubes are to meet the same general requirements as pipes.

3.13 Pipe Fittings

Pipe Fittings refer to piping components such as sleeves, elbows, tees, bends, flanges, etc., which are used to join together sections of pipe.

3.15 Valves

The term Valve refers to gate valves, globe valves, butterfly valves, etc., which are used to control the flow of fluids in a piping system. For the purpose of these Rules, test cocks, drain cocks and other similar components which perform the same function as valves are considered valves.

3.17 Design Pressure

Design Pressure is the pressure to which each piping component of a piping system is designed. It is not to be less than the pressure at the most severe condition of coincidental internal or external pressure and temperature (maximum or minimum) expected during service. However, the Rules do impose in some instances a specific minimum design pressure that exceeds the maximum expected service pressure, see for example 4-6-4/13.7 for heated fuel oil systems.

3.19 Maximum Allowable Working Pressure

The Maximum Allowable Working Pressure is the maximum pressure of a piping system determined, in general, by the weakest piping component in the system or by the relief valve setting. The maximum allowable working pressure is not to exceed the design pressure.

3.21 Design Temperature

The Design Temperature is the maximum temperature at which each piping component is designed to operate. It is not to be less than the temperature of the piping component material at the most severe condition of temperature and coincidental pressure expected during service. For purposes of the Rules, it may be taken as the maximum fluid temperature.

For piping used in a low-temperature application, the design temperature is to include also the minimum temperature at which each piping component is designed to operate. It is not to be higher than the temperature of the piping component material at the most severe condition of temperature and coincidental pressure expected during service. For the purposes of the Rules, it may be taken as the minimum fluid temperature.

For all piping, the design temperature is to be used to determine allowable stresses and material testing requirements.

5 Classes of Piping Systems

Piping systems are divided into three classes according to service, design pressure and temperature, as indicated in 4-6-1/Table 1. Each class has specific requirements for joint design, fabrication and testing. The requirements in this regard are given in Section 4-6-2 for metallic piping. For plastic piping, see Section 4-6-3.

TABLE 1 Classes of Piping Systems (2013)

Piping Class →	Class I $P > P_2$ OR $T > T_2$	Class II Bounded by Class I and Class III - see chart above	Class III $P \leq P_1$ AND $T \leq T_1$
Piping System ↓	bar, °C (kgf/cm², psi) (°F)	bar, °C (kgf/cm², psi) (°F)	bar, °C (kgf/cm², psi) (°F)
Fuel oil Lubricating oil Flammable hydraulic oil	16 150 (16.3, 232) (302)	See chart	7 60 (7.1, 101.5) (140)
Other fluids (including water, air, gases, non-flammable hydraulic oil)	40 300 (40.8, 580) (572)	See chart	16 200 (16.3, 232) (392)

7 Certification of Piping System Components

7.1 Piping Components

Piping components are to be certified in accordance with 4-6-1/Table 2 and the following.

7.1.1 ABS Certification
Where indicated as 'required' in 4-6-1/Table 2, the piping component is to be certified by ABS. This involves design approval of the component, as applicable, and testing in accordance with the standard of compliance at the manufacturer's plant. Such components may also be accepted under the Type Approval Program, see 4-6-1/7.5.

7.1.2 Design Approval
Design approval is a part of the ABS certification process and where indicated as 'required' in 4-6-1/Table 2, the piping components are to meet an applicable recognized standard, or are to be design-approved by ABS. For the latter purpose, pipe fittings and valves are to be evaluated for their adequacy for the rated pressures and temperatures, and, as applicable, type inspection and testing are to be conducted as part of the design evaluation process. See also 4-6-1/7.5, 4-6-2/5 and 4-6-3/5.

7.1.3 Manufacturer's Certification
Where indicated as 'required' in 4-6-1/Table 2, the manufacturer is to certify that the piping component complies with the standard to which the component is designed, fabricated and tested, and to report the results of tests so conducted. For Class III components, manufacturer's trademark, pressure/temperature rating and material identification, as applicable, stamped or cast on the component and verifiable against the manufacturer's catalog or similar documentation will suffice.

7.1.4 Identification
Where indicated as 'permanent' in 4-6-1/Table 2, the piping component is to bear permanent identification, such as manufacturer's name or trademark, standard of compliance, material identity, pressure rating, etc., as required by the standard of compliance or the manufacturer's specification. Such markings may be cast or forged integral with, stamped on, or securely affixed by nameplate on the component, and are to serve as a permanent means of identification of the component throughout its service life.

Where indicated as 'temporary', the pipe is to have identification for traceability during fabrication.

TABLE 2 Piping Classes and Certification

Piping Component	Class	ABS Certification [1]	Design Approval [1]	Manufacturer's Certification [1]	Identification [1]
Pipes	I, II	Required [2]	Not applicable [3]	Required	Temporary [3]
	III	Not required [3]	Not applicable [3]	Required	Temporary [3]
Pipe fittings	I, II	Not required	Required [4, 6]	Required	Permanent
	III	Not required	Not required [5 ,6]	Required	Permanent
Valves	I, II	Not required	Required [4]	Required	Permanent
	III	Not required	Not required [5]	Required	Permanent

Notes:
1. See 4-6-1/7.1.1, 4-6-1/7.1.2, 4-6-1/7.1.3 and 4-6-1/7.1.4.
2. Except hydraulic piping.
3. Except for plastic piping. See Section 4-6-3.
4. Where not in compliance with a recognized standard.
5. Documentary proof of pressure/temperature rating is required. See 4-6-2/5.15.
6. Design of flexible hoses and mechanical pipe joints is to be approved in each case. See 4-6-2/5.7 and 4-6-2/5.9, respectively.

7.5 Certification Based on the Type Approval Program

7.5.1 Pipes (2003)

For pipes which are required to be ABS certified in accordance with 4-6-1/Table 2, the manufacturer may request that ABS approve and list them under the Type Approval Program described in Appendix 1-1-A3. Upon approval under 1-1-A3/5.5 (PQA) and listing under this program, the pipes will not be required to be surveyed and certified each time they are manufactured for use onboard a vessel.
To be considered for approval under this program, the manufacturer is to operate a quality assurance system that is certified for compliance with a recognized quality standard. In addition, quality control of the manufacturing processes is to cover all of the provisions of inspection and tests required by the Rules and applicable pipe standard, in accordance with 1-1-A3/5.5.

7.5.2 Pipe Fittings and Valves (2003)

For pipe fittings and valves which are not required to be certified but are required to be design approved in accordance with 4-6-1/Table 2, the manufacturer may request that ABS approve and list the component as a Design Approved Product described in 1-1-A3/5.1. The design is to be evaluated in accordance with 4-6-1/7.1.2. Upon approval and listing, and subject to renewal and updating of the certificates as required by 1-1-A3/5.7, it will not be necessary to submit the design of the component for approval each time it is proposed for use onboard a vessel.

The manufacturer may also request that the product be approved and listed under the Type Approval Program. In this case, in addition to the design approval indicated above, the manufacturer is to provide documented attestation that the product will be manufactured to consistent quality and to the design and specifications to which it is approved. See 1-1-A3/5.3 (AQS)/(RQS) or 1-1-A3/5.5 (PQA).

Part 4 – Chapter 6 – Section 2

1 Application

The provisions of Part 4, Chapter 6, Section 2 (referred to as Section 4-6-2) cover metallic piping. They include requirements for piping materials, design, fabrication, inspection and testing. They also include general requirements for shipboard installation practices. Requirements for plastic piping are provided in Section 4-6-3.

5 Design

5.1 Pipes

The wall thickness of a pipe is not to be less than the greater of the value obtained by 4-6-2/5.1.1 or 4-6-2/5.1.3. However, 4-6-2/5.1.2 may be used as an alternative to 4-6-2/5.1.1.

5.1.1 Pipes Subject to Internal Pressure (2002)

The minimum wall thickness is not to be less than that calculated by the following equations or that specified in 4-6-2/5.1.3, whichever is greater. Units of measure are given in the order of SI (MKS, US) units, respectively. The use of these equations is subject to the following conditions:

- The following requirements apply for pipes where the outside to inside diameter ratio does not exceed a value of 1.7.
- Ferrous materials are to be those that have specified elevated temperature tensile properties required below.

$t = (t_0 + b + c)m$

$$t_0 = \frac{PD}{KSe + P}$$

where

t = minimum required pipe wall thickness (nominal wall thickness less manufacturing tolerance) ; mm (in.)
t_0 = minimum required pipe wall thickness due to internal pressure only; mm (in.)
P = design pressure; bar (kgf/cm2, psi)
D = outside diameter of pipe; mm (in.)
K = 20 (200, 2) for SI (MKS, US) units of measure, respectively
S = permissible stress; N/mm2 (kgf/mm2, psi); to be determined by a) or b) below:

a) Carbon steel and alloy steel pipes with a specified minimum elevated temperature yield stress or 0.2% proof stress: S is to be the lowest of the following three values:

$$\frac{\sigma_T}{2.7} \quad \frac{\sigma_Y}{1.8} \quad \frac{\sigma_R}{1.8}$$

where

σ_T = specified minimum tensile strength at room temperature, i.e., 20°C (68°F).
σ_Y = specified minimum yield strength at the design temperature.
σ_R = average stress to produce rupture in 100,000 hours at the design temperature.

b) Copper and copper alloys: S is to be in accordance with 4-6-2/Table 2.

e = efficiency factor, to be equated to:

1.0 for seamless pipes
1.0 for electric-resistance welded pipes manufactured to a recognized standard
0.6 for furnace butt-welded pipes

For other welded pipes, the joint efficiency is to be determined based on the welding procedure and the manufacturing and inspection processes.

b = allowance for bending; mm (in.). The value for b is to be chosen in such a way that the calculated stress in the bend, due to the internal pressure only, does not exceed the permissible stress. When the bending allowance is not determined by a more accurate method, it is to be taken as:

$$b = 0.4 \frac{D}{R} T_0$$

R = mean radius of the bend; mm (in.)

c = corrosion allowance; mm (in.); to be determined as follows:
- For steel pipes, the value for c is to be in accordance with 4-6-2/Table 3.
- For non-ferrous metal pipes (excluding copper-nickel alloys containing 10% or more nickel), c = 0.8 mm (0.03 in.).
- For copper-nickel alloys containing 10% or more nickel, c = 0.5 mm (0.02 in.).
- Where the pipe material is corrosion resistant with respect to the media, e.g., special alloy steel, c = 0.

m = coefficient to account for negative manufacturing tolerance when pipe is ordered by its nominal wall thickness, calculated as follows:

$$= \frac{100}{100 - a}$$

a = percentage negative manufacturing tolerance, or 12.5% where a is not available

5.1.3 Minimum Pipe Wall Thickness and Bending (2005)

Notwithstanding 4-6-2/5.1.1 or 4-6-2/5.1.2, the minimum wall thickness of pipes is not to be less than that indicated in 4-6-2/Table 4 for steel pipes, and 4-6-2/Tables 5A and 5B for other metal pipes. The wall thicknesses listed in these tables are nominal wall thicknesses. When using the tables, no allowances need be made to account for negative tolerance or reduction in thickness due to bending.

Pipe bending is to be in accordance with 2-3-12/25 of the Rules for Materials and Welding (Part 2). Alternatively, bending in accordance with a recognized standard (e.g., ASME B31.1 - Section 129.1 and 129.3) or other approved specifications to a radius that will result in a surface free of cracks and substantially free of buckles may be acceptable.

5.5 Pipe Joints (2006)

5.5.1 Butt Welded Joints

Butt welded joints, where complete penetration at the root is achieved, may be used for all classes of piping. Degree of verification of sound root penetration is to be in accordance with 2-4-4/5 and 2-4-4/11.

5.5.2 Socket Welded Joints (2006)

Socket welded joints using standard fittings may be used for Classes I and II piping up to and including 80 mm (3 in) nominal diameter, except in toxic and corrosive fluid services (see 4-6-1/3.25 and 4-6-1/3.27) or services where fatigue, severe erosion or crevice corrosion is expected to occur. Socket welded joints using standard fittings may be used for Class III piping without limitation. The fillet weld leg size is to be at least 1.1 times the nominal thickness of the pipe. See 4-6-2/Figure 1.

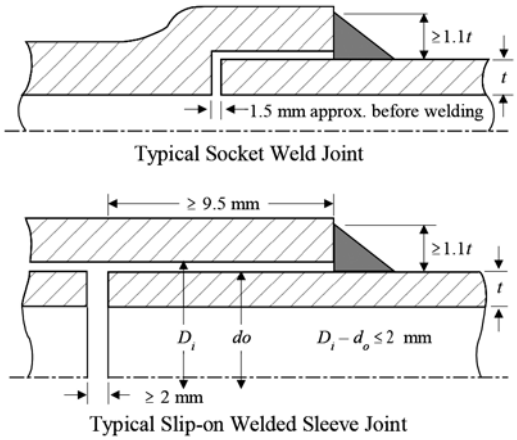
5.5.3 Slip-on Welded Sleeve Joints (2006)

Slip-on welded sleeve joints may be used for Classes I and II piping up to and including 80 mm (3 in.) nominal diameter except in toxic and corrosive fluid services (see 4-6-1/3.25 and 4-6-1/3.27) or services where fatigue, severe erosion or crevice corrosion is expected to occur, provided that:

- The inside diameter of the sleeve is not to exceed the outside diameter of the pipe by more than 2 mm (0.08 in.).
- The depth of insertion of the pipe into the sleeve is to be at least 9.5 mm (0.375 in.).
- The gap between the two pipes is to be at least 2 mm (0.08 in.).
- The fillet weld leg size is as per 4-6-2/5.5.2, see 4-6-2/Figure 1.

Slip-on welded sleeve joints may be used for Class III piping without size limitation. In such cases, joint design and attachment weld sizes may be in accordance with a recognized alternative standard.

FIGURE 1 Socket Welded and Slip-on Welded Sleeve Joints



5.5.4 Flanged Joints

Flanges of all types (see 4-6-2/Table 6 for typical types) conforming to and marked in accordance with a recognized national standard may be used within the pressure-temperature ratings of the standard, subject to limitations indicated in 4-6-2/Table 7. For flanges not conforming to a recognized standard, calculations made to a recognized method are to be submitted for review. Non-standard flanges are to be subjected to the same limitations indicated in 4-6-2/Table 7. Flanges conforming to a standard are to be attached to pipes by welding or other acceptable means as specified in the standard. For example, slip-on flanges conforming to ASME B16.5 are to be attached to pipes by a double fillet weld having throat size of not less than 0.7 times the wall thickness of the pipe. Non-standard flanges are to be attached to pipes by a method approved with the design.

5.5.5 Threaded Joints

5.5.5(a) Taper-thread joints. Threaded joints having tapered pipe threads complying with a recognized standard are not to be used for toxic and corrosive fluid services and for all services of temperatures exceeding 495°C (923°F). They may be used for Classes I and II piping subject to limitations indicated in the table below. They may be used for Class III piping without limitation. For hydraulic oil system, see 4-6-7/Table 1.

Pipe Nominal Diameter, d	
mm	in.
d > 80	d > 3
80 ≥ d > 50	3 ≥ d > 2
50 ≥ d > 25	2 ≥ d > 1
25 ≥ d > 20	1 ≥ d > 0.75
d ≤ 20	d ≤ 0.75

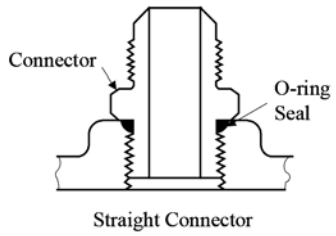
Maximum Pressure Permitted		
bar	kgf/cm^2	psi
Not permitted for Classes I & II		
27.6	28.1	400
41.4	42.2	600
82.8	84.4	1200
103	105.5	1500

5.5.5(b) Taper-thread joints for hydraulic oil system. Taper-thread joints up to 80 mm (3 in.) nominal diameter may be used without pressure limitation for connection to equipment only, such as pumps, valves, cylinders, accumulators, gauges and hoses. When such fittings are used solely to join sections of pipe, they are to be in accordance with 4-6-2/5.5.5(a). However, hydraulic systems for the following services are to comply with 4-6-2/5.5.5(a) in all respects:

- Steering gear hydraulic systems
- Controllable pitch propeller hydraulic systems
- Hydraulic systems associated with propulsion or propulsion control

5.5.5(c) Straight-thread 'o'-ring joints. For hydraulic oil piping, straight thread 'o'-ring type fittings (see 4-6-2/Figure 2) may also be used for connections to equipment, without pressure and service limitation, but are not to be used for joining sections of pipe.

FIGURE 2
Straight-thread 'O'-Ring Joints



5.7 Flexible Hoses (2006)

5.7.1 Definition
A flexible hose assembly is a short length of metallic or non-metallic hose normally with prefabricated end fittings ready for installation.

5.7.3 Design and Construction
5.7.3(a) Hose material. Flexible hoses are to be designed and constructed in accordance with recognized National or International standards acceptable to ABS. Flexible hoses constructed of rubber or plastics materials and intended for use in bilge, ballast, compressed air, oil fuel, lubricating, hydraulic and thermal oil systems are to incorporate a single or double closely woven integral wire braid or other suitable material reinforcement. Where rubber or plastics materials hoses are to be used in oil supply lines to burners, the hoses are to have external wire braid protection in addition to the integral reinforcement. Flexible hoses for use in steam systems are to be of metallic construction.

5.7.3(b) Hose end fittings. Flexible hoses are to be complete with approved end fittings in accordance with manufacturer's specification. Flanged end connections are to comply with 4-6-2/5.5.4 and threaded end connections with 4-6-2/5.5.5, as applicable and each type of hose/fitting combination is to be subject to prototype testing to the same standard as that required by the hose with particular reference to pressure and impulse tests.

5.7.4 Installation

Flexible hose assemblies are not to be installed where they may be subjected to torsion deformation (twisting) under normal operating conditions.

The number of flexible hoses, in piping systems is to be kept to minimum and is to be limited for the purpose stated in 4-6-2/5.7.2.

Flexible hoses are to be installed in clearly visible and readily accessible locations.

5.7.5 Tests

5.7.5(a) Test procedures. Acceptance of flexible hose assemblies is subject to satisfactory type testing. Type test programs for flexible hose assembles are to be submitted by the manufacturer and are to be sufficiently detailed to demonstrate performance in accordance with the specified standards.

5.7.5(b) Burst test. All flexible hose assemblies are to be satisfactorily type burst tested to an international standard to demonstrate they are able to withstand a pressure not less than four (4) times its design pressure without indication of failure or leakage.

Note:
The international standards, e.g. EN or SAE for burst testing of non-metallic hoses, require the pressure to be increased until burst without any holding period at 4 × MWP.

5.11 Valves

5.11.1 Standard

In general, valves are to comply with a recognized national standard and are to be permanently marked in accordance with the requirements of the standard (see 4-6-1/7.1.4). For valves not complying with a recognized national standard, see 4-6-2/5.15.

5.11.4 Manufacturer's Guarantee

The manufacturer of a valve is to guarantee that the valve is constructed to the standard and conforming to the identifications to which it is marked. The manufacturer is to guarantee also that the valve has been tested before shipment to the pressure required by the pressure rating of the valve. The certificate of test is to be submitted upon request.

7 Fabrication and Tests

7.3 Hydrostatic Tests (2002)

7.3.1 Hydrostatic Test of Pipes Before Installation Onboard

All Classes I and II pipes and integral fittings after completion of shop fabrication, but before insulation and coating, are to be hydrostatically tested in the presence of a Surveyor, preferably before installation, at the following pressure.

$P_H = 1.5P$

where P_H = test pressure, and P = design pressure.

Small bore pipes and tubes of less than 15 mm outside diameter may be exempted from the required hydrostatic test, depending on the intended application.

Where it is not possible to carry out the required hydrostatic tests for all segments of pipes and integral fittings before installation, the remaining segments, including the closing seams, may be so tested after installation. Or, where it is intended to carry out all of the required hydrostatic tests after installation, such tests may be conducted in conjunction with those required in 4-6-2/7.3.3. In both of these cases, testing procedures are to be submitted to the Surveyor for acceptance.

7.3.3 Tests After Installation

7.3.3(a) General. All piping systems are to be tested in the presence of the Surveyor under working conditions after installation and checked for leakage. Where necessary, other techniques of tightness test in lieu of a working pressure test may be considered.

9 Installation Details

9.5 Provisions for Expansion and Contraction of Piping (2004)

Provisions are to be made to take care of expansion and contraction of piping due to temperature and pressure variations as well as working of the hull. Suitable provisions include, but are not limited to, piping bends, elbows, offsets and changes in direction of the pipe routing or expansion joints.

9.11 Temperature and Pressure Sensing Devices

9.11.1 Temperature

Where thermometers or other temperature sensing devices are fitted in piping systems, thermometer wells are to be used so that the devices can be removed without impairing the integrity of the pressurized system.

9.11.2 Pressure

Where pressure gauges or other pressure sensing devices are fitted in piping systems, valves are to be provided so that the devices can be isolated and removed without impairing the integrity of the pressurized system.

TABLE 3 Corrosion Allowance c for Steel Pipes (see 4-6-2/5.1.1) (2007)

Piping Service	Corrosion Allowance, c	
	mm	in.
Hydraulic oil	0.3	0.012

TABLE 4 Minimum Wall Thickness for Steel Pipes (See 4-6-2/5.1.3)

Nom. Size mm	Outside Dia. mm	Wall Thickness, mm				
		A	B	C	D	E
6	10.2	1.6				
8	13.5	1.8				
10	17.2	1.8				
15	21.3	2.0	2.8			
20	26.9	2.0	2.8			
25	33.7	2.0	3.2	4.2	6.3	6.3
32	42.4	2.3	3.5	4.2	6.3	6.3
40	48.3	2.3	3.5	4.2	6.3	6.3
50	60.3	2.3	3.8	4.2	6.3	6.3
65	76.1	2.6	4.2	4.2	6.3	7.0
80	88.9	2.9	4.2	4.2	7.1	7.6
90	101.6	2.9	4.5	4.5	7.1	8.1
100	114.3	3.2	4.5	4.5	8.0	8.6
125	139.7	3.6	4.5	4.5	8.0	9.5
150	168.3	4.0	4.5	4.5	8.8	11.0
200	219.1	4.5	5.8	5.8	8.8	12.5
250	273.0	5.0	6.3	6.3	8.8	12.5
300	323.9	5.6	6.3	6.3	8.8	12.5
350	355.6	5.6	6.3	6.3	8.8	12.5
400	406.4	6.3	6.3	6.3	8.8	12.5
450	457.0	6.3	6.3	6.3	8.8	12.5

Nom. Size mm	Outside Dia. mm	Wall Thickness, mm				
		A	B	C	D	E
1/8	0.405	0.063				
1/4	0.540	0.071				
3/8	0.675	0.071				
1/2	0.840	0.079	0.110			
3/4	1.050	0.079	0.110			
1	1.315	0.079	0.126	0.165	0.248	0.248
1 1/4	1.660	0.091	0.138	0.165	0.248	0.248
1 1/2	1.900	0.091	0.138	0.165	0.248	0.248
2	2.375	0.091	0.150	0.165	0.248	0.248
2 1/2	2.875	0.102	0.165	0.165	0.248	0.276
3	3.500	0.114	0.165	0.165	0.280	0.300
3 1/2	4.000	0.114	0.177	0.177	0.315	0.318
4	4.500	0.126	0.177	0.177	0.315	0.337
5	5.563	0.142	0.177	0.177	0.346	0.375
6	6.625	0.157	0.177	0.177	0.346	0.432
8	8.625	0.177	0.228	0.228	0.346	0.5
10	10.750	0.197	0.248	0.248	0.346	0.5
12	12.750	0.220	0.248	0.248	0.346	0.5
14	14.000	0.220	0.248	0.248	0.346	0.5
16	16.000	0.248	0.248	0.248	0.346	0.5
18	18.000	0.248	0.248	0.248	0.346	0.5

Columns:
A (2003) Pipes in general, except where Columns B, C, D or E are applicable

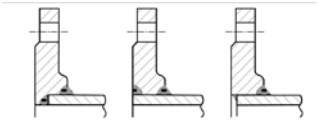
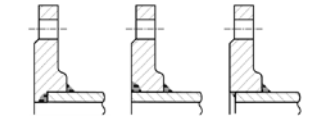
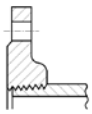
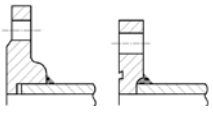
Notes:
1 (2002) The minimum thicknesses are the smallest thicknesses selected from those thicknesses specified in ISO 4200 Series 1, JIS, or ASTM Standards. Notwithstanding the requirements of this Table, diameters and thicknesses specified in other recognized standards will also be acceptable.

TABLE 5B Minimum Wall Thickness for Austenitic Stainless Steel Pipes, (see 4-6-2/5.1.3) (2007)

External Diameter		Minimum Wall Thickness	
mm	in.	mm	in.
10.2 – 17.2	0.40 – 0.68	1.0	0.039
21.3 – 48.3	0.84 – 1.90	1.6	0.063
60.3 – 88.9	2.37 – 3.50	2.0	0.079
114.3 – 168.3	4.50 – 6.63	2.3	0.091
219.1	8.63	2.6	0.102
273.0	10.75	2.9	0.114
323.9 – 406.4	12.75 – 16.00	3.6	0.142
Over 406.4	Over 16.00	4.0	0.157

Note: (2007) Diameters and thicknesses according to national or international standards may be accepted.

TABLE 6 Typical Flange Types (see 4-6-2/5.5.4) (2002)

Flange Type	Typical Configuration
Type A Weld neck flange, raised face or flat face with ring type gasket.	
Type B Slip-on welded hub (or without hub) flange; attached to pipe with at least a groove weld deposited from the back of the flange and a fillet weld or equivalent on the other side; raised face or flat face with ring type gasket.	
Type C Slip-on welded hub (or without hub) flange; attached to pipe with double fillet welds or equivalent; raised face or flat face with ring type gasket.	 (Must be with hub)
Type D Threaded hub flange; attached to pipe by tapered threads; some designs require the pipe be expanded, or the threaded ends be seal-welded; raised face or flat face with ring type gasket.	
Type E Unattached flange; no attachment to pipe.	
Type G Socket-welded flange; attached to pipe by single fillet weld, with or without groove weld, deposited from one side of the flange only; raised face (with gasket) or flat face (with o-ring).	

Notes:

1 "Integral" flanges are designs where the flange is cast or forged integrally with the pipe wall, or otherwise welded in such a manner that the flange and the pipe wall are considered to be the equivalent of an integral structure.

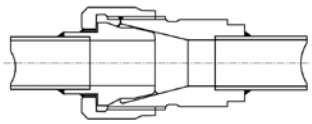
2 "Loose" flanges are designs where the method of attachment of the flange to the pipe is not considered to give the mechanical strength equivalent of an integral flange, or in which the flange has no direct connection to the pipe wall. Slip-on welded flange attached to pipe with fillet welds only is generally considered a loose flange.

TABLE 7 Limitation of Use for Typical Flange Types (see 4-6-2/5.5.4) (2005)

Flange Type	Class of Piping	Limitations
A	I, II, III	None
B	I, II, III	Pressure/temperature rating ≤ ASME B16.5 Class 300 or equivalent recognized national standard. For steam piping additionally limited to pipe sizes d ≤ NPS 100 mm (4 in.) Slip-on flanges for higher ratings, which comply with ASME or other recognized standards, will be subject to special consideration. [Ref. 2-4-2/9.5.3, 2-4-4/5.7 and 2-4-4/17.5]
C	I, II, III	Same as for type B above.
D	II, III	Not for toxic fluid, corrosive fluid, volatile flammable liquid (1), liquefied gas, fuel oil, lubricating oil, thermal oil and flammable hydraulic oil. For other services as per limitations for type B above.
E	II, III	Not for toxic fluid, corrosive fluid, volatile flammable liquid (1), liquefied gas, fuel oil, lubricating oil, thermal oil, flammable hydraulic oil and steam systems. For water and open-ended lines. For other services, see 4-6-2/5.15.
G	I, II, III	Pressure/temperature rating ≤ ASME B16.5 Class 600 and NPS ≤ 80 mm (3 in.), or equivalent recognized national standard. Pressure/temperature rating ≤ ASME B16.5 Class 1500 and NPS ≤ 65 mm (2.5 in.), or equivalent recognized national standard Not to be used in steering gear and controllable pitch propeller systems. [Ref. 2-4-4/5.7 and 2-4-4/17.5]

Note:
1 Volatile flammable liquid is a flammable liquid heated to above its flash point, or a flammable liquid having a flash point at or below 60°C (140°F) other than cargo oil.

TABLE 9 Examples of Mechanical Joints (2006)

	Pipe Unions
Welded and Brazed Types	

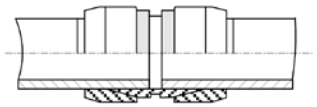
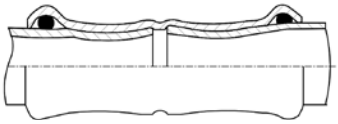
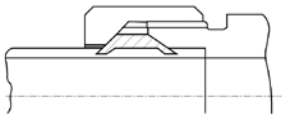
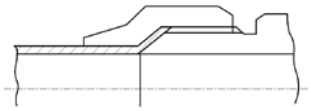
	Compression Couplings
Swage Type	
Press Type	
Bite Type	
Flared Type	

TABLE 10 Application of Mechanical Joints (2006)

The following table indicates systems where the various kinds of joints may be accepted. However, in all cases, acceptance of the joint type is to be subject to approval for the intended application, and subject to conditions of the approval and applicable Rules.

Systems		**Kind of Connections**		
		Pipe Unions	Compression Couplings [6]	Slip-on Joints
Flammable Fluids (Flash Point > 60°)				
11	Hydraulic oil	Y	Y	Y [2, 3, 12]

Abbreviations:
Y – Application is allowed
N – Application is not allowed

Footnotes:
1 Inside machinery spaces of category A – only approved fire resistant types.
2 Not inside machinery spaces of category A or accommodation spaces. May be accepted in other machinery spaces provided the joints are located in easily visible and accessible positions.
3 Approved fire resistant types.
12 Not permitted in steering gear hydraulic systems, otherwise Class III systems only.

TABLE 11 Application of Mechanical Joints Depending Upon the Class of Piping (2006)

Types of Joints	Classes of Piping Systems		
	Class I	Class II	Class III
Pipe Unions			
Welded and brazed type	Y (OD ≤ 60.3 mm)	Y(OD ≤ 60.3 mm)	Y
Compression Couplings			
Swage type	Y	Y	Y
Bite type	Y (OD ≤ 60.3 mm)	Y (OD ≤ 60.3 mm)	Y
Flared type	Y (OD ≤ 60.3 mm)	Y (OD ≤ 60.3 mm)	Y
Press type	N	N	Y
Slip-on joints			
Machine grooved type	Y	Y	Y
Grip type	N	Y	Y
Slip type	N	Y	Y

Abbreviations:
Y – Application is allowed
N – Application is not allowed

Part 4 - Chapter 6 - Section 7

1 General

Part 4, Chapter 6, Section 7 (referred to as Section 4-6-7) covers provisions for piping systems not covered in Section 4-6-4, Section 4-6-5 and Section 4-6-6. It includes fluid power piping systems, helicopter refueling piping systems and oxygen-acetylene piping systems. The provisions of Section 4-6-1, Section 4-6-2 and Section 4-6-3 apply to piping systems in Section 4-6-7.

3 Hydraulic Oil Systems

3.1 Application

The provisions of 4-6-7/3 apply to all shipboard hydraulic oil systems. Hydraulic oil systems fitted in self-contained equipment not associated with propulsion and maneuvering of the vessel (e.g., a crane) and completely assembled by the equipment manufacturer need not comply with this subsection. Such hydraulic oil systems, however, are to comply with the accepted industry standards.
Hydraulic oil systems essential for the propulsion and maneuvering of the vessel are subject to further requirements. Controllable pitch propeller hydraulic system and steering gear hydraulic systems are also to comply with the requirements in Section 4-3-3 and Section 4-3-4, respectively.
Hydraulic oil systems associated with remote propulsion control are also to comply with 4-9-1/11.5 for, among other requirements, duplication of hydraulic pumps. The same systems associated with propulsion machinery spaces intended for centralized or unattended operation (ACC/ACCU notation) are also to meet the provisions of 4-9-7/9 for, among other requirements, flash point of hydraulic fluid.

3.5 Hydraulic System Components

3.5.1 Pipes and Fittings

Pipes, pipe fittings and joints are to meet the general requirements of certification in 4-6-1/7.1 (except that ABS certification is not required for all classes of hydraulic piping); materials in 4-6-2/3; and design in 4-6-2/5, subject to limitations in 4-6-7/Table 1.

TABLE 1 Pipe Joint Limitations for Hydraulic Piping (2006)

Types of joint	Class I	Class II	Class III
Butt welded joint	No limitation	No limitation	No limitation
Socket welded joint (1)	Max. 80 mm (3 in.)	Max. 80 mm (3 in.)	No limitation
Slip-on welded sleeve joint (2)	Max. 80 mm (3 in.)	Max. 80 mm (3 in.)	No limitation
Flanged joint (3)	Types A, B & G only. For type B, ≤ 400°C (752°F) For type G, see 4-6-2/Table 7	Types A, B, C, D & G only. For type D, ≤ 250°C (482°F). For type G, see 4-6-2/Table 7	Types A, B, C, D & G only. For type G, see 4-6-2/Table 7
Taper-thread joint (4)	≤ 80 mm (3 in.), or ≤ 495°C (923°F), permissible pressure/size: see 4-6-2/5.5.5(a).	As for Class I	No limitation.
Straight thread O-ring joint	Straight thread O-ring type fittings may be used for pipe connection to equipment such as pumps, valves, cylinders, accumulators, gauges and hoses, without size and pressure limitations. However, such fittings are not to be used for connecting sections of pipe.		
Compression couplings (5)	≤ 60 mm (2.4 in.) OD.	As for Class I	No size limitation.
Hoses	Subject to fire resistance test. See 4-6-2/5.7..3(c)	As for Class I	As for Class I
Molded non-metallic expansion joint	Not permitted	Not permitted	Not permitted
Molded expansion joint of composite construction	Subject to compliance with 4-6-2/5.8.1	Subject to compliance with 4-6-2/5.8.1	Subject to compliance with 4-6-2/5.8.1
Slip-on Joints	Not permitted	Not permitted	See Note 5

Pipe sizes indicated are nominal pipe size unless specified otherwise.

Notes:

1 See 4-6-2/5.5.2 for further operational limitations.

2 See 4-6-2/5.5.3 for further operational limitations.

3 (2004) Split flanges are not permitted in steering gear system, certified thruster systems, nor in systems which are vital to the propulsion or safety of the vessel, and are subject to special consideration in other cases.

4 Taper-thread joints up to 80 mm (3 in.) may be used without pressure limitation for pipe connection to equipment, such as pumps, valves, cylinders, accumulators, gauges and hoses. When such joints are used to connect sections of pipe, they are to be in accordance with limitations shown. However, hydraulic systems for the following services are to comply with the stated limitations in all respects [see 4-6-2/5.5.5(b) and 4-6-2/5.5.5(c)]:
- Steering gear hydraulic systems.
- Controllable pitch propeller hydraulic systems.
- Hydraulic systems associated with propulsion or propulsion control.

5 See 4-6-2/5.9 for further limitations

3.5.2 Hoses

Hoses are to comply with the requirements of 4-6-2/5.7 for flammable fluid service.

3.5.3 Valves

Valves are to meet the general requirements of certification in 4-6-1/7.1; materials in 4-6-2/3; and design in 4-6-2/5.11 and 4-6-2/5.13.

3.7 System Requirements

3.7.2 Relief Valves

Relief valves are to be fitted to protect the system from overpressure. The relieving capacity is not to be less than full pump flow with a maximum pressure rise in the system of not more than 10% of the relief valve setting.

Det Norske Veritas

Det Norske Veritas (DNV)

Rules for Classification of Ships / Newbuildings Machinery and Systems - Main Class / Piping Systems / January 2013

Part 4 – Chapter 6 – Section 1

B Definitions

B 100 Terms

103 Classes of piping systems. For the purpose of testing, type of joint to be adopted, heat treatment and welding procedure, piping is subdivided into three classes as indicated in Table B1.

Table B1 Classes of piping systems

Piping system for	Class I 1)		Class II 1)		Class III 1)	
	p (bar)	t (°C)	p (bar)	t (°C)	p (bar)	t (°C)
Steam, thermal oil	> 16	or > 300	≤ 16	and ≤ 300	≤ 7	and ≤ 170
Fuel oil, lubricating oil, flammable hydraulic oil	> 16	or > 150	≤ 16	and ≤ 150	≤ 7	and ≤ 60
Other media 2)	> 40	or > 300	≤ 40	and ≤ 300	≤ 16	and ≤ 200

p = Design pressure, as defined in Sec.7 A 303
t = Design temperature, as defined in Sec.7 A 304
1) For class II and III piping both specified conditions shall be met, for class I piping one condition only is sufficient.
2) Cargo oil pipes on oil carriers and open ended pipes (drains, overflows, vents, boiler escape pipes etc.) independently of the pressure and temperature, are pertaining to class III.
3) Cargo piping systems for flammable liquids on Offshore Supply Vessels are pertaining to the same pipe class as fuel oil systems.
Outside Machinery spaces of Category A, class II piping is sufficient.

Rules for Classification of Ships / High Speed, Light Craft and Naval Surface Craft / Newbuildings Materials and Welding / Metallic Materials / January 2013

Part 2 – Chapter 2 – Section 4

A General Requirements

A 200 Manufacture

201 All pipes delivered with NV or works certificate shall be made by works approved by the Society. The steel used shall be made by works approved by the Society.

A 1000 Certification

1001 The manufacturer shall provide the type of inspection certificate required in the relevant design and construction rules giving the following particulars for each test unit which has been accepted:
– purchaser's name, order number and vessel identification, where known
– manufacturer's name
– description of pipes and material quality
– identification marking of pipes
– heat number and chemical composition
– results of mechanical tests and technological tests
– results of leak tightness testing
– results of any supplementary and additional test requirements specified.

A Piping Systems

A 200 Carbon and low alloy steels

201 Steel pipes for classes I and II shall be seamless drawn or fabricated by a welding method considered equivalent to seamless pipes. See Pt.2 Ch.2 Sec.4.

A 800 Material certificates

801 The materials used in piping systems shall be certified and documented according to Table A2. For definitions related to the various types of documentation of material certification, see Pt.1 Ch.1 Sec.4.
The requirements for material certification and documentation concerning piping systems for chemical carriers and liquefied gas carriers can be found in Pt.5 Ch.4 Sec.2D and Pt.5 Ch.5 Sec.2E, respectively.

Guidance note:
The control and monitoring system for valves and pumps for systems listed in Sec.1 C102 is not required to be delivered with NV product certificate.

Table A2 Material certificates

Component	Material	Class of piping system	Nominal diameter (mm)	Design temperature (°C)	Type of documentation		
					NV certificate	Works certificate	Test report
Pipes 1)		I	> 50		x		
		II, III	> 50			x	
		I, II, III	≤ 50				x
Flanges and bolts				> 400	x		
				≤ 400			x
Bodies of valves and fittings 1), source materials of steel expansion bellows, other pressure containing components not considered as pressure vessels	Steel	I	> 100	> 400	x		
			≤ 100	> 400		x	
	Steel or nodular cast iron	I, II	> 100	≤ 400		x	
			≤ 100	≤ 400			x
		III					
	Cast iron	III					x
	Copper alloys	I, II	> 50			x	
			≤ 50				x
		III					x
Pump housings		I				x	
		II, III					x

1) Pipes and bodies of valves fitted on ship's side and bottom and bodies of valves fitted on collision bulkhead shall be provided with documentation as required for Class II piping systems.

B 100 General

101 Certification of materials, components and systems will be documented by the following types of documents:

1) Det Norske Veritas Certificate (NV):
A document validated and signed by a surveyor of the Society stating:
— conformity with rule requirements
— that tests are carried out on the certified product itself and/or
— that tests are made on samples taken from the certified product itself
— that tests are performed in presence of the surveyor or in accordance with special agreements.

2) Det Norske Veritas Type Approval Certificate (TA):
A document validated and signed by a surveyor of the Society stating:
— Conformity with rule design requirements.

3) EU Mutual Recognition Type Approval Certificate:
A document validated and signed by a surveyor of a recognised organisation (RO) within EU stating:
— Conformity with the commonly agreed design requirements for Mutual Recognition as laid down in the individual RO's governing documents.

Guidance note:
These certificates are normally mutually accepted by all EU RO's.
Covers only agreed components. These are at any time listed in the overview of Type Approval for Mutual Recognition on the DNV Internet.

4) Works Certificate (W):
A document signed by the manufacturer stating:
— conformity with rule requirements
— that tests are carried out on the certified product itself and/or
— that tests are made on samples taken from the certified product itself
— that tests are witnessed and signed by a qualified department of the manufacturers.

5) Test Report (TR):
A document signed by the manufacturer stating:
— conformity with rule requirements
— that tests are carried out on samples from the current production.
The applicable chapters and sections of the rules specify which of the above mentioned documents are required.

Rules for Classification of Ships / Newbuildings / Machinery and Systems - Main Class / Piping Systems / January 2013

Part 4 – Chapter 6 – Section 3

A Arrangement

A 100 Piping systems

101 Piping systems shall consist of permanently installed pipes and fittings supported in such a way that their weight is not taken by connected machinery or that heavy valves and fittings do not cause large additional stresses in adjacent pipes.

102 Axial forces due to internal pressure, change in direction or cross-sectional area and movement of the ship shall be taken into consideration when mounting the piping system.

103 The support of the piping system shall be such that detrimental vibrations will not arise in the system.

Part 4 – Chapter 6 – Section 5

H Hydraulic Systems

H 500 Hydraulic equipment

502 Piping and tubing to actuators and between actuators and local accumulators shall be hydrostatically tested to 1.5 times the system design pressure for 15 minutes

504 Piping, tubing and components in systems required to operate in a fire scenario shall have adequate fire resistance properties to ensure correct system operation. This is particularly important for systems where hydraulic energy is required to activate or maintain control over the system. The Society may request fire test certificates for such system components.

505 Piping and tubing shall be flushed and cleaned before being connected to control systems.

Part 4 – Chapter 6 – Section 7

A Pipes

A 200 Minimum wall thickness

201 The minimum wall thickness is generally not to be less than given in Table A1, Table A2 and Table A3 for pipes of copper or copper alloy, steel and stainless steel, respectively.

A 300 Calculation of wall thickness of pipes being subject to internal pressure

301 The wall thickness of pipes subjected to internal pressure shall be calculated as specified in this subsection. The nominal wall thickness is, however, not to be less than specified in 200.

302 Definition of symbols:

t1 = nominal wall thickness (mm)
t0 = strength thickness (mm)
t = minimum required wall thickness (mm)
c = corrosion allowance (mm)
b = bending allowance (mm)
σt = permissible stress (N/mm2)
σb = specified minimum tensile strength of the material at 20°C (N/mm2)
σ ft = specified minimum yield stress or 0.2% proof stress of the material at design material temperature (N/mm2)
p = design pressure (bar)
D = outer diameter of pipe (mm)
σb 100 000 = average value for stress to rupture after 100 000 hours at design material temperature (N/mm2)
a = percentage negative manufacturing tolerance
e = strength ratio.

303 The design pressure p to be used in the formula in 306, is defined as the maximum working pressure, and shall not be less than the highest set pressure of the safety valve or relief device. For special cases, the design pressure will be specially considered.

Table A2 Minimum wall thickness for steel pipes	
External diameter D (mm)	Pipes in general
10.2 to 12 13.5 to 17.2 20	1.6 1.8 2
21.3 to 25 26.9 to 33.7 38 to 44.5	2 2 2
48.3 51 to 63.5 70	2.3 2.3 2.6
76.1 to 82.5 88.9 to 108 114.3 to 127	2.6 2.9 3.2
133 to 139.7 152.4 to 168.3 177.8	3.6 4 4.5
193.7 219.1 244.5 to 273	4.5 4.5 5
298.5 to 368 406 to 457	5.6 6.3

Table A3 Minimum wall thickness for stainless steel pipes	
External diameter D (mm)	Minimum wall thickness (mm)
10.2 to 17.2	1.0
21.3 to 48.3	1.6
60.3 to 88.9	2.0
114.3 to 168.3	2.3
219.1	2.6
273.0	2.9
323.9 to 406.4	3.6
over 406.4	4.0

306 The strength thickness, t0, shall not be less than calculated by the following formula:

$$t_0 = \frac{pD}{20\,\sigma_t e + p}$$

The formula is valid for pipes having a ratio of wall thickness to outside diameter of 0.17 or less. For higher ratios the calculation of wall thickness will be given special consideration.

307 For steel pipes the permissible stress, σ_t, is in general to be based on the lower value of the following criteria:

$$\frac{\sigma_b}{2.7} \text{ and } \frac{\sigma_{ft}}{1.6} \text{ (for austenitic) or}$$

$$\frac{\sigma_{ft}}{1.8} \text{ and } \frac{\sigma_{b\,100\,000}}{1.8} \text{ (for other materials)}$$

Values for specified minimum yield or proof stress shall be in accordance with recognised standards given in Pt.2 Ch.2 Sec.4.

Table A5 Corrosion allowance c for steel pipes	
Compressed air	1
Hydraulic oil	0.3
Lubricating oil	0.3
1) For pipes passing through tanks, an additional allowance for external corrosion shall be considered according to the figures given in the Table, depending on the external medium. 2) For pipes efficiently protected against corrosion, the corrosion allowance may upon approval be reduced up to 50%. 3) For stainless steels the corrosion allowance may be omitted.	

310 When the allowance for bending b is not determined by a more accurate procedure, or when the bending is not carried out by a bending procedure ensuring a control of the wall thickness, the allowance shall not be less than:

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

R = mean radius of the bend (mm).
In case the bending ratio:

$$\frac{D}{R}$$

is not given, this ratio will be taken equal to 1:3.

311 For steel pipes the corrosion allowance c shall be as specified in Table A5
For pipes of copper, brasses, copper-tin alloys and Cu—Ni alloys with Ni-content < 10% the corrosion allowance is 0.8 mm. For pipes of Cu—Ni alloys with Ni-content ≥ 10% the corrosion allowance is 0.5 mm.
For media with small corrosive action in respect of the material employed, the corrosion allowance may upon approval be reduced to zero.
For pipes where there is a risk of heavy corrosion and/or erosion, a greater corrosion allowance may be required.

312 For seamless pipes and for welded pipes delivered by manufacturer approved for making welded pipes which are considered equivalent to seamless pipes, the strength ratio e = 1.
For welded pipes from other approved pipe manufacturers, e = 0.9.

313 The value of t does not account for any negative manufacturing tolerance, therefore the nominal wall thickness, t1, shall not be less than:

$$t_1 = \frac{t}{1 - \frac{a}{100}}$$

C Valves

C 300 Certification of valves

301 DNV product certificates are required for valves with DN > 100 mm having a design pressure, p > 16 bar and for ship side valves with DN > 100 mm regardless of pressure rating. For other valves manufacturers certificate may be accepted.

302 Valves shall be delivered with material certificates in accordance with Sec.2 Table A2.

D Flexible Hoses

D 100 General

103 For hoses of non-metallic materials documentation, showing the suitability of the hose for its intended use, shall be submitted for approval.

104 Every hose shall be hydrostatically tested at a hydrostatic pressure of 1.5 times the working pressure.

105 For hoses of non-metallic materials documentation, showing the suitability of the hose for its intended use, shall be submitted for approval.

107 Every hose shall be hydrostatically tested at a hydrostatic pressure of 1.5 times the design pressure.

A Welding

A 200 Welded connections

201 Welded butt joints shall be of the full penetration type. For class I pipes special provisions shall be taken to ensure a high quality of the root side.

202 Branches shall be welded to the main pipe by means of full penetration welds. For reinforcement in way of branches, see Sec.7 A.

Table A1 Preheating prior to welding of steel pipes

Type of steel	Thickness of thicker part (mm)	Minimum preheating temperature (°C)
C and C/Mn Steel, $C + \frac{Mn}{6} \leq 0.40$	≥ 20 [2]	50
C and C/Mn Steel, $C + \frac{Mn}{6} > 0.40$	≥ 20 [2]	100

Table A2 Stress relieving heat treatment after forming and welding

Type of steel	Thickness of thicker part (mm)	Stress relief heat treatment temperature (°C)
C and C/Mn Steel	≥ 15 [1] [3]	550 to 620

1) When steel with specified Charpy V- notch impact properties at low temperature is used, the thickness above which post-weld heat treatment shall be applied may be increased by special agreement.
3) For C and C-Mn steel, stress relieving heat treatment may be omitted up to 30 mm thickness by special agreement.

A 500 Non-destructive testing

501 In general, the welded joints including the inside wherever possible shall be visually examined. Nondestructive tests will be required depending on the class of pipes and type of joints as hereunder indicated:

Butt welded joints:

- for class I pipes with an outer diameter greater than 76.1 mm, 100% radiographic testing (RT) is required.
- for class II pipes with an outer diameter greater than 101.6 mm and for class I pipes with an outer diameter ≤ 76.1 mm, at least 10% random radiographic testing is required. More stringent requirements may be applied at the surveyors discretion depending on the kind of materials, welding procedure and controls during the fabrication.

Fillet welds:

- for fillet welds of flange type connections in class I pipes with an outer diameter greater than 76.1 mm, 100% magnetic particle testing (MT) is required.
- for class II pipes with an outer diameter greater than 101.6 mm and for class I pipes with an outer diameter ≤ 76.1 mm, random magnetic particle testing at the discretion of the surveyor is required.

In addition welded joints in pipes for thermal oil shall be subject to at least 10% random radiographic testing.

C Pipe Bending

C 100 General

101 The bending procedure shall be such that the flattening of the pipe cross-section is as small as possible.
Guidance note:

For class I and II pipes the out-of-roundness, η should preferably not exceed 7% where η is defined by:

$$\eta = 2\,\frac{D_{max} - D_{min}}{D_{max} + D_{min}}\,100\%$$

D = outer pipe diameter.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

102 Pipe bends in class I and II pipes shall be free from wrinkles on the inner side of the bend.

104 For tolerances in wall thickness and allowance for bending, see Sec.7 A305 and Sec.7 A310.

E Hydrostatic Tests of Piping

E 100 Hydrostatic testing before installation on board

101 All class I and II pipes and integral fittings, after completion of manufacture but before insulation and coating, if any, shall be subjected to a hydrostatic test in the presence of the surveyor at the following pressure:

$$P_H = 1.5\ p$$

P_H = test pressure in bar
p = design pressure in bar as defined in Sec.7 A303.

For steel pipes and integral fittings for design temperatures above 300°C the test pressure shall be determined by the following formula but need not exceed 2 p:

$$P_H = 1.5\,\frac{\sigma_{t100}}{\sigma t}\,p$$

σt100 = permissible stress at 100°C
σt = permissible stress at the design temperature.

The value of the test pressure may be reduced with the approval of the surveyor, to 1.5 p in order to avoid excessive stress in way of bends, branches etc.
In any case the membrane stress shall not exceed 0.9 the yield stress at the testing temperature.

E 200 Hydrostatic testing after assembly on board

201 The piping shall be hydrostatically tested in the presence of the surveyor after installation on board, according to Table E1.

Table E1 Hydrostatic testing after installation on board	
Piping system	**Test pressure**
Hydraulic piping	1.5 × design pressure. The test pressure need not exceed the design pressure by more than 70 bar

Germanischer Lloyd (GL)

Rules for Classification and Construction | Ship Technology / 1. Seagoing Ships / 2. Machinery Installations / 2013

Chapter 2 – Section 11

A General

3. Pipe classes

For the testing of pipes, selection of joints, welding and heat treatment, pipes are subdivided into three classes as indicated in Table 11.1.

B Materials, Testing

TABLE 11.1 Classification of pipes into pipe classes

Medium/type of pipeline		Design pressure PR [bar] Design temperature t [°C]	
Pipe class	I	II	III
Air, gas Non-flammable hydraulic fluid Boiler feedwater, condensate Seawater and fresh water for cooling Brine in refrigerating plant	PR > 40 or t > 300	PR ≤ 40 and t ≤ 300	PR ≤ 16 and t ≤ 200
1 Classification in Pipe Class II is possible if special safety arrangements are available and structural safety precautions are arranged.			

2. Materials

2.1 Material manufacturers

Pipes, elbows, fittings, valve casings, flanges and semi-finished products intended to be used in pipe class I and II are to be manufactured by GL approved manufacturers. For the use in pipe class III piping systems an approval according to other recognized standards may be accepted.

2.2 Pipes, valves and fittings of steel

Pipes belonging to Classes I and II are to be either seamless drawn or fabricated by a welding procedure approved by GL. In general, carbon and carbonmanganese steel pipes, valves and fittings are not to be used for temperatures above 400 °C.

2.6.3 Quality control during manufacture

2.6.3.1 The manufacturer is to have a quality system that meets ISO 9000 series standards or equivalent. The quality system is to consist of elements necessary to ensure that pipes and fittings are produced with consistent and uniform mechanical and physical properties.

2.6.3.2 Each pipe and fitting is to be tested by the manufacturer at a hydrostatic pressure not less than 1,5 times the nominal pressure. Alternatively, for pipes and fittings not employing hand lay up techniques, the hydrostatic pressure test may be carried out in accordance with the hydrostatic testing requirements stipulated in the recognised national or international standard to which the pipe or fittings are manufactured, provided that there is an effective quality system in place.

2.6.3.3 Piping and fittings are to be permanently marked with identification. Identification is to include pressure ratings, the design standards that the pipe or fitting is manufactured in accordance with, and the material of which the pipe or fitting is made.

TABLE 11.1a Fire endurance requirements matrix

Piping systems		Location										
No.	Designation	A	B	C	D	E	F	G	H	I	J	K
11	Hydraulic oil	X	X	L1	X	X	0	0	0	0	L1	L1

Location definitions:

A	Machinery spaces of category A	Machinery spaces of category A as defined in SOLAS Regulation II-2/Reg. 3, 31
B	Other machinery spaces and pump rooms	Spaces other than category A machinery spaces and cargo pump rooms, containing propulsion machinery, boilers, steam and internal combustion engines, generators and major electrical machinery, pumps, oil filling stations, refrigerating, stabilising, ventilation and air-conditioning machinery and similar spaces and trunks to such spaces
C	Cargo pump rooms	Spaces containing cargo pumps and entrances and trunks to such spaces
D	Ro-ro cargo holds	Ro-ro cargo holds are ro-ro cargo spaces and special category as defined in SOLAS Reg. II-2/Reg. 3, 41, 46
E	Other dry cargo holds	All spaces other than ro-ro cargo holds used for non-liquid cargo and trunks to such spaces
F	Cargo tanks	All spaces used for liquid cargo and trunks to such spaces
G	Fuel oil tanks	All spaces used for fuel oil (excluding cargo tanks) and trunks
H	Ballast water tanks	All spaces used for ballast water and trunks to such spaces
I	Cofferdams, voids, etc.	Cofferdams and voids are those empty spaces between two bulk heads, separating two adjacent compartments
J	Accommodation, service	Accommodation spaces, service and control stations as defined in SOLAS Regulation II-2/Reg. 3, 1, 45
K	Open decks	Open deck spaces as defined in SOLAS Regulation II-2/ Reg. 9, 2.3.3.2 (10)

Abbreviations:

L1 Fire endurance test (Appendix 1) in dry conditions, 60 minutes
0 No fire endurance test required
X Metallic materials having a melting point greater than 925 °C

2.6.4 Installation

2.6.4.1 The selection and spacing of pipe supports are to take into account pipe dimensions, mechanical and physical properties of the pipe material, mass of pipe and contained fluid, external pressure, operating temperature, thermal expansion effects, loads due to external forces, thrust forces, water hammer, vibrations, maximum accelerations to which the system may be subjected. Combination of loads is to be considered.

2.6.4.3 When calculating the thermal expansions, account is to be taken of the difference between the operating temperature of the system and the ambient temperature during installation.

2.6.4.4 Pipes are to be protected during installation and service from mechanical damage where necessary.

2.6.4.7 Pipe penetrations through watertight bulkheads or decks as well as through fire divisions are to be type approved by GL.

3. Testing of materials

3.1 For piping systems belonging to class I and II, tests in accordance with GL Rules II – Materials and Welding, Part 1 – Metallic Materials and under GL supervision are to be carried out in accordance with Table 11.3 for:
– pipes, bends and fittings
– valve bodies and flanges
– valve bodies and flanges > DN 100 in cargo and process pipelines on gas tankers with design temperature < -55 °C

4. Hydraulic tests on pipes

4.1 Definitions

4.1.1 Maximum allowable working pressure, PB [bar], Formula symbol: pe,zul

This is the maximum allowable internal or external working pressure for a component or piping system with regard to the materials used, piping design requirements, the working temperature and undisturbed operation.

4.1.2 Nominal pressure, PN [bar]

This is the term applied to a selected pressure temperature relation used for the standardization of structural components. In general, the numerical value of I - Part 1 GL 2013 Section 11 Piping Systems, Valves and Pumps Chapter 2 Page 11–7 B the nominal pressure for a standardized component made of the material specified in the standard will correspond to the maximum allowable working pressure PB at 20 °C.

TABLE 11.2 Approved materials

Material or application		Pipe class		
		I	II	III
Steels	Pipes	Steel pipes for high temperatures above 300 °C, pipes made of steel with high/low temperature toughness at temperatures below – 10 °C, stainless steel pipes for chemicals	Pipes for general applications	Steel not subject to any special quality specification, weldability in accordance with Rules
	Forgings, plates, flanges, steel sections and bars	Steel suitable for the corresponding service and processing conditions, high temperature steel for temperatures above 300 °C, steel with high/low-temperature toughness for temperatures below –10 °C		
	Bolts, nuts	Bolts for general machinery constructions, high-temperature steel for temperatures above 300 °C, steel with high/low temperature toughness for temperatures below –10 °C	Bolts for general machine construction	

TABLE 11.3 Approved materials and types of material Certificates

Type of component	Approved materials	Design temperature	Pipe class	Nominal diameter DN	Type of Certificate [2]		
					A	B	C
Pipes[1]. Pipe elbows, Fittings	Steel, Copper, Copper alloys, Aluminium Aluminium alloys Plastics	–	I + II	> 50 ≤ 50	x –	– x	– –
			III	All	–	–	–
Valves [1], Flanges,	Steel, Cast steel, Nodular cast iron	> 300 °C	I, II	DN > 100 DN ≤ 100	x –	– x	– –
	Copper, Copper alloys	> 225 °C					
	Steel, Cast steel, Nodular cast iron	≤ 300 °C	I, II	PB × DN > 2500 or DN > 250	×	–	–
				PB × DN ≤ 2500 and DN ≤ 250	–	x	–
	Steel, Cast steel, Nodular cast iron, Grey cast iron	–	III	All	–	–	x
	Copper, Copper alloys	≤ 225 °C	I, II	PB × DN > 1500	x	–	–
	Aluminium, Aluminium alloys	≤ 200 °C		PB × DN ≤ 1500	–	x	–
	Plastics	Acc. to Type Approval Certificate	III	All	–	–	x
Semi-finished products, Screws and other components	According to Table 11.2	–	I, II	–	–	x	–
			III		–	–	x

[1] Casings of valves and pipes fitted on ship's side and bottom and bodies of valves fitted on collision bulkhead are to be included in pipe class II

[2] Test Certificates acc. to GL Rules for Principles and Test Procedures (II-1-1), Section 1, H. with the following abbreviations: A: GL Material Certificate, B: Manufacturer Inspection Certificate, C: Manufacturer Test Report

4.1.3 Test pressure, PP [bar] F
ormula symbol: pp

This is the pressure to which components or piping systems are subjected for testing purposes.

4.1.4 Design pressure, PR [bar]
Formula symbol: pc

This is the maximum allowable working pressure PB for which a component or piping system is designed with regard to its mechanical characteristics. In general, the design pressure is the maximum allowable working pressure at which the safety equipment will interfere (e.g. activation of safety valves, opening of return lines of pumps, operating of overpressure safety arrangements, opening of relief valves) or at which the pumps will operate against closed valves. The design pressure for fuel pipes is to be chosen according to Table 11.4.

TABLE 11.4 Design pressure for fuel pipes

Max. working temperature / Max. working pressure	T ≤ 60 °C	T > 60 °C
PB ≤ 7 bar	3 bar or max. working pressure, whichever is greater	3 bar or max. working pressure, whichever is greater
PB > 7 bar	max. working pressure	14 bar or max. working pressure, whichever is greater

4.2 Pressure test prior to installation on board

4.2.1 All Class I and II pipes as well as steam lines, feed water pressure pipes, compressed air and fuel lines having a design pressure PR greater than 3,5 bar together with their integral fittings, connecting pieces, branches and bends, after completion of manufacture but before insulation and coating, if this is provided, are to be subjected to a hydraulic pressure test in the presence of the Surveyor at the following value of pressure:

$p_p = 1{,}5 \cdot pc$ [bar]

where pc is the design pressure. For steel pipes and their integral fittings intended to be used in systems with working temperature above 300 °C the test pressure PP is to be as follows:

$$P_p = 1{,}5 \cdot \frac{\sigma_{zul}\,(100°)}{\sigma_{zul}\,(t)} \cdot P_c$$

σ_{zul} (100°) = permissible stress at 100 °C

σ_{zul} (t) = permissible stress at the design temperature t [°C]

However, the test pressure need not exceed:

$p_p = 2 \cdot pc$ [bar]

With the approval of GL, this pressure may be reduced to 1,5 pc where it is necessary to avoid excessive stress in way of bends, T-pieces and other shaped components. In no case may the membrane stress exceed 90 % of the yield strength or 0,2 % of the maximum elongation.

4.2.2 Where for technical reasons it is not possible to carry out complete hydraulic pressure tests on all sections of piping before assembly on board, proposals are to be submitted to GL for approval for testing pipe connections on board, particularly in respect of welding seams.

4.2.3 Where the hydraulic pressure test of piping is carried out on board, these tests may be conducted in conjunction with the tests required under 4.3.

4.2.4 Pressure testing of pipes with less than DN 15 may be omitted at GL's discretion depending on the application.

4.3 Test after installation on board

4.3.1 After assembly on board, all pipelines covered by these requirements are to be subjected to a tightness test in the presence of a GL Surveyor. In general, all pipe systems are to be tested for leakage under operational conditions. If necessary, special techniques other than hydraulic pressure tests are to be applied.

4.4 Pressure testing of valves

The following valves are to be subjected in the manufacturer's works to a hydraulic pressure test in the presence of a GL Surveyor:
– valves of pipe classes I and II to 1,5 PR
– valves on the ship's side to not less than 5 bar
Shut-off devices of the above type are to be additionally tested for tightness with the nominal pressure.
Shut-off devices for boilers, see Section 7a, E.13.

C Calculation of Wall Thickness and Elasticity

1. Minimum wall thickness

1.1 The pipe thicknesses stated in Tables 11.5 to 11.8 are the assigned minimum thicknesses, unless due to stress analysis, see 2., greater thicknesses are necessary. Provided that the pipes are effectively protected against corrosion, the wall thicknesses of group M and D stated in Table 11.6 may, with GL's agreement, be reduced by up to 1 mm, the amount of the reduction is to be in relation to the wall thickness. Protective coatings, e.g. hot-dip galvanizing, can be recognized as an effective corrosion protection provided that the preservation of the protective coating during installation is guaranteed. For steel pipes the wall thickness group corresponding to the location is to be as stated in Table 11.5.

1.2 The minimum wall thicknesses for austenitic stainless steel pipes are given in Table 11.7.

1.3 For the minimum wall thickness of air, sounding and overflow pipes through weather decks, see R., Table 11.20a. For CO2 fire extinguishing pipelines, see Section 12, Table 12.6.

1.4 Where the application of mechanical joints results in reduction in pipe wall thickness (bite type rings or other structural elements) this is to be taken into account in determining the minimum wall thickness.

TABLE 11.5 Minimum wall thickness groups N, M and D of steel pipes and approved locations

	Location															
Piping system	Machinery spaces	Cofferdams / void spaces	Cargo holds	Ballast water tanks	Fuel and changeover tanks	Fresh cooling water tanks	Lubricating oil tanks	Hydraulic oil tanks	Drinking water tanks	Thermal oil tanks	Condensate and feedwater tanks	Accommodation	Cargo tanks, tank ships	Cofferdams, tank ships	Cargo pump rooms	Weather deck
Hydraulic lines						X	X			X		X	N			

X Pipelines are not to be installed.

2. Calculation of pipe wall thicknesses

2.1 The following formula is to be used for calculating the wall thicknesses of cylindrical pipes and bends subject to internal pressure:

$$s = s_o + c + b \text{ [mm]} \qquad (1)$$

$$s_o = \frac{d_a \cdot p_c}{20 \cdot \sigma_{zul} \cdot V + P_c} \text{ [mm]} \qquad (1a)$$

s = minimum wall thickness [mm], see 2.7

s_o = calculated thickness [mm]

d_a = outer diameter of pipe [mm]

p_c = design pressure [bar] 2, see B.4.1.4

q_{zul} = maximum permissible design stress [N/mm2], see 2.3

b = allowance for bends [mm], see 2.2

v = weld efficiency factor [–], see 2.5

c = corrosion allowance [mm], see 2.6

---

2 For pipes containing fuel heated above 60 °C the design pressure is to be taken not less than 14 bar.

2.2 For straight cylindrical pipes which are to be bent, an allowance (b) is to be applied for the bending of the pipes. The value of (b) is to be such that the stress due to the bending of the pipes does not exceed the maximum permissible design stress σ_{zul}. The allowance (b) can be determined as follows:

$$b = 0{,}4 \cdot \frac{d_a}{R} \cdot s_o \qquad (2)$$

R = bending radius [mm]

2.3 Permissible stress σ_{zul}

2.3.1 Steel pipes

The permissible stress σ_{zul} to be considered in formula (1a) is to be chosen as the lowest of the following values:

a) design temperature ≤ 350 °C

$$\sigma_{ml} = \min\left\{\frac{R_{m,20°}}{A}, \frac{R_{eH,t}}{B}, \frac{R_{P0,2,t}}{B}\right\}$$

$Rm,_{20°}$ = specified minimum tensile strength at room temperature

$R_{eH,t}$ = specified minimum yield stress at design temperature; or

$p_{0,2\ ,t\ R}$ = minimum value of the 0,2 % proof stress at design temperature

b) design temperature > 350 °C, whereby it is to be checked whether the calculated values according to a) give the decisive smaller value

$$\sigma_{zul} = \min\left\{\frac{R_{m,100000,t}}{B}, \frac{R_{P1,100000,t}}{B}, \frac{R_{m,100000,(t+15)}}{B}\right\}$$

$R_{m,100000,t}$ = minimum stress to produce rupture in 100000 hours at the design temperature t

$p_{1,100000,t\,R}$ =average stress to produce 1 % creep in 100000 hours at the design temperature t

$R_{m,100000,(t+15)}$ = average stress to produce rupture in 100000 hours at the design temperature t plus 15 °C, see 2.4

In the case of pipes which:
– are covered by a detailed stress analysis acceptable to GL and
– are made of material tested by GL, GL may, on special application, agree to a safety factor B of 1,6 (for A and B see Table 11.10).

TABLE 11.10 Coefficients A, B for determining the permissible stress σ_{zul}

Material \ Pipe class	I		II, III	
	A	B	A	B
Unalloyed and alloyed carbon steel	2,7	1,6	2,7	1,8
Rolled and forged stainless steel	2,4	1,6	2,4	1,8
Steel with yield strength[1] > 400 N/mm²	3,0	1,7	3,0	1,8
Gray cast iron	–	–	11,0	–
Nodular cast iron	–	–	5,0	3,0
Cast steel	3,2	–	4,0	–

1) Minimum yield strength or minimum 0,5 % proof stress at 20 °C.

2.4 Design temperature

2.4.1 The design temperature is the maximum temperature of the medium inside the pipe.

2.5 Weld efficiency factor v

– For seamless pipes v = 1,0
– In the case of welded pipes, the value of v is to be taken according to the works acceptance test of GL.

2.6 Corrosion allowance c

The corrosion allowance c depends on the application of the pipe, in accordance with Tables 11.11a and 11.11b. With the agreement of GL, the corrosion allowance of steel pipes effectively protected against corrosion may be reduced by not more than 50 %.

TABLE 11.11a Corrosion allowance c for carbon steel pipes

Type of piping system	Corrosion allowance c [mm]
Hydraulic oli lines, Lubricating oil lines	0,3

2.7 Tolerance allowance t

The negative manufacturing tolerances on the thickness according to the standards of the technical terms of delivery are to be added to the calculated wall thickness so and specified as the tolerance allowance t. The value of t may be calculated as follows:

$$t = \frac{a}{100-a} \cdot s_o \text{ [mm]} \qquad (3)$$

a = negative tolerance on the thickness [%]
s_o = calculated wall thickness according to 2.1 [mm]

4. Fittings

Pipe branches may be dimensioned according to the equivalent surface areas method where an appropriate reduction of the maximum permissible stress as specified in 2.3 is to be proposed. Generally, the maximum permissible stress is equal to 70 % of the value according to 2.3 for pipes with diameters over 300 mm. Below this figure, a reduction to 80 % is sufficient. Where detailed stress measuring, calculations or approvals are available, higher stresses can be permitted.

5. Calculation of flanges

Flange calculations by a recognized method and using the permitted stress specified in 2.3 are to be submitted if flanges do not correspond to a recognized standard, if the standards do not provide for conversion to working conditions or where there is a deviation from the standards. Flanges in accordance with standards in which the values of the relevant stresses or the material are specified may be used at higher temperatures up to the following pressure:

$$Pzul = \frac{\sigma_{zul\ standard}}{\sigma_{zul(t,material)}} \cdot Pstandard$$

$\sigma_{zul\ (t,\ material)}$ = permissible stress according to 2.3 for proposed material at design temperature t

$\sigma_{zul\ standard}$ = permissible stress according to 2.3 for the material at the temperature corresponding to the strength data specified in the standard

$p_{standard}$ = nominal pressure PN specified in the standard

D Principles for the Construction of Pipes, Valves, Fittings and Pumps

2. Pipe connections

2.1 The following pipe connections may be used:
- full penetration butt welds with/without provision to improve the quality of the root
- socket welds with suitable fillet weld thickness and where appropriate in accordance with recognized standards
- steel flanges may be used in accordance with the permitted pressures and temperatures specified in the relevant standards
- mechanical joints (e.g. pipe unions, pipe couplings, press fittings, etc.) of an approved type

For the use of welded pipe connections, see Table 11.12 2.2 Flange connections 2.2.1 Dimensions of flanges and bolting are to comply with recognized standards.

TABLE 11.12 Pipe connections

Types of connections	Pipe class	Outside diameter
Welded butt-joints with special provisions for root side	I, II, III	all
Welded butt-joints with special provisions for root side	II, III	
Socket weld brazed connections [1)]	III	
	II	≤ 60,3 mm

1) For flammable liquids brazed connections are only permitted between pipes and components which are directly connected to machinery and equipment.

brazed connections in piping systems conveying flammable media which are arranged in machinery spaces of category A are not permitted

2.2.2 Gaskets are to be suitable for the intended media under design pressure and maximum working temperature conditions and their dimensions and construction is to be in accordance with recognized standards. 2.2.3 Steel flanges may be used as shown in Tables 11.16 and 11.17 in accordance with the permitted pressures and temperatures specified in the relevant standards.

TABLE 11.13 Examples of mechanical joints

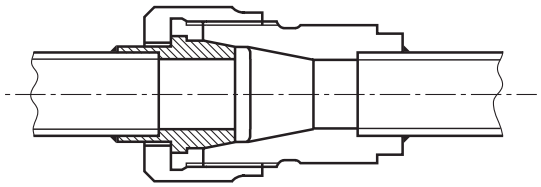
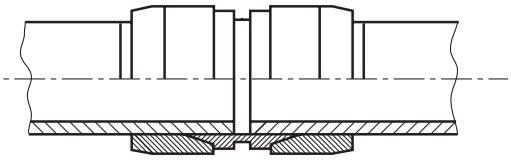
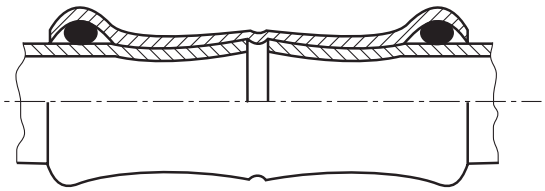
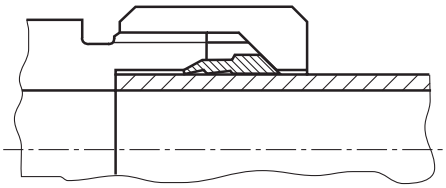
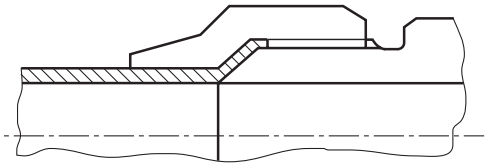
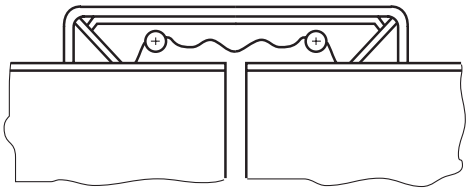
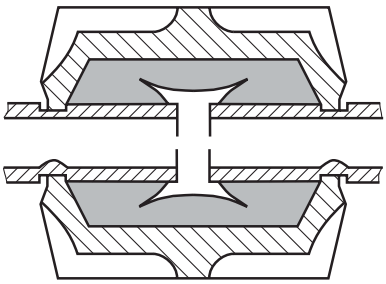
Pipe Unions	
Welded and brazed type	
Compression Couplings	
Swage type	
Press type	
Bite type	
Flared type	
Slip-on Joints	
Grip type	
Machine grooved type	

TABLE 11.13 Examples of mechanical joints (continued)

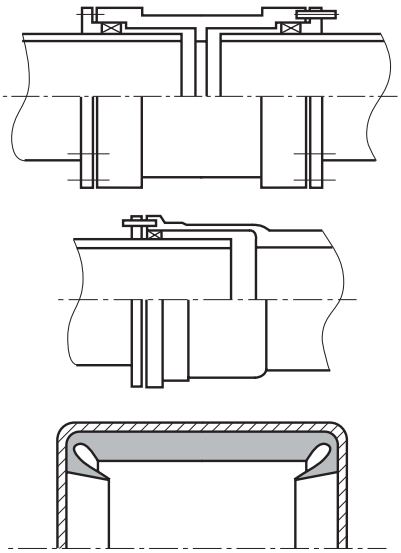
Slip type	

TABLE 11.14 Application of mechanical joints

	Kind of connections		
Systems	Pipe Unions	Compression couplings	Slip on joints
Flammable fluids (Flash point > 60 °C)			
Hydraulic oil	+	+	+ 2, 3

Abbreviations:	**Footnotes:**
+ Application is allowed – Application is not allowed	1 Inside machinery spaces of category A – only approved flame resistant types [7] 2 Not inside machinery spaces of category A or accommodation spaces. May be accepted in other machinery spaces provided the joints are located in easily visible and accessible positions. 3 Approved flame resistant types [7]

TABLE 11.15 Application of mechanical joints depending upon the class of piping

Types of joints	Classes of piping systems		
	I	II	III
Pipe Unions			
Welded and brazed type	+ ($d_a \leq 60,3$ mm)	+ ($d_a \leq 60,3$ mm)	+
Compression couplings			
Swage type	+	+	+
Press type	–	–	+
Bite type Flared type	+ ($d_a \leq 60,3$ mm)	+ ($d_a \leq 60,3$ mm)	+
Slip on Joints			
Machine grooved	+	+	+
Grip type	–	+	+
Slip type	–	+	+
Abbreviations: + Application is allowed – Application is not allowed			

TABLE 11.16 Use of flange types

Pipe class	Lubrication oil, fuel oil
	Type of flange
I	A, B
II	A, B, C, E [2)]
III	A, B, C, E
[2)] Type E only for t < 150 °C and PR < 16 bar	

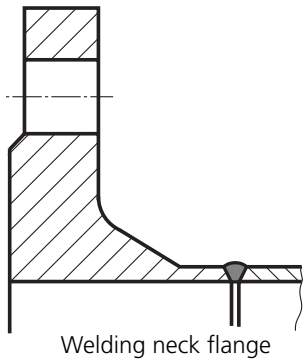
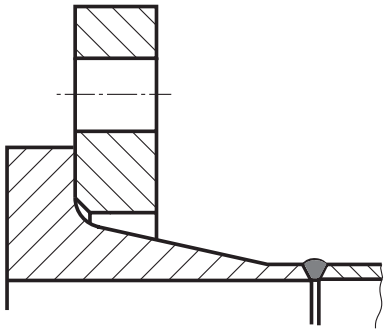
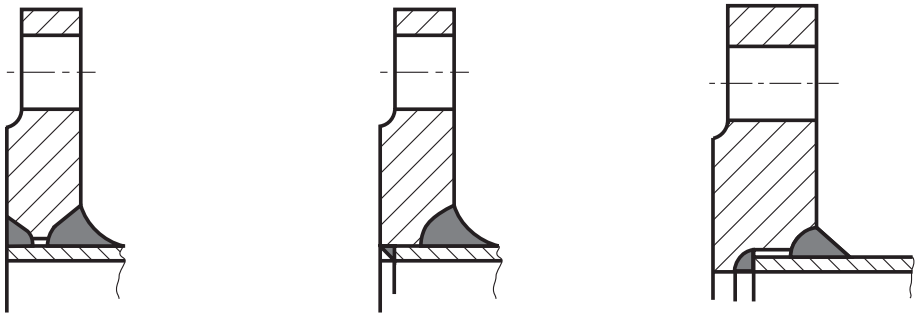
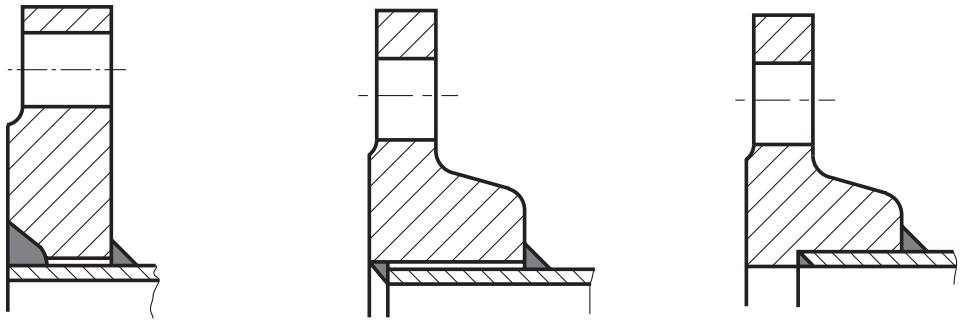
4. Shut-off devices

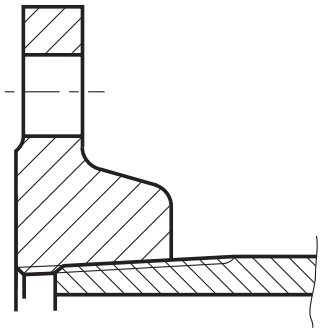
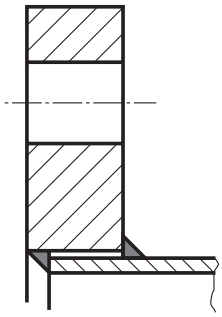
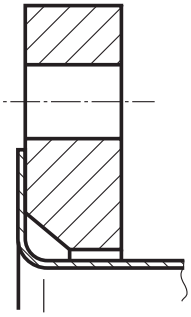
4.1 Shut-off devices are to comply with a recognized standard. Valves with screwed-on covers are to be secured to prevent unintentional loosening of the cover.

4.2 Hand-operated shut-off devices are to be closed by turning in the clockwise direction

4.3 Valves are to be clearly marked to show whether they are in the open or closed position. 4.4 Change-over devices in piping systems

TABLE 11.17 Types of flange connections

Type A	
 Welding neck flange	 Loose flange with welding neck
Type b	
 Slip-on welding flange - fully welded	
Type c	
 Slip-on welding flange	

Type D	Type E	Type F
 Socket screwed flange -conical threads-	 Plain flange -conical threads-	 Lap joint flange -conical threads-

6. Remote control of valves

6.1 Scope
These requirements apply to hydraulically, pneumatically or electrically operated valves in piping systems and sanitary discharge pipes.

6.2 Construction
6.2.1 Remote controlled bilge valves and valves important for the safety of the ship are to be equipped with an emergency operating arrangement.

6.2.2 For the emergency operation of remote controlled valves in cargo piping systems, see Section 15, B.2.3.3.

6.3 Arrangement of valves

6.3.1 The accessibility of the valves for maintenance and repair is to be taken into consideration. Valves in bilge lines and sanitary pipes are to be always accessible.

9. Piping on ships with Character of Classification ✠ or ✠

9.3 For pipe penetrations through watertight bulkheads, see GL Rules for Hull Structures (I-1-1), Section 11, A.3.4.

U Hose Assemblies and Compensators

1. Scope

1.1 The following requirements are applicable for hose assemblies and compensators made of nonmetallic and metallic materials.

1.1.1 Hose assemblies and compensators made of non-metallic and metallic materials may be used according to their suitability in fuel-, lubricating oil-, hydraulic oil-, bilge-, ballast-, fresh water cooling-, sea water cooling-, fire extinguishing-, compressed air-, auxiliary steam12 (pipe class III) exhaust gas and

[12] Metallic hose assemblies and compensators only thermal oil systems as well as in secondary piping systems.

2. Definitions

2.2 Low-pressure hose assemblies and compensators made of non-metallic materials

Hose assemblies or compensators which are suitable for use in systems with predominant static load characteristics.

2.3 Maximum allowable working pressure respectively nominal pressure of hose assemblies and compensators made of nonmetallic materials

2.4 Test pressure

2.4.1 For non-metallic high pressure hose assemblies the test pressure is 2 times the maximum allowable working pressure.

2.4.2 For non-metallic low pressure hose assemblies and compensators the test pressure is 1,5 times I - Part 1 GL 2013 Section 11 Piping Systems, Valves and Pumps Chapter 2 Page 11–51 U the maximum allowable working pressure respectively the nominal pressure.

2.4.3 For metallic hose assemblies and compensators the test pressure is 1,5 times the maximum allowable working pressure respectively the nominal pressure.

2.5 Burst pressure

For non-metallic as well as metallic hose assemblies and compensators the burst pressure is to be at least 4 times the maximum allowable working pressure or the nominal pressure. Excepted hereof are nonmetallic hose assemblies and compensators with a maximum allowable working pressure or nominal pressure of not more than 20 bar. For such components the burst pressure has to be at least 3 times the maximum allowable working pressure or the nominal pressure.

For hose assemblies and compensators in process and cargo piping for gas and chemical tankers the burst pressure is required to be at least 5 times the maximum allowable working pressure or nominal pressure.

3. Requirements

3.1 Compensators and hoses assemblies (hose and hose end fitting) used in the systems mentioned in 1.1.1 are to be of approved type. 13

3.2 Manufacturers of hose assemblies and compensators 14, 15 are to be recognized by GL. For production of hose assemblies and compensators intended to be installed in mass produced engines with a piston diameter up to 300 mm the procedure specified in the GL Guidelines for Mass Produced Engines (VI-4-1) may be applied.

3.3 Hose assemblies and compensators including their couplings are to be suitable for media, pressures and temperatures they are designed for.

3.4 The selection of hose assemblies and compensators is to be based on the maximum allowable working pressure of the system concerned.

3.5 Hose assemblies and compensators for the use in fuel-, lubricating oil-, hydraulic oil-, bilge- and sea water systems are to be flame-resistant. [13]

[13] See GL Guidelines Test Requirements for Systems of Mechanical Engineering and Offshore Technology (VI-7-8)

4. Installations

4.1 Hose assemblies and compensators are only to be used at locations where they are required for compensation of relative movements. They are to be kept as short as possible under consideration of the installation instructions of the hose manufacturer. The number of hose assemblies and compensators is to be kept to minimum.

4.2 The minimum bending radius of installed hose assemblies is not to be less than specified by the manufacturers.

4.3 Non-metallic hose assemblies and compensators are to be located at visible and accessible positions.

4.4 In fresh water systems

6. Marking of hose assemblies and compensators

Hose assemblies and compensators are to be permanently marked to ensure traceability to the hose assembly manufacturer, production date and product type. The scope of marking should be as follows:
- date of manufacture (month/year)
- product type according to type approval certificate
- nominal diameter
- maximum allowable working pressure or nominal pressure
- maximum allowable working temperature

Alternatively:
- GL Test Certificate Number
- maximum allowable working pressure

Chapter 2 – Section 14

A Steering Gears

1. General

1.1 Scope

The requirements contained in A. apply to the steering gear including all the equipment used to operate the rudder, the steering station and all transmission elements from the steering station to the steering gear. For the rudder and manoeuvring arrangement, see GL Rules for Hull Structures (I-1-1), Section 14.

The requirements set out in SOLAS Chapter II-1, Regulation 29 and 30 in their most actual version are integral part of this rule and are to be applied in their full extent.

1.2 Documents for approval

Assembly and general drawings of all steering gears, diagrams of the hydraulic and electrical equipment together with detail drawings of all important loadtransmitting components are to be submitted to GL in triplicate for approval.

F Hydraulic Systems

1. General

1.1 Scope

The requirements contained in F. apply to hydraulic systems used, for example, to operate hatch covers, closing appliances in the ship's shell and bulkheads, and hoists. The requirements are to be applied in analogous manner to the ship's other hydraulic systems except where covered by the requirements of Section 11.

2. Materials

2.1 Approved materials

2.1.1 Components fulfilling a major function in the power transmission system normally are to be made of steel or cast steel in accordance with the Rules II – Materials and Welding, Part 1 – Metallic Materials. The use of other materials is subject to special agreement with GL.

2.1.2 Pipes are to be made of seamless or longitudinally welded steel tubes.

2.1.3 The pressure-loaded walls of valves, fittings, pumps, motors, etc. are subject to the requirements of Section 11, B.

2.2 Testing of materials

The following components are to be tested under supervision of GL in accordance with the Rules II – Materials and Welding, Part 1 – Metallic Materials:

a) Pressure pipes with DN > 50 (see Section 11, Table 11.3)

3. Hydraulic operating equipment for hatch covers

3.1 Design and construction

3.1.1 Hydraulic operating equipment for hatch covers may be served either by one common power station for all hatch covers or by several power stations individually assigned to a single hatch cover. Where a common power station is used, at least two pump units are to be fitted. Where the systems are supplied individually, change-over valves or fittings are required so that operation can be maintained should one pump unit fail.

3.2 Pipes

3.2.1 Pipes are to be installed and secured in such a way as to protect them from damage while enabling them to be properly maintained from outside. Pipes may be led through tanks in pipe tunnels only. The laying of such pipes through cargo spaces is to be restricted to the essential minimum. The piping system is to be fitted with relief valves to limit the pressure to the maximum allowable working pressure.

3.2.2 The piping system is to be fitted with filters for cleaning the hydraulic fluid.

3.3 Hose assemblies

The construction of hose assemblies is to conform to Section 11, U. The requirement that hose assemblies should be of flame-resistant construction may be set aside for hose lines in spaces not subject to a fire hazard and in systems not important to the safety of the ship.

4. Hydraulically operated closing appliances in the ship's shell

4.1 Scope

The following requirements apply to the power equipment of hydraulically operated closing appliances in the ship's shell such as shell and landing doors which are normally not operated while at sea. For the design and arrangement of the closures, see GL Rules for Hull Structures (I-1-1), Section 6, H.

4.3 Pipes, hose assemblies

3.2 and 3.3 are to be applied in analogous manner to the pipes and hose lines of hydraulically operated closing appliances in the ship's shell.

5. Bulkhead closures

5.1 General

5.1.1 Scope

5.1.1.1 The following requirements apply to the power equipment of hydraulically-operated watertight bulkhead doors on passenger and cargo vessels.

5.1.1.2 For details of the number, design and arrangement of bulkhead doors, see GL Rules for Hull Structures (I-1-1), Section 11, 26 and 28. The SOLAS regulations, Chapter II-1, Regulations 15, 16 and 25.9 are not affected by these provisions.

5.1.3 Piping

5.1.3.1 Wherever applicable, the requirements for pipes in hydraulic bulkhead closing systems are governed by the Rules in 3.2, with the restriction that the use of flexible hose assemblies is not permitted.

5.1.3.2 The hydraulic fluids must be suitable for the intended ambient and service temperatures.

5.1.4 Drive unit

5.1.4.3 The control system is to be designed in such a way that an individual fault inside the control system, including the piping, does not have any adverse effect on the operation of other bulkhead doors

6. Hoist

6.1 Definition

For the purposes of these requirements, hoists include hydraulically operated appliances such as wheelhouse hoists, lifts, lifting platforms and similar equipment.i

6.3 Pipes, hose assemblies

3.2 and 3.3 apply in analogous manner to the pipes and hose lines of hydraulically operated hoists.

Lloyd´s Register

Lloyd´s Register (LR)

Rules and Regulations for the Classification of Naval Ships / January 2013

Volume 1

Part 2 – Chapter 1 – Section 3

Certification of materials

3.1 General

3.1.1 All materials subject to these Rules are to be supplied with appropriate certification, as required by the relevant requirements of these Rules. This will normally be a LR certificate or a manufacturer's certificate validated by LR, although a manufacturer's certificate may be accepted where allowed by the relevant requirements of these Rules.

3.1.2 Manufacturers approved under the MaterialsQuality Scheme are licensed to apply the scheme mark to manufacturer's certificates according to the requirements of the scheme, see 2.4.

3.1.3 The following certificate types are to be used, (a) and (b) for the Materials Survey Scheme, and (d) for the Materials Quality Scheme:

(a) LR Certificate
This type of certificate is issued by LR based on the results of testing and inspection being satisfactorily carried out in accordance with the requirements of these Rules.

(b) Manufacturer's certificate validated by LR
A manufacturer's certificate, validated by LR on the basis of inspection and testing carried out on the delivered product in accordance with the requirements of these Rules may be accepted. In this case, the certificate will include the following statement:

"We hereby certify, that the material has been made by an approved process and satisfactorily tested in accordance with the Rules of Lloyd's Register."

(c) Manufacturer's certificate
This type of certificate is issued by the manufacturer, based on the results of testing and inspection being satisfactorily carried out in accordance with the requirements of these Rules, or the applicable National or International standard. The certificate is to be validated by the manufacturer's authorised representative, independent of the manufacturing department. The certificate will contain a declaration that the products are in compliance with the requirements of these Rules or the applicable National or International standard.

(d) Manufacturer's certificate issued under the Materials Quality Scheme
Where a manufacturer is approved according to the Materials Quality Scheme, they will issue manufacturer's certificates bearing the scheme mark. The certificates must also bear the following statement:

"This certificate is issued under the arrangementsauthorised by Lloyd's Register (operating group) in accordance with the requirements of the Materials Quality Scheme and certificate number MQS ……."

3.1.4 Where these Rules allow for the issue of a manufacturer's certificate for materials, either validated by an LR Surveyor, or bearing the Materials Quality Scheme mark, the manufacturer is to ensure that a copy of the certificate is supplied to LR.

Chapter 1 – Section 4

General requirements for manufacture

4.1 General

4.1.1 The following definitions are applicable to these Rules:

Item: A single forging, casting, plate, tube or other rolled product as delivered.

Piece: The rolled product from a single slab or billet or from a single ingot if this is rolled directly into plates, strip, sections or bars.

Batch: A number of similar items or pieces presented as a group for acceptance testing.

4.1.4 The manufacturer is to maintain all test and inspection records required by these Rules for at least seven years Records are to be made available to LR on request.

TABLE 1.4.1 Conversions from SI units to metric and Imperial units

1 N/mm^2 or MPa	=	0,102 kgf/mm^2
1 N/mm^2 or MPa	=	0,0647 $tonf/in^2$
1 N/mm^2 or MPa	=	0,145 x 10^3 lbf/in^2
1J	=	0,102 kgf m
1J	=	0,738 tf lbs
1 kgf/mm^2	=	9,81 N/mm^2 or MPa
1 $tonf/in^2$	=	15,4 N/mm^2 or MPa
1 lbf/in^2	=	6,89 x 10^{-3} N/mm2 or MPa
1 kgf m	=	9,81 J
1 ft lbf	=	1,36 J

4.8 Identification of materials

4.8.1 The manufacturer is to adopt a system of identification, which will enable all finished materials to be traced to the original cast, and the Surveyors are to be given full facilities for tracing the material when required. When any item has been identified by the personal mark of a Surveyor, or his deputy, this is not to be removed until an acceptable new identification mark has been made by a Surveyor. Failure to comply with this condition will render the item liable to rejection.

4.8.2 Before any item is finally accepted, it is to be clearly marked by the manufacturer in at least one place with the particulars detailed in the appropriate specific requirements.

4.8.3 Where hard stamps such as the LR brand stampare issued to manufacturers to carry out the stamping on behalf of LR, the procedure for issue, maintenance and use of stamps is to be agreed in writing.

4.8.4 Hard stamping is to be used except where this may be detrimental to the material, in which case stencilling, painting or electric etching is to be used. Paints used to identify alloy steels are to be free from lead, copper, zinc or tin, i.e., the dried film is not to contain any of these elements in quantities of more than 250 ppm.

Chapter 6 – Section 1

General requirements

1.13 Certification of materials

1.13.1 Unless a LR certificate is specified in other parts of the Rules, a manufacturer's certificate validated by LR is to be issued, see Ch 1,3.1.

1.13.2 The manufacturer is to provide LR with the following information:

(a) Purchaser's name and order number.
(b) If known, the contract number for which the material isintended.
(c) Address to which material is despatched.
(d) Specification or the grade of material.
(e) Description and dimensions.
(f) Identification number and/or initials.
(g) Cast number and chemical composition of ladlesamples.
(h) Mechanical test results, and results of the intercrystallinecorrosion tests where applicable.
(j) Condition of supply.

1.13.3 As a minimum, the chemical composition stated on the certificate is to include the content of all the elements detailed in the specific requirements. Where rimming steel is supplied, this is to be stated on the certificate.

1.13.4 When steel is not produced at the pipe or tube mill, a certificate is to be supplied by the steelmaker stating the process of manufacture, the cast number and the ladle analysis.

Chapter 6 – Section 2

Seamless pressure pipes

2.4 Mechanical tests

2.4.1 All pipes are to be presented in batches as defined in Section 1.

2.4.3 The results of all mechanical tests are to comply with the appropriate requirements given in Table 6.2.2.

TABLE 6.2.3 Heat treatment

Type of steel	Condition of supply
Cold finished	Normalised (see note 2)
NOTES 2. Normalised and tempered at the option of the manufacturer.	

TABLE 6.2.2 Mechanical properties for acceptance purposes: seamless pressure pipes (maximum wall thickness 40 mm), see 2.1.2

Type of steel	Grade	Yield stress	Tensile strenght	Elongation on $5{,}65\sqrt{S_o}$ % minimum	Flattening test constant C	Bend test diameter of former (t=thickness)
Carbon and carbon-manganese	490	285	490–610	21	0,07	4t

TABLE 6.2.4 Mechanical properties for design purposes: seamless pressure pipes

Type of steel	Grade	Nominal minumum lower yield or 0,2 % proof stress N/mm²
		Temperature °C 50
Carbon and carbon-manganese	490	256

Chapter 6 – Section 5

Austenitic stainless steel pressure pipes

5.1 Scope

5.1.3 Where it is intended to supply seamless pipes in the direct quenched condition, a programme of tests for approval is to be carried out under the supervision of the Surveyors, and the results are to be to the satisfaction of LR, see Ch 1,2.2.

5.2 Manufacture and chemical composition

5.2.1 Pipes are to be manufactured by a seamless or a continuous automatic electric fusion welding process.

5.2.3 The chemical composition of the ladle samples is to comply with the appropriate requirements of Table 6.5.1.

5.4 Mechanical tests

5.4.1 All pipes are to be presented in batches as defined in Section 1 for Class I and II piping systems..

TABLE 6.5.1 Chemical composition

Type of steel	Grade	Chemical composition of ladle sample								
		C max.	Si	Mn	P max.	S max.	Cr	Mo	Ni	Others
316L	490	0,03	<1,00	<2,00	0,045	0,030	16,0–18,5	2,0–3,0	11,0–14,5	–

TABLE 6.5.2 Mechanical properties for acceptance purposes

Type of steel	Grade	0,2 % proof stress N/mm² (see note)	1,0 % proof stress N/mm²	Tensile strength N/mm²	Elongation on $5{,}65\sqrt{S_o}$ % minimum	Flattening test constant C	Bend test diameter of former (t=thickness)
316L	490	185	215	490–690	30	0,09	3t
NOTE: The 0,2 % proof stress values given for information purposes and unless otherwise agreed are not required to be verified by test.							

5.7 Certification of materials

5.7.1 Each test certificate is to be of the type and give the information detailed in Ch 1,3.1 together with general details of heat treatment and, where applicable, the results obtained from intercrystalline corrosion tests. As a minimum, the chemical composition is to include the content of all the elements detailed in Table 6.5.1.

Volume 2

Part 7 – Chapter 1 – Section 1

Scope

1.1 Application

1.1.1 This Chapter applies to all naval ships intended to be classed and covers the design and construction of piping systems, including components and fittings forming part of such systems.

Part 7 – Chapter 1 – Section 2

General

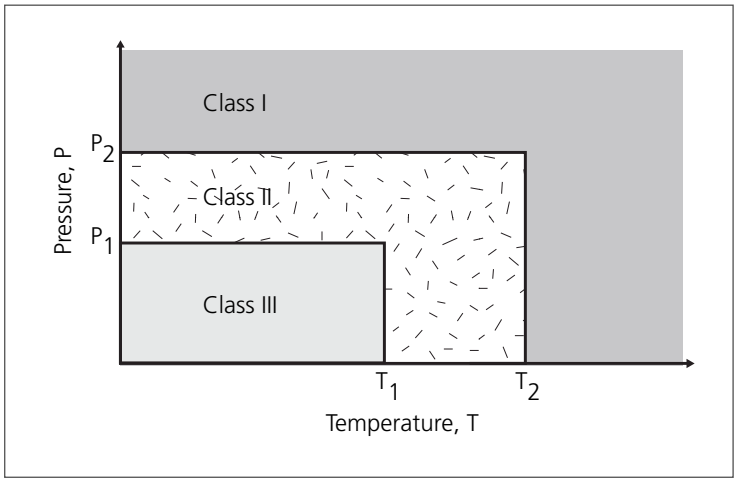
2.3 Classes of piping systems and components

2.3.1 For the purpose of testing, the type of joint to be adopted, heat treatment and welding procedure, pipes are subdivided into three classes as indicated in Table 1.2.1.

TABLE 1.2.1 Maximum pressure and temperature conditions for Class II and III piping systems

Piping system	Class II		Class III	
	p bar	Tdeg C	p bar	T deg C
Flammable liquids (see notes)	16,0	150	7,0	60
Other media	40,0	300	16,0	200
NOTES 1. Flammable liquids include; oil fuel; lubrication oil and flammable hydraulic oil				

FIG. 1.2.1 Classes of piping system



Assessment

3.2 Design symbols

3.2.1 The symbols used in this Chapter are defined as follows:

a = percentage negative manufacturing tolerance on thickness
c = corrosion allowance, in mm
d = inside diameter of pipe, in mm, see 3.2.3
e = weld efficiency factor, see 3.2.4
p = design pressure, in bar, see 3.3
p_t = hydraulic test pressure, in bar
t = the minimum thickness of a straight pipe, in mm, including corrosion allowance and negative tolerance, where applicable
t_b = the minimum thickness of a straight pipe to be used for a pipe bend, in mm, including bending allowance, corrosion allowance and negative tolerance, where applicable
D = outside diameter of pipe, in mm, see 3.2.2
R = radius of curvature of a pipe bend at the centre line of the pipe, in mm
T = design temperature, in °C, see 3.4
σ = maximum permissible design stress, in N/mm^2.

3.3 Design pressure

3.3.1 The design pressure, p, is the maximum permissible working pressure and is to be not less than the highest set pressure of the safety valve or relief valve.

3.4 Design temperature

3.4.1 The design temperature is to be taken as the maximum temperature of the internal fluid, but in no case is it to be less than 50°C.

Part 7 – Chapter 1 – Section 4

Materials

4.1 Metallic materials

4.1.1 Materials for Class I and II piping systems and components as defined in Table 1.2.1, also for shell valves and fittings and fittings on the collision bulkhead, are to be manufactured and tested in accordance with the Rules for the Manufacture, Testing and Certification of Materials (hereinafter referred to as the Rules for Materials).

4.1.4 The Manufacturer's materials certificate validated by LR will be accepted for all classes of piping and components in lieu of an LR materials certificate where the maximum design conditions are less than either of the values shown in Table 1.4.1. See Ch 1,3.1.3(b) of the Rules for Materials.

TABLE 1.4.1 Maximum conditions for pipes, valves and fittings for which Manufacturer's materials test certificate is acceptable

Material	Working temperature °C	DN=Nominal diameter, mm P_w=working pressure, bar
Carbon and low alloy steel. Stainless steel. Spheroidal or nodular cast iron.	< 300	DN < 50 or P_w x DN < 2500

TABLE 1.5.4 Application of mechanical joints depending on class of piping

Types of joints	Classes of piping systems		
	Class I	Class II	Class III
Pipe unions			
Welded and brazed type	+(OD ≤ 60,3 mm)	+(OD ≤ 60,3 mm)	+
Compression couplings			
Swage type Bite type Flared type Press type	– +(OD ≤ 60,3 mm) +(OD ≤ 60,3 mm) –	– +(OD ≤ 60,3 mm) +(OD ≤ 60,3 mm) –	+ + + +
Slip on joints			
Machine grooved type Grip type Slip type	+ – –	+ + +	+ + +
KEY + Application is allowed – Application is not allowed			

Part 7 – Chapter 1 – Section 5

Pipe connections

5.1 General

5.1.1 Connections in piping systems may be made by any of the methods described in this Section, or by special types of approved joints which have been shown to be suitable for the design conditions. Details of connection methods, not described in this Section are to be submitted for consideration.

5.1.2 The selection of pipe connections in piping systems is to recognise the boundary fluids, pressure and temperature conditions, external or cyclic loading and location.

5.1.3 Pipe connections in accordance with national or other established standards will be accepted where the standards are appropriate to the piping system.

5.1.4 The type and location of pipe connections are to recognise the need to facilitate Periodic Survey of piping systems and associated items of machinery and the need for cold 'pull up' if required.

5.1.5 Pipe connections are not to be used to compensate for pipe misalignment.

5.1.6 Piping with joints is to be adequately adjusted, aligned and supported. Supports or hangers are not to be used to force alignment of piping at the point of connection.

5.1.7 Pipes passing through, or connected to, watertight decks are to be continuous or provided with an approved bolted or welded connection to the deck or bulkhead.

5.2.1 The dimensions and configuration of flanges and bolting are to be selected in accordance with recognised standards. The dimensions and bolting arrangements of nonstandard flanges will be the subject of special consideration.

FIG. 1.5.1 Typical welded-on flanges

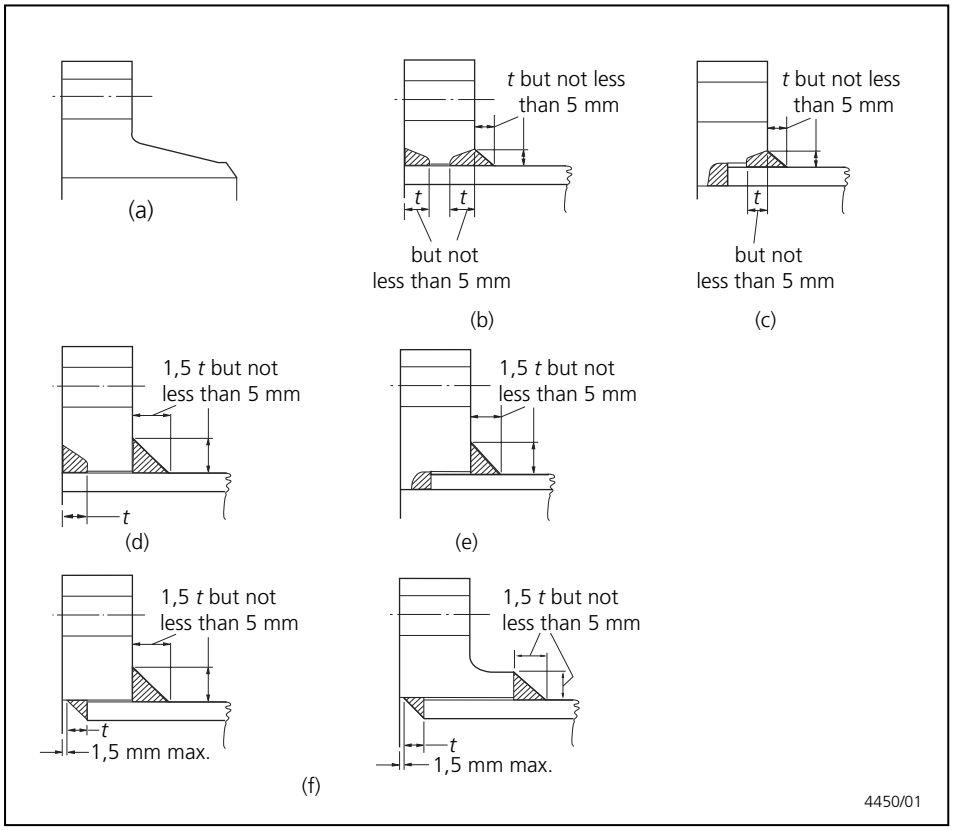


TABLE 1.5.1 Limiting design conditions for flange types

Flange type	Maximum pressure	Maximum temperature	Maximum pipe o.d.	Minimum pipe bore
		°C	mm	mm
(a)	Pressure-temperature ratings to be in accordance with a recognised standard	No restriction	No restriction	No restriction
(b)		No restriction	168,3 for alloy steels*	No restriction
(c)		No restriction	168,3 for alloy steels*	75
(d)		425	No restriction	No restriction
(e)		425	No restriction	75
(f)		425	No restriction	No restriction

* No restriction for carbon steels

5.4.2 Butt welded joints are generally to be of the full penetration type and are to meet the requirements of Chapter 13 of the Rules for Materials.

5.4.3 Welded-on flanges are not to be a tight fit on the pipes. The maximum clearance between the bore of the flange and the outside diameter of the pipe is to be 3 mm at any point, and the sum of the clearances diametrically opposite is not to exceed 5 mm.

5.4.4 Where butt welds are employed in the attachment of flange type (a), in pipe-to-pipe joints or in the construction of branch pieces, the adjacent pieces are to be matched at the bores. This may be effected by drifting, roller expanding or machining, provided that the pipe wall is not reduced below the designed thickness. If the parts to be joined differ in wall thickness, the thicker wall is to be gradually tapered to the thickness of the thinner at the butt joint. The welding necks of valve chests are to be sufficiently long to ensure that the valves are not distorted as the result of welding and subsequent heat treatment of the joints.

5.4.5 Where backing rings are used with flange type (a) they are to fit closely to the bore of the pipe and should be removed after welding. The rings are to be made of the same material as the pipes or of mild steel having a sulphur content not greater than 0,05 per cent.

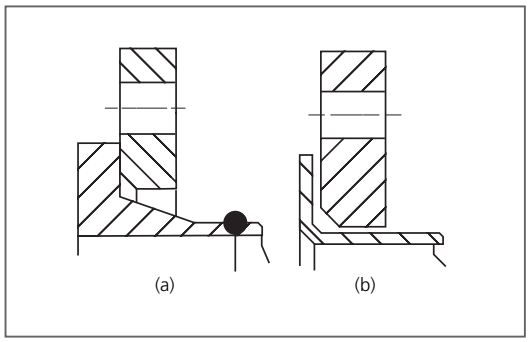
5.4.6 Branches may be attached to pressure pipes by means of welding provided that the pipe is reinforced at the branch by a compensating plate or collar or other approved means, or alternatively that the thickness of pipe and branch are increased to maintain the strength of the pipe. These requirements also apply to fabricated branch pieces.

5.4.7 Welding may be carried out by means of the shielded metal arc, inert gas metal arc, oxy-acetylene or other approved process, but, in general, oxy-acetylene welding is suitable only for flange type (a) and is not to be applied to pipes exceeding 100 mm diameter or 9,5 mm thick. The welding is to be carried out in accordance with the appropriate paragraphs of Pt 1, Ch 3.

5.5 Loose flanges

5.5.1 Loose flange designs as shown in Fig. 1.5.3 may be used provided they are in accordance with a recognised National or International Standard.

FIG. 1.5.3 Loose flange arrangements



5.5.2 Loose flange designs where the pipe end is flared as shown in Fig. 1.5.3(b) are only to be used for water pipes and on open ended lines.

5.6 Socket weld joints

5.6.1 Socket weld joints may be used in Class III systems with carbon steel pipes of any outside diameter. Socket weld fittings are to be of forged steel and the material is to be compatible with the associated piping. In particular cases, socket welded joints may be permitted for piping systems of Class I and II having outside diameter not exceeding 88,9 mm. Such joints are not to be used where fatigue, severe erosion or crevice corrosion is expected to occur or where toxic media are conveyed.

5.6.2 The thickness of the socket weld fittings is to meet the requirements of 6.1.3, but is to be not less than 1,25 times the nominal thickness of the pipe or tube. The diametrical clearance between the outside diameter of the pipe and the bore of the fitting is not to exceed 0,8 mm, and a gap of approximately 1,5 mm is to be provided between the end of the pipe and the bottom of the socket.

5.6.3 The leg lengths of the fillet weld connecting the pipe to the socket weld fitting are to be such that the throat dimension of the weld is not less than the nominal thickness of the pipe or tube.

5.7 Threaded

5.8 Welded sleeve joints

5.8.1 Welded sleeve joints may be used in Class III systems with carbon steel pipes of any outside diameter. In particular cases, welded sleeve joints may be permitted for piping systems of Class I and II having outside diameter not exceeding 88,9 mm. Such joints are not to be used where fatigue, severe erosion or crevice corrosion is expected to occur or where toxic media are conveyed.

5.8.2 Welded sleeve joints are not to be used in the following locations:
- Bilge pipes in way of deep tanks.
- Cargo oil piping outside of the cargo area for bow or stern loading/discharge.
- Air and sounding pipes passing through cargo tanks.

5.8.3 Welded sleeve joints may be used in piping systems for the storage, distribution and utilisation of oil fuel, lubricating or other flammable oil systems in machinery spaces provided they are located in readily visible and accessible positions, see also Ch 3,2.8.2.

5.8.4 Welded sleeve joints are not to be used at deck/bulkhead penetrations that require continuous pipe lengths.

5.8.5 The thickness of the sleeve is to satisfy the requirements of 6.1.3 and Table 1.6.4 but is to be not less than 1,42 times the nominal thickness of the pipe in order to satisfy the throat thickness requirement in 5.8.6. The radial clearance between the outside diameter of the pipe and the internal diameter of the sleeve is not to exceed 1 mm for pipes up to a nominal diameter of 50 mm, 2 mm on diameters up to 200 mm nominal size and 3 mm for larger size pipes. The pipe ends are to be separated by a clearance of approximately 2 mm at the centre of the sleeve.

5.8.6 The sleeve material is to be compatible with the associated piping and the leg lengths of the fillet weld connecting the pipe to the sleeve are to be such that the throat dimension of the weld is not less than the nominal thickness of the pipe or tube.

5.8.7 The minimum length of the sleeve is to conform to the following formula:

$L_s = 0{,}14D + 36$ mm

where

L_{si} is the length of the sleeve

D is defined in in 3.2.1.

5.9 Screwed fittings

5.9.1 Screwed fittings, including compression fittings, of an approved type may be used in piping systems for pipes not exceeding 51 mm outside diameter. Where the fittings are not in accordance with an acceptable standard then LR may require the fittings to be subjected to special tests to demonstrate their suitability for the intended service and working conditions.

5.10 Mechanical connections for piping

5.10.1 Pipe unions, compression couplings, or slip-on joints, as shown in Fig. 1.5.4, may be used if Type Approved for the service conditions and the intended application. The Type Approval is to be based on the results of testing of the actual joints. The acceptable use for each service is indicated in Table 1.5.3 and dependence upon the Class of piping, with limiting pipe dimensions, working pressure and temperature is indicated in Table 1.5.4.

5.10.2 Where the application of mechanical joints results in a reduction of pipe wall thickness due to the use of bite type rings or other structural elements, this is to be taken into account in determining the minimum wall thickness of the pipe to withstand the design pressure.

5.10.3 The construction of mechanical joints is to prevent the possibility of tightness failure affected by pressure pulsation, piping vibration, temperature variation and other similar adverse effects during operation on board.

5.10.4 The materials used in the construction of mechanical joints are to be compatible with the piping material and internal/external media.

5.10.5 Mechanical joints for pressure pipes are to be tested to a burst pressure of 4 times the design pressure. For design pressures above 200 bar the required burst pressure will be specially considered.

5.10.6 In general, mechanical joints are to be of fire resistant type where required by Table 1.5.3.

5.10.7 Mechanical pipe connections having sealing components sensitive to heat are not to be used in spaces where leakage or failure caused by fire could result in fire spread, flooding or loss of an essential service.

5.10.8 Mechanical joints, which in the event of damage could cause fire or flooding, are not to be used in piping sections directly connected to the sea openings or tanks containing flammable fluids.

5.10.9 The mechanical joints are to be designed to withstand internal and external pressure as applicable and where used in suction lines are to be capable of operating under vacuum.

5.10.10 Generally, slip-on joints are not to be used in pipelines in cargo holds, tanks, and other spaces which are not easily accessible. Application of these joints inside tanks may only be accepted where the medium conveyed is the same as that in the tanks.

5.10.11 Unrestrained slip-on joints are only to be used in cases where compensation of lateral pipe deformation is necessary. Usage of these joints as the main means of pipe connection is not permitted.

5.10.12 Restrained slip-on joints are permitted in steam pipes with a design pressure of 10 bar or less on the weather decks of oil and chemical tankers to accommodate axial pipe movement, see Ch 2,2.7.

FIG. 1.5.4 Examples of mechanical joints

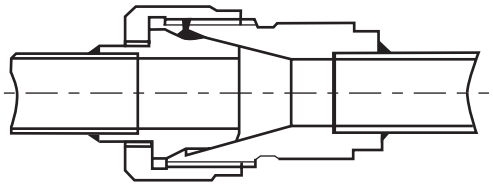
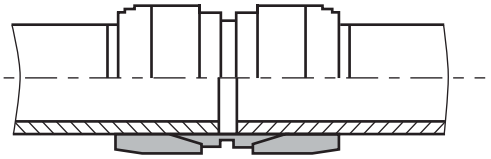
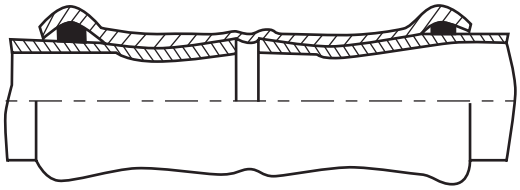
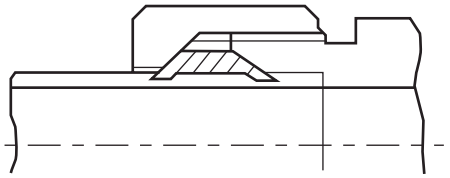
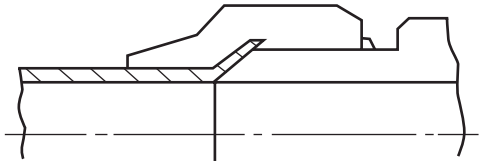
Pipe Unions	
Welded and brazed type	
Compression Couplings	
Swage type	
Press type	
Bite type	
Flared type	

FIG. 1.5.4 Examples of mechanical joints

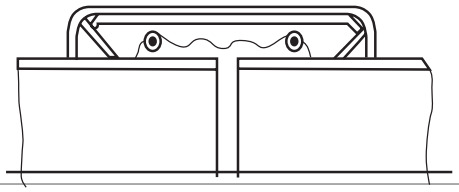
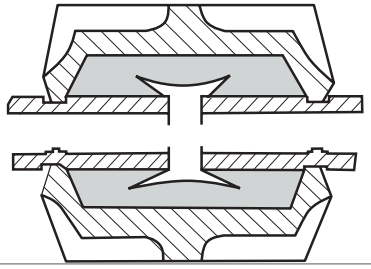
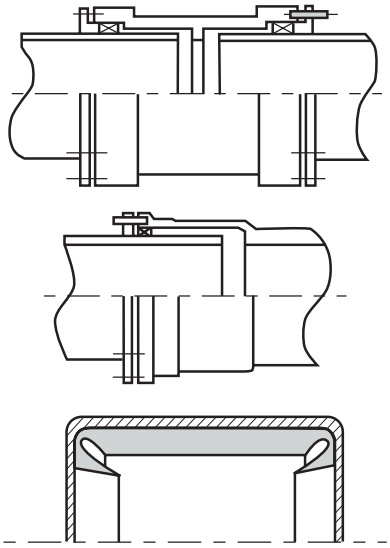
Slip-on joints	
Grip type	
Machine Grooved type	
Slip type	

FIG. 1.5.4 Examples of mechanical joints

Systems	Kind of connections		
	Pipe unions	Compression Couplings (6)	Slip-on joints
Flammable fluids (Flash point >60° C)			
Hydraulic oil	+	+	+2,3

KEY
+ Application is allowed
– Application is not allowed

NOTES
2. Not inside machinery spaces of category A or accommodation spaces. May be accepted in other machinery spaces provided the joints are located in easily visible and accessible positions.
3. Approved fire resistant types. Fire resistant type is a type of connection which, when installed in the system and in the event offailure caused by fire, the failure would not result in fire spread, flooding or the loss of an essential service.

FIG. 1.5.4 Application of mechanical joints depending on class of piping

Types of joints	Classes of piping systems		
	Class I	Class II	Class III
Pipe Unions			
Welded and brazed type	+(OD ≤ 60,3 mm)	+(OD ≤ 60,3 mm)	+
Compression couplings			
Swage type	–	–	+
Bite type	+(OD ≤ 60,3 mm)	+(OD ≤ 60,3 mm)	+
Press type	+(OD ≤ 60,3 mm)	+(OD ≤ 60,3 mm)	+
Flared type	–	–	+
Slip on Joints			
Machine grooved	+	+	+
Grip type	–	+	+
Slip type	–	+	+
KEY + Application is allowed – Application is not allowed			

Part 7 – Chapter 1 – Section 6

Carbon and low alloy steel piping and components

6.1 Wrought steel pipes and bends

6.1.1 The maximum permissible design stress, σ, is to be taken as the lowest of the following values:

$$\sigma = \frac{E_t}{1,6} \qquad \sigma = \frac{R_{20}}{2,7} \qquad \sigma = \frac{S_R}{1,6}$$

where

E_t = specified minimum lower yield or 0,2 per cent proofstress at the design temperature. In the case of stain less steel, the 1,0 per cent proof stress atdesign temperature is to be used

R_{20} = specified minimum tensile strength at ambient temperature

S_R = average stress to produce rupture in 100000 hoursat the design temperature

Values of the maximum permissible design stress, σ, obtained from the properties of the steels specified in Chapter 6 of theRules for Materials are shown in Tables 1.6.1 and 1.6.2. Forintermediate values of specified minimum strengths andtemperatures, values of the permissible design stress may be obtained by interpolation.

6.1.3 The minimum thickness, t, of straight steel pipes isto be determined by the following formula:

$$t = \left(\frac{pD}{20\sigma e + p} + c\right)\frac{100}{100 - a} \text{ mm}$$

where

p, D, eand aare as defined in 3.2.

c is obtained from Table 1.6.3

σ is defined in 2.2.1 and obtained from Table 1.6.1 or Table 1.6.2

For pipes passing through tanks, an additional corrosion allowance is to be added to take account of external corrosion; the addition will depend on the external medium and the value is to be in accordance with Table 1.6.4. Where the pipes are efficiently protected, the corrosion allowance may be reduced by not more than 50 per cent.

6.1.4 The minimum thickness, t_b, of a straight steel pipe to be used for a pipe bend is to be determined by the following formula, except where it can be demonstrated that the use of a thickness less than t_b would not reduce the thickness below t at any point after bending:

$$t_b = \left[\left(\frac{pD}{20\sigma e + p}\right)\left(1 + \frac{D}{2{,}5R}\right) + c\right]\frac{100}{100 - a} \text{ mm}$$

where
p, D, R, e and a are as defined in 3.2.1
σ and c are as defined in 6.1.3. In general, R is to be not less than $3D$.

6.1.5 Where the minimum thickness calculated by 6.1.3 or 6.1.4 is less than that shown in Table 1.6.4, the minimum nominal thickness for the appropriate standard pipe sizes hown in the Table is to be used. No allowance is required for negative tolerance, corrosion or reduction in thickness due to bending on this nominal thickness. For larger diameters, the minimum thickness will be considered.

TABLE 1.6.1 Carbon and carbon-manganese steel pipes

Specified minimum tensile strength, N/mm²	Maximum permissible sterss, N/mm²
	Maximum design temperature, °C 50
490	160

Valves

12.1 Design requirements

12.1.1 The design, construction and operational capability of valves is to be in accordance with an acceptableNational or International Standard appropriate to the piping system.Where valves are not in accordance with an acceptable standard, details are to be submitted for consideration. Where valves are fitted, the requirements of 12.1.2 to 12.1.8 are to be satisfied.

12.1.2 Valves are to be made of steel, cast iron, copperalloy, or other approved material suitable for the intended purpose.

12.1.5 Valves are to be arranged for clockwise closing and are to be provided with indicators showing whetherthey are open or shut, unless this is readily obvious. Legible name-plates are to be fitted.

12.1.7 Valves are to be used within their specified pressure and temperature rating for all normal operating conditions, and are to be suitable for the intended purpose.

Flexible hoses

13.1 General

13.1.1 A flexible hose assembly is a short length of metallic or non-metallic hose normally with prefabricated endfittings ready for installation.

13.1.2 For the purpose of approval for the applications in13.2, details of the materials and construction of the hoses, and the method of attaching the end fittings together with evidence of satisfactory prototype testing, are to be submitted for consideration. The materials used in the construction of flexible hoses are to be suitable for the intended purposes.

13.1.3 Hose clamps and similar types of end attachments are not be used for flexible hoses in piping systems for steam, flammable media, starting air systems or for sea-watersystems where failure may result in flooding. In other pipingsystems, the use of hose clamps may be accepted where the working pressure is less than 5 bar and provided that thereare two clamps at each end connection.

13.1.4 Flexible hoses are to be limited to a length necessary to provide for relative movement between fixed and flexibly mounted items of machinery/equipment or systems.

13.1.5 Flexible hoses are not to be used to compensate for misalignment between sections of piping.

13.1.6 Flexible hose assemblies are not to be installed where they may be subjected to torsional deformation (twisting) under normal operating conditions.

13.1.7 The number of flexible hoses in piping systems mentioned in this section is to be kept to a minimum and to be limited for the purpose stated in 13.2.1.

13.1.9 Flexible hoses are to be installed in clearly visible and readily accessible locations

13.1.10 The installation of flexible hose assemblies is to bein accordance with the manufacturer's instructions and use limitations with particular attention to the following: (a)Orientation. (b)End connection support (where necessary). (c) Avoidance of hose contact that could cause rubbing andabrasion. (d)Minimum bend radii.

13.1.11 Flexible hoses are to be permanently marked by the manufacturer with the following details: (a)Hose manufacturer's name or trademark. (b)Date of manufacture (month/year). (c)Designation type reference. (d)Nominal diameter. (e) Pressure rating. (f)Temperature rating. Where a flexible hose assembly is made up of items from different manufacturers, the components are to be clearly identified and traceable to evidence of prototype testing.

13.2 Applications

13.2.3 Rubber hoses, with single, double or more closelywoven integral wire braid or other suitable material reinforcement, or convoluted metal pipes with wire braid protection,may be used in bilge, ballast, compressed air, fresh water, sea-water, fuel oil, lubricating oil, Class III steam, hydraulic and thermal oil systems.

13.3 Design requirements

13.3.1 Flexible hose assemblies are to be designed andconstructed in accordance with recognised National or International Standards acceptable to LR.

13.3.2 Flexible hoses are to be complete with approvedend fittings in accordance with manufacturer's specification End connections which do not have flanges are to complywith 5.2 as applicable and each type of hose/fitting combina-tion is to be subject to prototype testing to the same standardas that required by the hose with particular reference to pressure and impulse tests.

13.3.3 Flexible hose assemblies intended for installation inpiping systems where pressure pulses and/or high levels of vibration are expected to occur in service, are to be designedfor the maximum expected impulse peak pressure and forcesdue to vibration. The tests required by 13.4 are to take intoconsideration the maximum anticipated in-service pressures,vibration frequencies and forces due to installation.

13.4 Testing

13.4.2 For a particular hose type complete with endfittings, the tests, as applicable, are to be carried out on different nominal diameters for pressure, burst, impulse andfire resistance in accordance with the requirements of the relevant standard. The following standards are to be used asapplicable:

- ISO 6802 – Rubber and plastics hoses and hose assemblies – Hydraulic pressure impulse test without flexing.
- ISO 6803 – Rubber and plastics hoses and hose assemblies – Hydraulic pressure impulse test with flexing.

13.4.3 All flexible hose assemblies are to be satisfactorilyprototype burst tested to an International Standard* to demonstrate they are able to withstand a pressure of not lessthan four times the design pressure without indication of failure or leakage.

NOTE: The International Standards, e.g., EN or SAE for burst testingof non-metallic hoses, require the pressure to be increased until burst without any holding period at 4 x Maximum Working Pressure.

Part 7 – Chapter 1 – Section 16

Testing

16.1 Hydraulic tests before installation on board

16.1.1 All Class I and II pipes and their associated fittings are to be tested by hydraulic pressure to the Surveyor's satisfaction. Further, all steam, feed, compressed air and fuel oil pipes, together with their fittings, are to be similarly tested where the design pressure is greater than 7,0 bar. The test isto be carried out after completion of manufacture and before installation on board and, where applicable, before insulating and coating.

16.1.2 Where the design temperature does not exceed300°C, the test pressure is to be 1,5 times the design pressure, as defined in 3.3.

16.1.7 Valves and fittings non-integral with the piping system, intended for Classes I and II, are to be tested in accordance with recognised standards, but to not less than1,5 times the design pressure. Where design features are such that modifications to the test requirements are necessary, alternative proposals for hydraulic tests are to be submitted for special consideration.

16.2 Testing after assembly on board

16.2.1 Heating coils in tanks, gas fuel and oil fuel piping are to be tested by hydraulic pressure, after installation on board, to 1,5 times the design pressure but in no case to less than 4 bar.

16.2.2 Where pipes specified in 16.1.1 are butt welded together during assembly on board, they are to be tested byhydraulic pressure in accordance with the requirements of 16.1 after welding. The pipe lengths may be insulated, except in way of the joints made during installation and before thehydraulic test is carried out.

16.2.3 The hydraulic test required by 16.2.2 may be omitted provided non-destructive tests by ultrasonic or radiographic methods are carried out on the entire circumference of all butt welds with satisfactory results. Where ultrasonic tests have been carried out, the manufacturer is to provide the Surveyor with a signed statement confirming that ultrasonic examination has been carried out by an approved operator and that there were no indications of defects which could be expected to have prejudicial effect on the serviceperformance of the piping.

Part 7 – Chapter 5 – Section 11

Hydraulic power actuating systems

11.1 General

11.1.2 The arrangements for storage, distribution and utilisation of hydraulic and flammable oils employed under pressure in power transmission systems, control and actuating systems, heating systems and hydraulic media in systems which are providing essential services, are to comply with the requirements of this Section.

11.1.4 Hydraulic fluids are to be suitable for the intendedpurpose under all operating service conditions and conform to the Naval Authority's safety policy where applicable.

11.1.5 Materials used for all parts of hydraulic seals are to be compatible with working fluid at the appropriate working temperature and pressure.

11.3.2 All hydraulic pumps are to be provided with reliefvalves. Each relief valve is to be in closed circuit, i.e., arranged to

discharge back to the suction side of the pump and effectively to limit the pump discharge pressure to the design pressure of the system.

11.4 Supply systems and arrangements

11.4.5 Provision is to be made for emergency hand pump or hand wheel operation of hydraulic systems.

11.4.6 Where a hydraulic securing is applied, the system is to be capable of being mechanically locked in the closed position so that, in the event of hydraulic system failure, these curing arrangements will remain locked.

11.4.7 Where pilot operated non-return valves are fitted tohydraulic cylinders for locking purposes, the valves are to be connected directly to the actuating cylinder(s) without intermediate pipes or hoses.

11.4.8 Hydraulic circuits for securing and locking of bow, inner, stern or shell doors are to be arranged such that they are physically unable to be affected by operation of other hydraulic circuits when securing and locking devices are in the closed position. For requirements relating to hydraulic steering gear arrangements, see Pt 6, Ch 1,5.3.

11.4.9 Suitable oil collecting arrangements for leaks shall be fitted below hydraulic valves and cylinders.

Flushing and Pressure Testing Procedure

General Guidelines for Pressure Testing and Flushing of Hydraulic Systems . 154
Pressure Testing 156
Flushing 159
Schematics Instructions 164

General Guidelines for Pressure Testing and Flushing of Hydraulic Systems

1. Condition of components

1.1 All Components should be supplied in a way that they are ready for assembly into the system and in a clean condition, inhibited with preservation oil and all openings sealed. Temporary sealing devices, plugs and others should only be removed prior to assembly. Particular attention should be given to piping which should be free from scale, rust, flux etc. Piping which is in an unclean condition should either be rejected and replaced or cleaned before assembly.

2. Site conditions

2.1 In some cases hydraulic systems are assembled in clean-room condition. However, in the majority of cases, site conditions cannot be controlled and great care must be exercised during system assembly to minimize the ingress of contamination.

2.2 Piping and components awaiting assembly should be stored in a dry place or at least elevated and covered with all ports and openings sealed.

3. System preparation

3.1 System components which may present a restriction to flow or which may be damaged by high flushing flow should be by-passed with suitable make-up pieces. These components, which may have been flushed on assembly, include reservoirs, pumps, motors, dead-end components such as cylinders, servo valves, flow regulators and other valves containing small orifices. Filters may be left in place but with their elements removed.

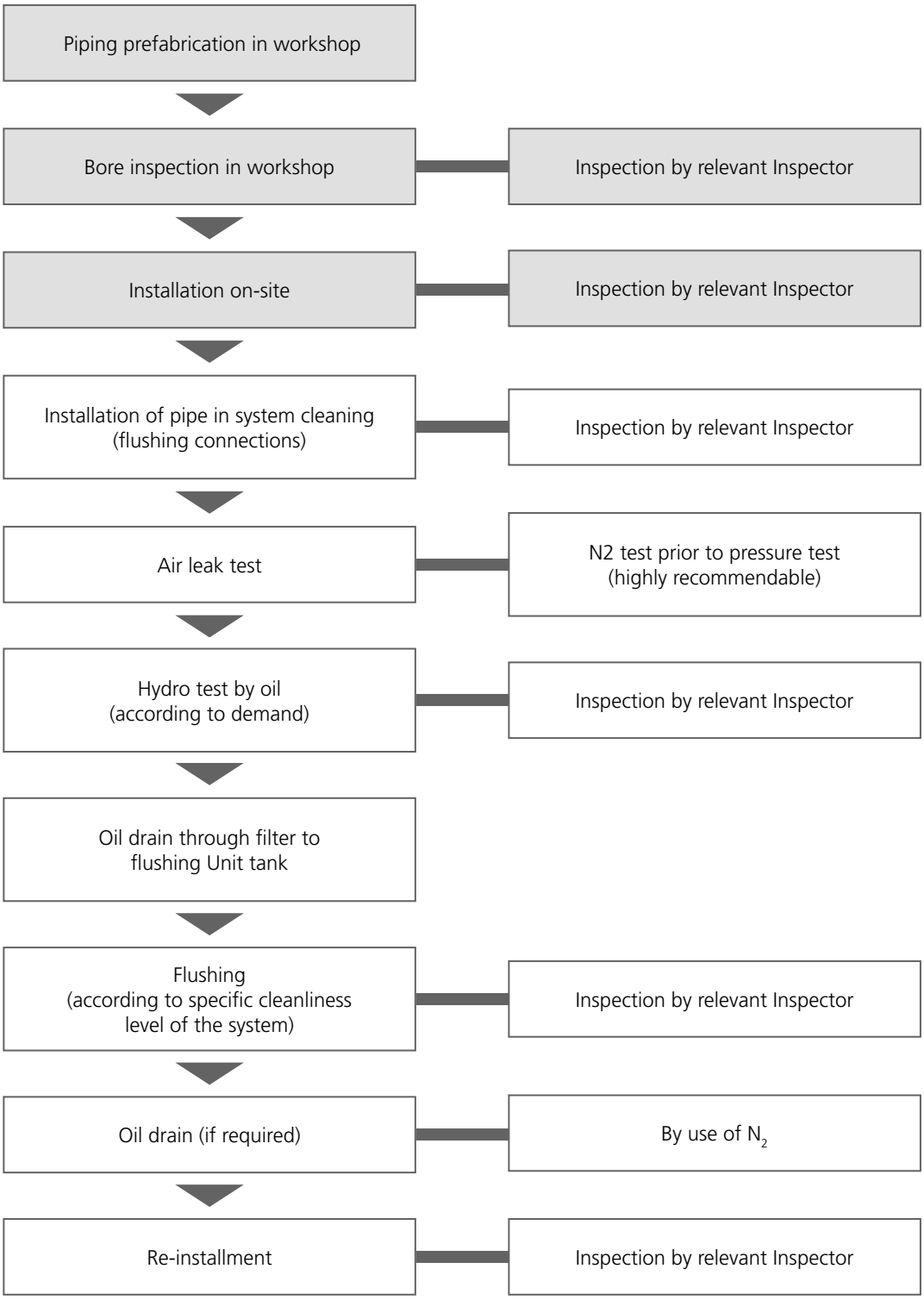
3.2 Flushing connections, preferably of the self-seal type, should be fitted to each loop in the system. The connections should be large enough to pass the flushing flow at a low pressure drop.

3.3 Only the simplest system can be flushed in one operation. In the majority of systems, they should be divided into sections or loops, the sections being flushed in turn.

3.4 The separate loops should be arranged onsite using jumper leads, make-up pieces etc. to give the least number of flushing circuits possible to ensure a continuous circulation of oil with no dead-ends returning to the flushing rig reservoir.

3.5 The oil flushing and pressure testing procedure is presented in Figure 1. The installation of several bleeding points on the highest points of each line should be pressure tested in order to purge air out of the installation. With this operation, pressure stabilization time will reduce significantly.

FIGURE 1 Oil flushing and pressure testing procedure



4. System preparation

4.1 ITP (Inspection and Test Plan) shall be submitted for approval to the customer before flushing and pressure testing begins.

Pressure Testing

1 Purpose of pressure testing

1.1 Pressure testing is always done prior to flushing a hydraulic piping system. Pressure testing can however be done independently of flushing to ensure that the mechanical strength of the system is sufficient for the working loads during the lifetime of the piping system. The leak tightness of the system will also be verified.

2 Activities before pressure test

2.1 Collate and review all relevant certificates and documentation. This may include:

- Description of the system, number, test pack, gauge, pump, flange specifications, etc.
- Pre-fabrication acceptance
- Scope of test and support drawings; this will include details of the pressure ranges to be applied to the different elements of the pipe work as necessary
- Risk assessments and method statements
- Contamination assessments
- Relevant regulatory for the type of application and the PPE requirements, e.g. reference to stipulations in the contract, Company Handbook, etc.
- Customer H&S regulations
- Main contractor regulations

3 Securing the area

3.1 Extreme caution should be exercised at all times during pressure testing.

3.2 Inform the customer of the planned pressure test schedule and invite the customer and/or other witnessing parties to attend.

3.3 Obtain work permits signed by the customer and supplier as necessary.

3.4 The working area is to be clearly identified with safety boards and segregated with red and white barriers such as tape, rope or chain.

3.5 All non-essential personnel should be removed from the working area.

3.6 Positioning behind suitable protective equipment/screen/barrier should be available for the pressure tester.

3.7 Warning signs "Pressure test in progress" (in English and local language) including the type of fluid and test pressure should be prominently displayed at strategic locations and remain so until the process is completed and test pressure reduced to zero.

4. Pressure test preparation

4.1 Customer shall review P&ID's to establish the limits of each system to be tested. Customer shall check each test system to ensure that maximum allowable test pressure of the weakest component in the system is not exceeded by test pressure.

4.2 Brief all staff on the relevant safety considerations and any exceptions items, e.g. use of harnesses, crafts, etc.

4.3 Check availability of appropriate test fluid, e.g. hydraulic oil or water-glycol, and that its use is acceptable to the customer.

4.4 Ensure that blanks and looping hoses which are to be used are rated appropriately for the pressures which are to be applied.

4.5 Remove all instruments and equipment which cannot stand the proposed test pressures; either replace them with dummies or blind them off.

4.6 Mount test gaskets if necessary.

4.7 All terminations should be connected with adjacent pipe work to provide a continuous loop.

4.8 All pipe work should be inspected by the customer if required.

4.9 All inline inspection items that might be damaged by dirt as well as loose scale should be isolated from the piping during testing.

4.10 Customer shall provide test package that includes pressure test diagram and P&ID, piping ISO etc.

4.11 Test package shall contain the following information:

- List of lines in the test system, service, test pressure, medium and test duration
- Marked up P&ID showing limits of system test
- Relevant isometric drawings
- Punch list clearance

4.12 Pressure gauges and records shall be calibrated and calibration record submitted prior to starting the test. Gauges and recorders exceeding 6 months from last certified calibration shall not be used. Accuracy of gauges and recorders shall be 1~2% at full scale. If there is a deviation of more than 2% between gauge and recorder during test, the test shall be stopped and gauge/recorder re-calibrated.

4.13 Pressure measurements should be made between 20%~80% of the full pressure span of the gauge.

5 Pressure testing performance

5.1 Two pressure gauges shall be installed in each pressure test package, one to be located at highest point and the other at the lowest point of the piping system.

5.2 A pressure recorder shall be provided and connected to test equipment.

5.3 A temperature recorder shall be connected at highest point of the piping system.

5.4 The pressure and temperature recorder shall record both pressurizing, stabilization, actual test and de-pressurization.

5.5 Fill the system completely; ensuring no air is entrapped with test media which is usually hydraulic oil. Test pressure should be built up in steps, first 20 bar, then with 30% increments until the test pressure is reached.

5.6 The first step increase should provide a satisfactory leak test.

5.7 At each pressure step perform lock and hold so that a physical check can be done. The pressure gauge will provide a pressure indication but visual confirmation of zero leaks is also needed.

5.8 Pressure drop can be caused by temperature drop. If pressure drop is discovered during pressure test, one should check leakage of all connecting points. When there is no visual leakage at the points, the test would be accepted.

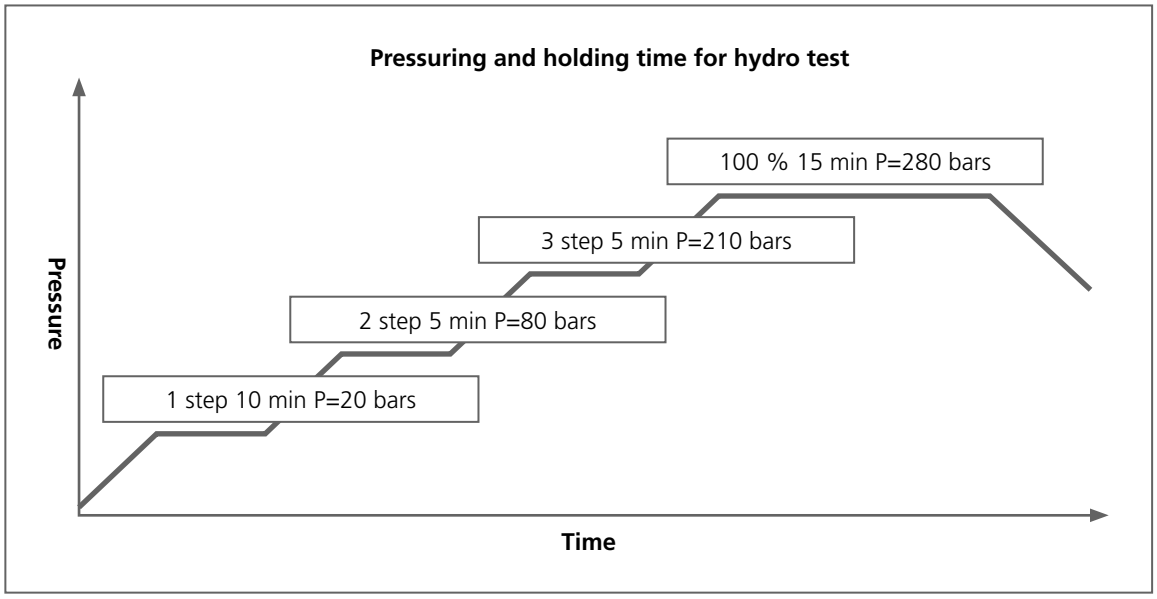
5.9 If any leaks occur at any time, immediately abandon the test.

5.10 Shut off / isolate pump and check that the test pressure is maintained for at least 1 hour. Holding time can be reduced to 15 minutes.

5.11 During pressurization of the system and testing, the actual pressure shall be closely monitored to not exceed maximum allowable pressure for the system.

5.12 The chart recorder should record the pressure from start of pressurization and stop when piping system starts depressurization. The starting time shall be recorded on chart including package number, date of test and test temperature. Upon successful completion of the test, QA personnel of customer and certification representative shall sign the record chart. It shall be retained as permanent record and this chart shall be part of pressure tests records.

FIGURE 2 Example of pressure testing



6 After pressure test

6.1 The pressure shall be released gradually. After depressurization and prior to drain, vents are first opened by removing blind flanges and then followed by opening of drain valves.

6.2 After completion of drain, all temporary blinds and blanks, supports and temporary test connections shall be removed.

6.3 Remove the safety boards and barriers.

6.4 Instruct all relevant personnel that the pressure testing has been completed and that the working area is now available for normal use.

6.5 Drain the oil from the pipe work.

6.6 All opening pipe shall be sealed with caps, blind flanges.

6.7 Disconnect all pipe work and reconnect to flushing work (care should be taken to ensure that all pressure in the pipes is released before removing plugs, hoses, etc.).

6.8 Blank off pipe work if not required for immediate installation.

7 Documentation

7.1 Calibration reports of all measuring devices, test certificates, pressure and temperature charts will form part of the final documentation.

7.2 After a successful pressure test, the pressure test package shall be submitted to Site Manager. It includes the following:

- Diagram of each test package
- Piping pre-test check sheet
- Flushing/Testing/Drying
- Re-instatement check sheet

Flushing

1 Purpose of flushing

1.1 After fabrication (and installation) and pressure testing of piping systems, it may be necessary to clean the piping system to remove all particles and contamination from inside the pipes and components. The aim of flushing is to remove any contamination by passing fluid through the system at velocity much higher than during normal operation, but based on calculations of Reynolds numbers.

1.2 All components ready for assembly into the system should be in a clean condition, inhibited with preservation oil and all openings sealed. All piping must be free from scale, rust, flux, etc., otherwise is will be rejected and replaced, or cleaned prior to assembly. Any contamination that may have been introduced in transit or during system assembly, and may be harmful to equipment connected to it, must be removed.

1.3 Flushing is often performed immediately after pressure testing. Some of the following conditions may therefore have been set up during pressure testing but are repeated for completeness and added safety.

2 Activities before flushing

2.1 Pressure testing may have recently taken place and completed, the same documents and certificates will remain relevant for flushing. These may include:

- Description of the system, number, test pack, gauge, pump, flange specifications, etc.
- Pre-fabrication acceptance details
- Scope of test and support drawings
- Risk assessments and method statements
- Contamination assessments
- Relevant regulatory for the type of application and the PPE requirements, e.g. reference to stipulations in the contract, Company Handbook, etc.
- Customer H&S regulations
- Main contractor regulations

3 Securing the area

3.1 Inform the customer of the planned flushing operation and invite the customer and/or other witnessing parties to attend.

3.2 Obtain work permits signed by the customer and supplier as necessary.

3.3 The working area is to be clearly identified with safety boards and segregated with red and white barriers such as tape, rope or chain.

3.4 All non-essential personnel should be removed from the working area.

3.5 Positioning behind suitable protective equipment/screen/barrier should be available for the flushing.

3.6 Warning signs "Oil Flushing in progress" (in English and local language) including the type of fluid should be prominently displayed at strategic locations.

3.7 Grinding, welding or shot blasting activities shall not be carried out in the area immediately prior to flushing.

4 System preparation

4.1 All pipe systems should be pressure tested before oil flushing.

4.2 Mark-up drawings should be prepared and confirmed by customer before starting the oil flushing.

4.3 Brief all staff on the relevant safety considerations and any exceptional items, e.g. use of harnesses, crafts, etc.

4.4 System components which may restrict flow or which may be damaged by the high flushing flow should be by-passed with suitable make-up pieces. These components may have been flushed on assembly and include reservoirs, pumps, motors, dead-end components such as cylinders, servo valves, flow regulators and other valves containing small orifices.

4.5 Filters may be left in place but with their elements removed.

4.6 If required, remove flexible hoses in the pipelines and replace with jumper leads.

4.7 Flushing connections, preferably of the self-seal type should be fitted to each loop in the system. The connections should be large enough to pass the flushing flow at a low-pressure drop.

4.8 Only the simplest system can be flushed in one operation. In the majority of cases, systems should be divided into sections or loops, the sections being flushed in turn.

4.9 The separate sections / loops should be arrange onsite using jumper leads, make-up pieces etc. to give the least number of flushing circuits possible thus ensuring a continuous circulation of oil with no dead-ends and returning to the flushing rig reservoir.

4.10 Temporary hoses and pipes for flushing loops should be inspected by QA prior to installation.

4.11 All equipment nozzles should be inspected. If any particles are discovered after disconnection of pipe for oil flushing, it should be cleaned out.

5 Flushing equipment

5.1 Check that the flushing rig which consists of pumps, reservoir, filters, thermometer, particle counter, hose connections, is in a clean condition throughout.

5.2 All terminations should be connected with adjacent pipe work to provide a continuous loop.

5.3 Check that the adjustable relief valves are set at a pressure above that required to pass the full pump flow through the system which is to be flushed.

5.4 The filters may be of disposable element type. The filters should incorporate clogging indicators.

5.5 The filter size should be selected to pass the specified pump delivery at a low-pressure drop. Select a filter size to meet the requirements of the system to be flushed. It should have a generous dirt holding capacity.

5.6 Temperature gauge and flow meter should be calibrated and calibration record submitted prior to start flushing. Gauges and flow meter exceeding 6 months from last certified calibration should not be used.

5.7 Flushing oil should be specified according to system demands.

6 Flushing fluid

6.1 The flushing fluid must be compatible with the fluid specified for the system and with system materials, especially the seals.

6.2 In all cases the appropriate technical and regulatory standards will apply to the fluid selection, including supplier specifications, e.g. in the use of synthetic hydraulic oils.

6.3 The fluid should preferably have rust inhibiting and de-watering properties. Hydraulic oil, rust inhibited oils of lower viscosity or special flushing oils can be used for flushing.

6.4 Flushing oils containing petroleum solvents, e.g. kerosene or non-petroleum solvents, e.g. carbon tetrachloride and solutions containing water, caustic compounds or other active materials, must not be used for flushing.

6.5 The recommended flushing fluid is normally the same grade as the working fluid.

7 Flushing velocity and temperature

7.1 To ensure that the system is flushed as quickly and efficiently as possible, both fluid velocity and temperature should be as high as conveniently possible.

7.2 Heat oil during work to 55 °C ~ 60 °C for VG32 oil. The temperature shall be measured in the reservoir. Temperature shall not exceed 62 °C.
7.3 The flushing flow is calculated and based upon achieving turbulent flow. This is achieved when Reynolds number is greater than 4000.

Flow	=	$\frac{Re \times ID \times Vsc}{21220}$
Re	=	Reynolds number
ID	=	Inside diameter of largest pipe to be flushed
Vsc	=	Oil viscosity at flushing temperature

NB Re of 4000 minimum is preferred.

7.4 A reasonable temperature limit for mineral oils is 60 °C, for water-in-oil emulsions and water-glycols it is 50 °C. Higher temperatures are acceptable for silicone and some other synthetic hydraulic fluids.

8 Flushing performance

8.1 With the system prepared, fill the system by feeding the flushing fluid to the flushing rig so that the fluid is filtered before entering the system. New fluid is often dirty by hydraulic standards.

8.2 Circulate the flushing fluid. Heat the fluid to approximately 50°C.

8.3 The local flow-meter has to be installed on the return line of each branch to confirm local velocity and flow rate. Those values are to be recorded in the check sheet.

8.4 The pipe should be tapped along its length with a soft headed/raw hide hammer to loosen contaminants adhering to the pipe (this is relevant for welded systems and hot-rolled pipe).

8.5 Flush the system as required, changing the filter elements as required by the operation of the filter clogging indicator or as indicated by the filter pressure drop being reached.

8.6 Oil sampling should take place at turbulent flow at return line. Three samplings should be taken every 10 minutes.

8.7 The degree of cleanliness required is agreed in advance with the customer. See Table 1 and Table 2 for more information.

8.8 If the system comprises several loops, change the flushing rig connections to another loop and repeat the above procedure.

8.9 If needed, the system may be thermally, mechanically and hydraulically shocked to dislodge dirt, particulate and foreign material.

8.9.1 Thermal shock
During the flushing, the oil temperature will be oscillated but if fluid temperature exceeds 62 °C it shall not be re-used.

8.9.2 Hydraulic shock
The system may be hydraulically shocked by shutting down valves to interrupt the flow.

8.9.3 Mechanical shock
Vibrator or rubber hammer can be used on the horizontal section and corners of the line to apply hammering effect on the pipe. The vibrator should re-locate from one horizontal section to another horizontal section during flushing work in order to provide hammering effect so that particles cannot settle down in any part of the piping.

8.10 If the flushing fluid is of a lower viscosity than the specified system fluid, check that the reduced viscosity is acceptable to the system pumps. If not, reduce the fluid temperature until an acceptable viscosity is attained or change to the specified system fluid.

8.11 After completion of the flushing performance, drain the system completely and leave the drains open for about half an hour. Examine the reservoir and clean if necessary.

9 System cleanliness

9.1 The code is constructed from the combination of two range numbers selected from Table 1. The first range number represents the number of particles in a 100 milliliter sample of the fluid that are larger than 5 microns, and the second number represents the number of particles that are larger than 15 microns.

TABLE 1 BS / ISO range number

More than	Up to and including	Range number
8×10^6	18×10^6	24
4×10^6	8×10^6	23
2×10^6	4×10^6	22
1×10^6	2×10^6	21
500×10^3	1×10^6	20
250×10^3	500×10^3	19
130×10^3	250×10^3	18
64×10^3	130×10^3	17
32×10^3	64×10^3	16
16×10^3	32×10^3	15
8×10^3	16×10^3	14
4×10^3	8×10^3	13
2×10^3	4×10^3	12
1×10^3	2×10^3	11
500	1×10^3	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

9.2 BS 5540 Part 4 (also ISO/DIS 4406 and CETOP RP 70-H) is the preferred sampling method of determining the number of solid contaminant particles (Table 2).

TABLE 2 Approximate equivalents of contamination classes

BS 5540/4 ISO/DIS 4406 CODE	DEF. STD 902/4		NAS 1638 CLASS	SAE 749 CLASS
	TABLE A	TABLE B		
11/8	-	-	2	-
12/9	-	-	3	0
13/10	-	-	4	1
14/9	-	400F	-	-
14/11	-	-	-	-
15/9	400	-	-	-
15/10	-	800F	-	-
15/12	-	-	6	3
16/10	800	-	-	-
16/11	-	1300F	-	-
16/13	-	-	7	-
17/11	1300	200F	-	-
17/14	-	-	8	-
18/12	2000	-	-	-
18/13	-	440F	-	-
18/15	-	-	9	6
19/13	4400	6300F	-	-
19/16	-	-	10	-
20/13	6300	-	-	-
20/17	-	-	11	-
21/14	15000	-	-	-
21/18	-	-	12	-
22/15	21000	-	-	-
23/17	100000	-	-	-

9.3 The levels to which all hydraulic piping system flushing needs to reach (minimum) is shown in Table 3.

TABLE 3 Minimum level of cleanliness

BS 5540/4 ISO/DIS 4406 CODE	DEF. STD 902/4		NAS 1638 CLASS	SAE 749 CLASS
	TABLE A	TABLE B		
16/13	-	-	7	-
16/10	800	-	-	-
16/11	-	1300F	-	-

10 Acceptance of cleanliness

10.1 Final acceptance shall be determined when the oil quality complies with the specified requirements. Final samples to undergo full particulate count and certificate shall be issued accordingly. A certificate will be issued to the customer. The flushing fluid shall remain in the line for system commissioning and operating after final acceptance of particulate count. If necessary, QA may carry out borescope inspection randomly to confirm internal surface is clean and free of rust, slag, scale, grease etc.

10.2 If either sample indicates the fluid is unacceptable, flushing system shall be dumped and replaced by clean fluid and flushing/cleaning process is repeated.

11 After flushing

11.1 Remove safety boards and barriers.

11.2 Instruct all relevant personnel that the flushing has been completed and that the working area is now available for normal use.

11.3 After completion of the flushing operation, drain the system completely and leave the drains open for half an hour. Drain the oil from the pipe work.

11.4 Disconnect all pipe work and store or reconnect to correct terminationsors as necessary (care should be taken to ensure that the pressure in the pipes is released before removing plugs, hoses, etc.).

11.5 Blank off pipe work if not required for immediate installation.

11.6 Clean up any oil spills.

11.7 A full charge of new hydraulic oil should be filled in the system as soon as possible. The oil should then be circulated and the equipment operated so that the cleaned surfaces will be properly protected.

Schematics Instructions

FIGURE 3 Detailed flushing loop

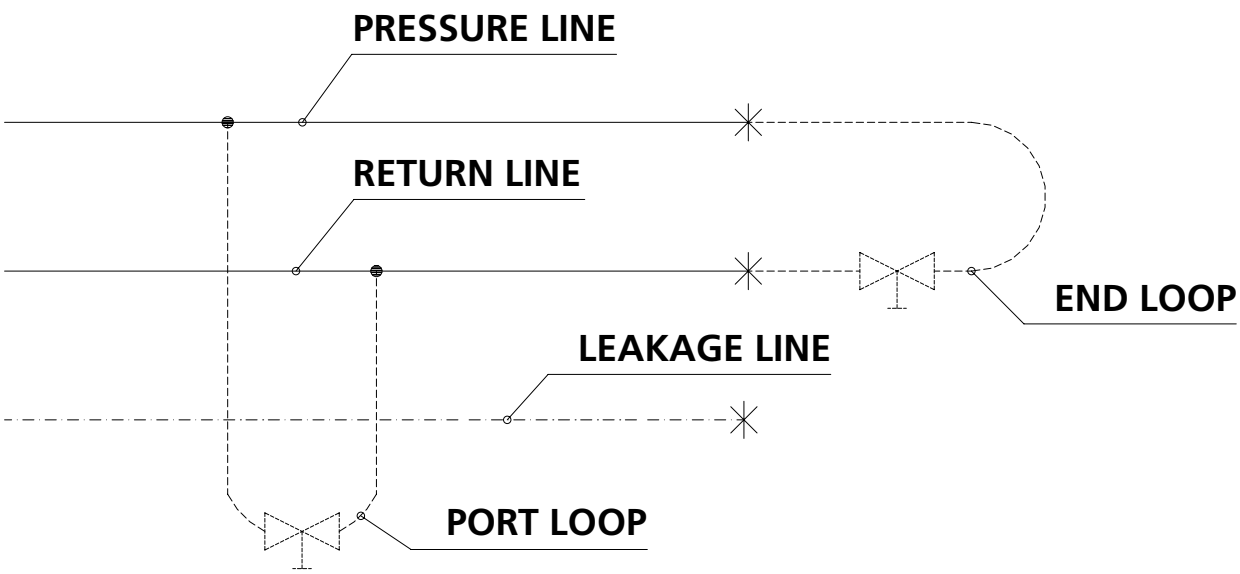


FIGURE 4 Typical flushing loops – Option 1

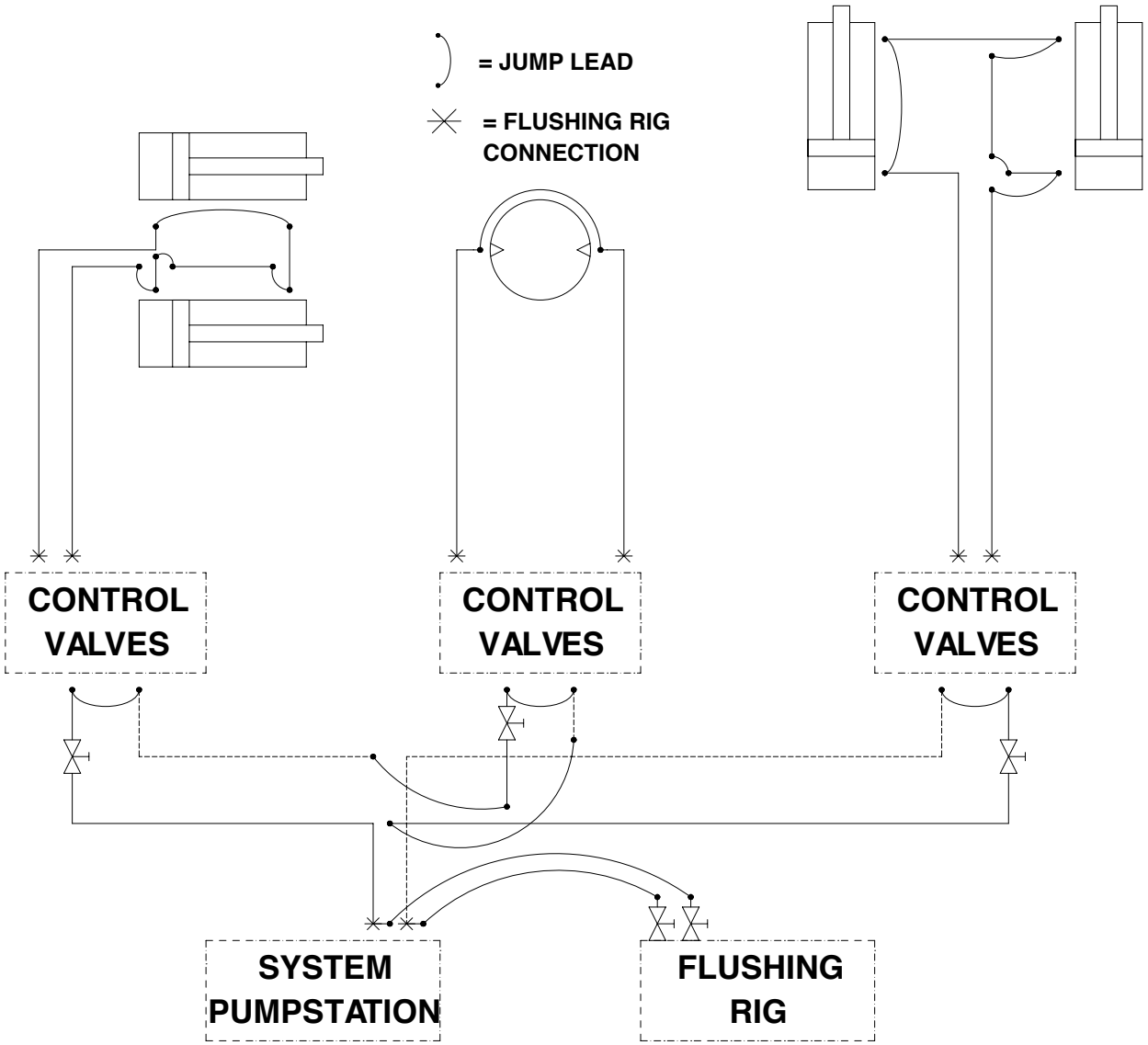
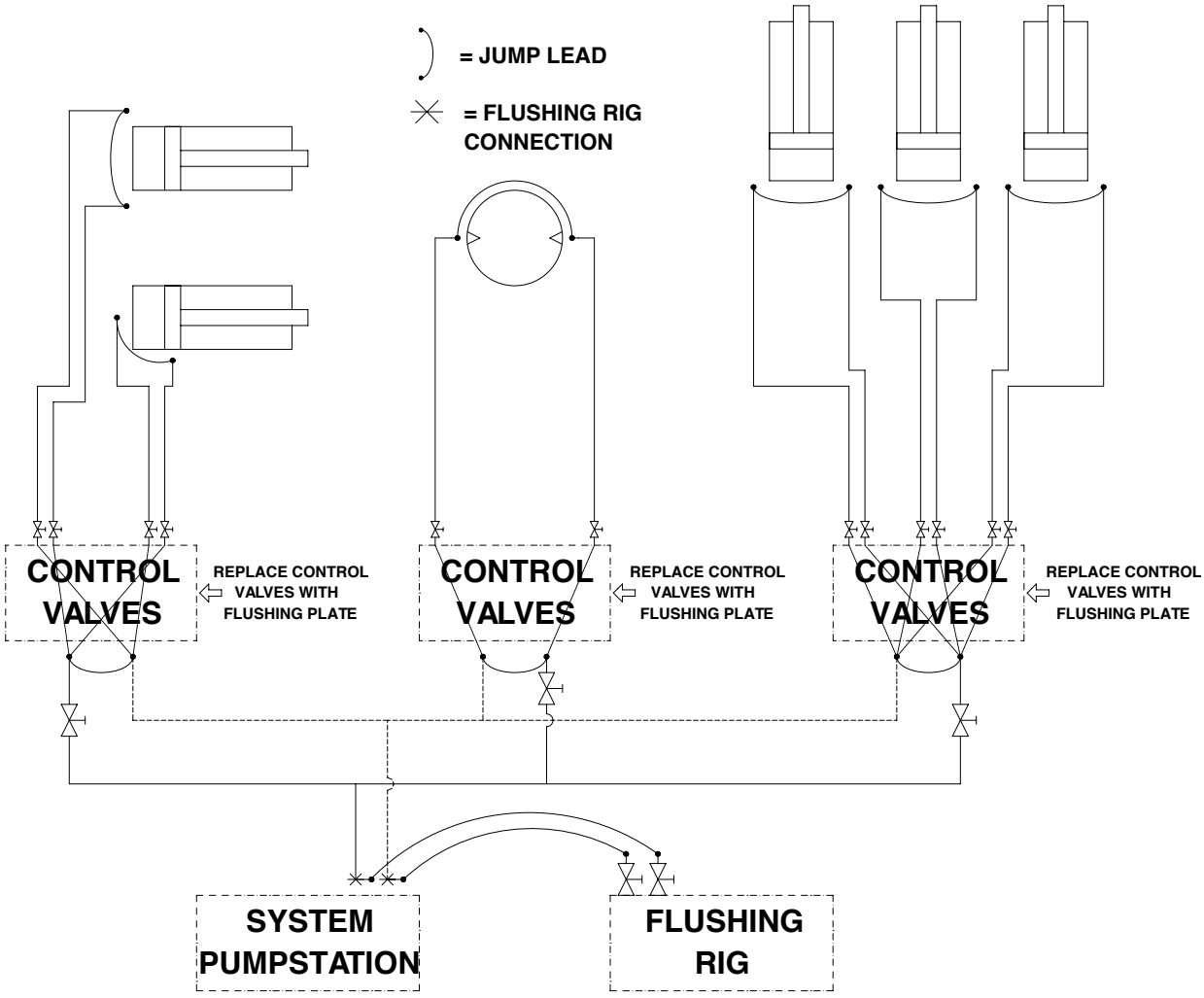


FIGURE 5 Typical flushing loops – Option 2



USEFUL

Technical Information

Piping System Design 168
- Choice of pipe size 168
- Fluid (oil) Velocities 170
- Pressure Loss 171

Mechanical Design 171
- Pipe and Tube Materials 171
- Fitting and Flanges 172
- Hoses and Hose Couplings 173
- Pipe Supports 174

Cleanliness 174
- ISO 4406:1987 and ISO 4406:1999 175
- NAS 1638 176
- SAE AS4059 176

Attachments 177

Useful Technical Information

The following technical information is provided as general guidelines on how to design hydraulic piping systems. In the design of a specific piping system the environment, the customer's specifications as well as local rules, regulations and laws must be followed at all times.The authors are not responsible for direct or consequential damages caused by possible mistakes or the wrong application of the following information.

1. Piping System 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 parameters have to be selected specifically for each case taking into account the customers' requirements as well as local rules, regulations and laws.

1.1 Choice of pipe size

Selecting a suitable pipe size is done by determining the inner diameter and wall thickness of the pipe. The wall thickness is selected based on the required pressure rating. The inner diameter can either be determined based on allowed pressure losses or on flow velocity. Dimensioning based on the pressure losses is usually considerably more difficult, which is why the dimensioning of the pressure and return lines are commonly done based on the flow velocity. Only suction and leakage lines considered critical are typically dimensioned based on allowed pressure losses.

1.1.1 Dimensioning based on flow velocity

When using the dimensioning method based on flow velocity, the inner diameter of the pipe can be determined by using the equation below, when a maximum flow rate and recommended flow velocity are known. The recommended flow velocities for different parts of the pipe system are presented in chapter 1.2.

$$d = \sqrt{\frac{4 \cdot Q_{max}}{\pi \cdot v}}$$

where
d = inner diameter of the pipe [m]
Q_{max} = maximum flow rate [m^3/s]
v = flow velocity [m/s]

The inner diameter can also be determined by using the chart presented in Attachment 1, which is based on the same equation.

1.1.2 Dimensioning based on pressure losses

When using the dimensioning method based on the pressure losses, the inner diameter of the pipe is selected so that the resulting pressure losses do not increase too much. The amount of the allowed pressure losses depends, among other things, on the pressure and utilisation level of the system. During continuous use the total pressure loss from the frame and actuator lines is allowed to be 3–5 % and during periodic use 7–10 % of the system supply pressure level.

Flow types

The flow type affects essentially the amount of pressure losses resulting in the pipe system. When the flow is laminar, all the fluid particles are moving parallel to the pipe. When flow velocity increases, the flow will become turbulent, which means the direction of the individual fluid particles varies and may at times even be against the actual direction of the flow. The flow type can be clarified by determining the so-called Reynolds number Re and comparing it to critical Reynolds number Re_{kr} value. The Reynolds number can be determined with the equation

$$Re = \frac{v \cdot d}{\nu}$$

where
Re = Reynolds number [-]
v = flow velocity [m/s]
d = the inner diameter of the pipe [m]
ν = the kinematic viscosity of the hydraulic fluid [m^2/s]

The type of flow is
- laminar when $Re < Re_{kr}$
- turbulent when $Re > Re_{kr}$

The critical Reynolds number Re_{kr} for pipe flow is 2300.

Frictional pressure losses

The overall pressure losses in the piping consists of frictional pressure losses arising in straight pipe sections, as well as individual pressure losses arising for example in bends and junctions of the pipe. The frictional pressure losses can be determined with the equation

$$\Delta p_a = \lambda \cdot \frac{l}{d} \cdot \frac{\rho \cdot v^2}{2}$$

where
Δp_a = frictional pressure loss [Pa]
λ = frictional resistance factor [-]
l = length of pipe [m]
d = the inner diameter of the pipe [m]
ρ = the hydraulic fluid density [kg/m^3]
v = flow velocity [m/s]

The way the frictional resistance factor λ is determined depends on whether the flow is laminar or turbulent. If the flow is laminar, the frictional resistance factor value only depends on the Reynolds number. The frictional resistance value for the laminar flow can be calculated with the equation

$$\lambda = \frac{64}{Re}$$

where
λ = frictional resistance factor [-]
Re = Reynolds number [-]

If the flow is turbulent, the frictional resistance factor value is affected by the pipe surface roughness and the pipe size in addition to the Reynolds number.

Individual pressure losses

In addition to the frictional pressure losses, the overall pressure losses in piping are caused by individual pressure losses, which occur for example in pipe bends, junctions and generally in pipe sections where the cross-sectional flow area or flow direction changes. Individual pressure losses can be calculated with the equation

$$\Delta p_b = \zeta \cdot \frac{\rho}{2} \cdot v^2$$

where
Δp_b = individual pressure loss [Pa]
ζ = individual resistance factor [-]
ρ = the hydraulic fluid density [kg/m^3]
v = flow velocity [m/s]

The value of the individual resistance factor ζ depends on the flow channel structure and dimensioning. Some indicative values of the individual resistance factor have been presented in attachment 4.

The total pressure losses

The total pressure losses in the piping are obtained by adding up the frictional pressure losses and the individual pressure losses, according to the equation below.

$$\Delta p_{tot} = \sum \Delta p_a + \sum \Delta p_b$$

where
Δp_{tot} = the total pressure loss [Pa]
Δp_a = frictional pressure loss [Pa]
Δp_b = individual pressure loss [Pa]

1.2. Fluid (oil) Velocities

Recommended oil velocities to be utilized for initial pipe sizing in suction and pressure lines can be seen below:

a) Suction lines

Viscosity v (mm^2/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 recommended flow velocities in different parts of the pipeline can be seen below:

Region of the pipeline	Recommend flow velocity v [m/s]	Maximum allowed flow velocity v [m/s]
Suction line	0,5–1,0	1,0 –1,5
Return line	1,0–3,0	3,0–4,0
Pressure line **6,3–10 MPa** **10–16 MPa** **16 –25 MPa** **25–40 MPa**	 4,0–4,5 4,5–5,0 5,0–5,5 5,5–6,0	 6,0 6,0 6,0 6,0
1 MPa is equal to 10 bar. E.g. 16 MPa = 160 bar.		

Please see Attachment 2 for information on oil flow rates at recommended maximum velocities.

1.3. Pressure loss

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 ~ v2). 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 3 and Attachment 4.

2. 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

2.1. Pipe and Tube Materials

Cold-drawn, seamless precision (carbon) steel tubes & pipes (St37.4 NBK and St52.4 NBK) and austentic stainless steel (AISI316L) tubes and pipes are recommended 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 and 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

It is recommended to use cold drawn seamless high tensile hydraulic tube according to DIN 2391C E 355N (ST52.4 NBK) 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 E 235N (ST37.4 NBK) – which is also recommendable material grade - leads to thicker tube and pipe walls and thus more weight (and potentially costs). The final selection between E 235N and E 355N is, however, an economical decision.

Material titles of hydraulic tubes can be seen below:

Standard	Carbon		Stainless		
			Austenitic	Acid-proof	
SFS-EN 10 027	E235	E355	-	-	-
DIN 1630 (old)	St 37.4	St 52.4	-	-	-
DIN 1629 (old)	St 35	St 52	-	-	-
Material n. (DIN/EN)	1.0308	1.0580	1.4307	1.4571	1.4404
ASTM/SAE	A53Gr. A	A252Gr. 3			
Alloy steel (DIN/EN)	-	-	X2 CrNi 18 11	X6 CrNiMoTi 17 12 2	X2 CrNiMo 17 13 2
AISI	-	-	304L	316Ti	316L

The types of tubes used in hydraulic systems are as follows:

Type of tube	Standard			
	Finland / Europe	Germany	America	International
Seamless cold drawn	SFS-EN 10305-1	DIN 2391	ASTM A519	ISO 3304
Welded cold drawn	SFS-EN 10305-2	DIN 2393	ASTM A512	ISO 3304
Welded cold sized	SFS-EN 10305-3	DIN 2394	ASTM A512	ISO 3306
Seamless stainless steel	SFS-EN 10216-5	DIN 17458	ASTM A269	ISO 2604/2
Welded stainless steel	SFS-EN 10217-7	DIN 17457	ASTM A269	ISO 2604/2

There can be large variations in temperature in hydraulic systems, especially in marine and offshore applications. Under certain conditions the temperature can vary for example from –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 length will vary almost 1.0 mm per 1 meter of pipe. The thermal expansion of steel pipes is presented in Attachment 5.

2.2. Fittings and Flanges

In hydraulic and other piping systems with high quality requirements it is recommended to use 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).

The recommended connection technology for various pipe sizes and pressure classes can be found in Chapter 1 in this Handbook.

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.

The tables in Chapter 1 provide a guideline to what type of connection to select for various materials and tube/pipe sizes.

1. Select the correct table in accordance with the tube/pipe material and maximum system working pressure:

- 16 bar, carbon steel/stainless steel
- 50 bar, carbon steel/stainless steel
- 150 bar, carbon steel/stainless steel
- 210 bar, carbon steel/stainless steel
- 250 bar, carbon steel/stainless steel
- 280 bar, carbon steel/stainless steel
- 315 bar, carbon steel/stainless steel
- 350 bar, carbon steel/stainless steel
- 380 bar, carbon steel/stainless steel
- 420 bar, carbon steel/stainless 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.

2.3. 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.

Hose types used in hydraulic systems can be seen in Attachment 6.

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.

For hose size selection nomogram please see Attachment 7.

Tolerances for hose assemblies according to the SAE J517 (Revised Oct 2007) standard can be seen below:

Tolerances on assembly lenght	
Lenght	Tolerance (Plus or Minus) mm
Up to 300 mm, included	3
Over 300 mm through 450 mm, included	5
Over 450 mm through 900 mm, included	7
Over 900 mm	1 %[1]
1. measured to nearest whole millimeter.	

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.

For pressure drop in hoses please see Attachment 8.

2.4. 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 utilized 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 material which resists wear (when the pipe moves). Pipe clamps conforming to DIN 3015-1...3 should be utilized.

The recommended (typical) maximum spacing between clamps in marine and industrial applications is shown in Attachment 9.

The final spacing of the clamps has to be selected based on the specific requirements of the application in question.

Please note that detailed engineering is recommended in order to ensure proper clamp locations and spacing.
A FEM-analysis of the stresses in the piping system can also be included in the engineering service (usually a FEM analysis is performed upon separate order).

3. 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 impurities are the welds in a welded piping system (or when utilizing welded flanges).

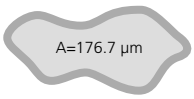
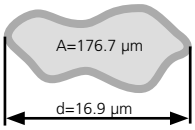
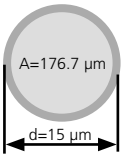
The oil purity is dependent on the application and equipment. All manufacturers have their own recommendations for their own, specific equipment and machinery. The following table provides the general guidelines for various types of hydraulic systems as well as a comparison between the various standards:

	ISO 4406: 1987 (ACTFD) ≥2/≥5/≥15 (c) pm	**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

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

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 utilized to identify the particle size. Definitions are below:

Particle		
Standard	ACFTD ISO 4402 (1991)v	ISO MTD ISO 11171 (1999)
Definition of particle size		
Particle size	16,9 µm	15 µm (c)

3.1. 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	(22)/16/13
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

3.2. 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:

Particle count / 100 ml					NAS-class.
5–15 µm	15–25 µm	25–50 µm	50–100 µm	> 100 µm	
123	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	2850	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

3.3. SAE AS4059

The SAE AS4059-standard is based on the NAS 1638-standard. The SAE AS4059-standard utilizes 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):

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

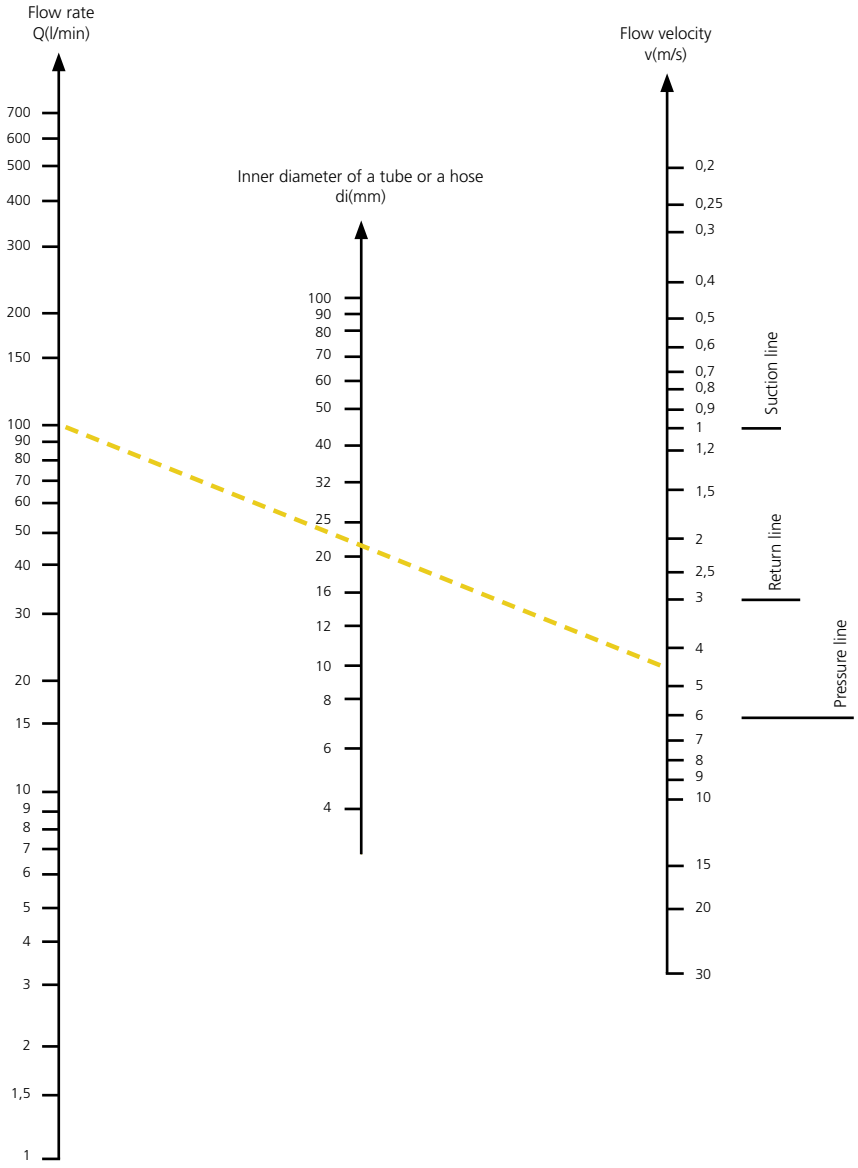
Example According to the SAE AS4506-standard the oil purity can be defined:

- with a single class; for instance 6 or 6B
- with an 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

Attachments

Attachment 1. Flow velocity in pipes 178
Attachment 2. Oil flow rates at recommended maximum velocities 179
Attachment 3. Pressure drop in pipes 180
Attachment 4. Pressure drop in bends, couplings etc. 181
Attachment 5. Thermal expansion of steel pipes 182
Attachment 6. Hose types in hydraulic systems 183
Attachment 7. Hose size selection 184
Attachment 8. Pressure Drop in Hoses. 185
Attachment 9. Spacing for Clamps. 186
Attachment 10. Notations and ratio factors 187

Attachment 1. Flow velocity in pipes

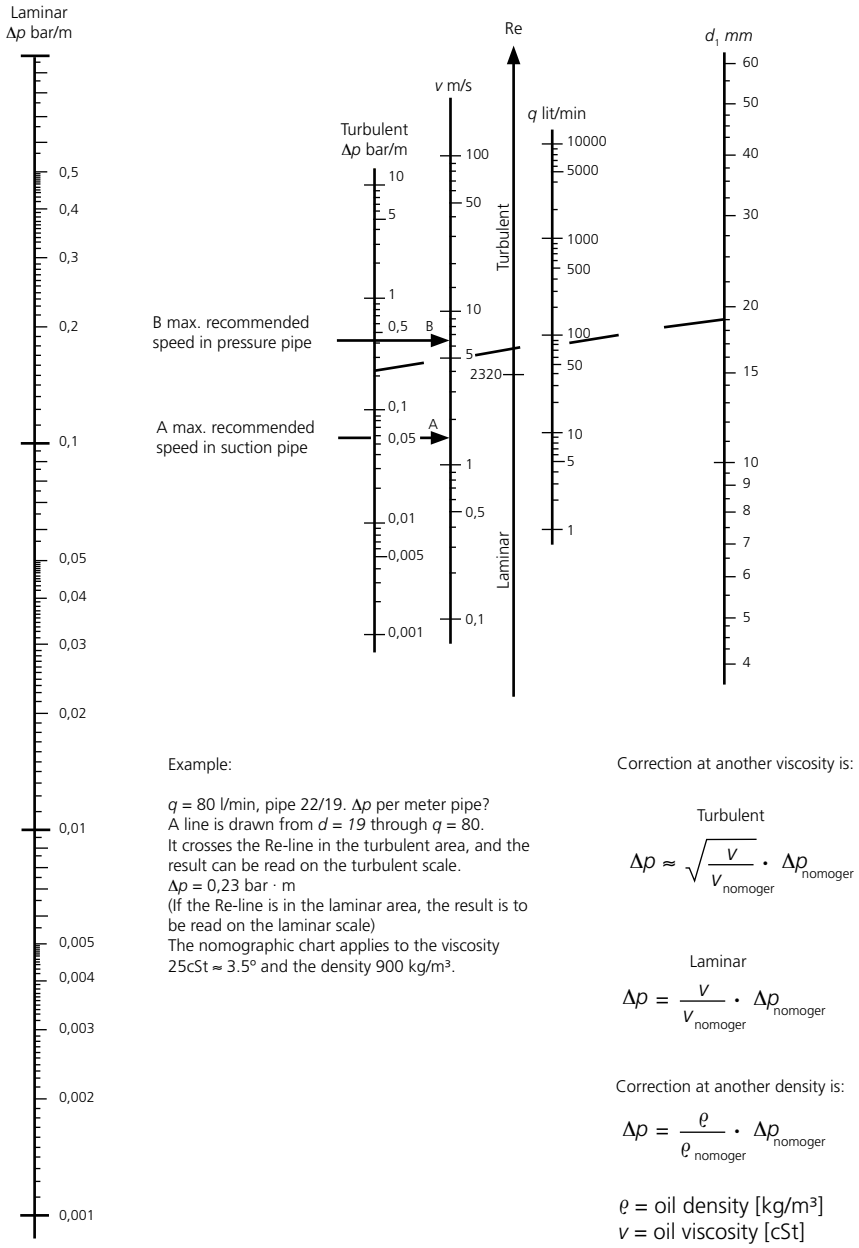


Attachment 2. Oil flow rates at recommended maximum velocities

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
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

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
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
50 x 6.0	88	340	204
60 x 3.0	178.5	686.7	412.0
60 x 5.0	153.1	588.8	353.3
60 x 6.0	141	543	326
66 x 8.5	147.0	565.4	339.3
73 x 3.0	275	1058	635
73 x 5.0	243	935	561
73 x 7.0	213	820	492
80 x 10	220.4	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
141 x 20	625	2404	1442
150 x 15	881.7	3391.2	2034.7
165 x 5.0	1471.1	5657.9	3394.7
168 x 25	853	3281	1968
220 x 6.0	2649.1	10188.7	6113.2
220 x 20	1985	7634	4580
250 x 25	2450	9425	5655
270 x 25	2965	11404	6842

Attachment 3. Pressure drop in pipes



Example:

q = 80 l/min, pipe 22/19. Δp per meter pipe?
A line is drawn from d = *19* through q = 80.
It crosses the Re-line in the turbulent area, and the result can be read on the turbulent scale.
Δp = 0,23 bar · m
(If the Re-line is in the laminar area, the result is to be read on the laminar scale)
The nomographic chart applies to the viscosity 25cSt ≈ 3.5° and the density 900 kg/m³.

Correction at another viscosity is:

Turbulent

$$\Delta p \approx \sqrt{\frac{v}{v_{nomoger}}} \cdot \Delta p_{nomoger}$$

Laminar

$$\Delta p = \frac{v}{v_{nomoger}} \cdot \Delta p_{nomoger}$$

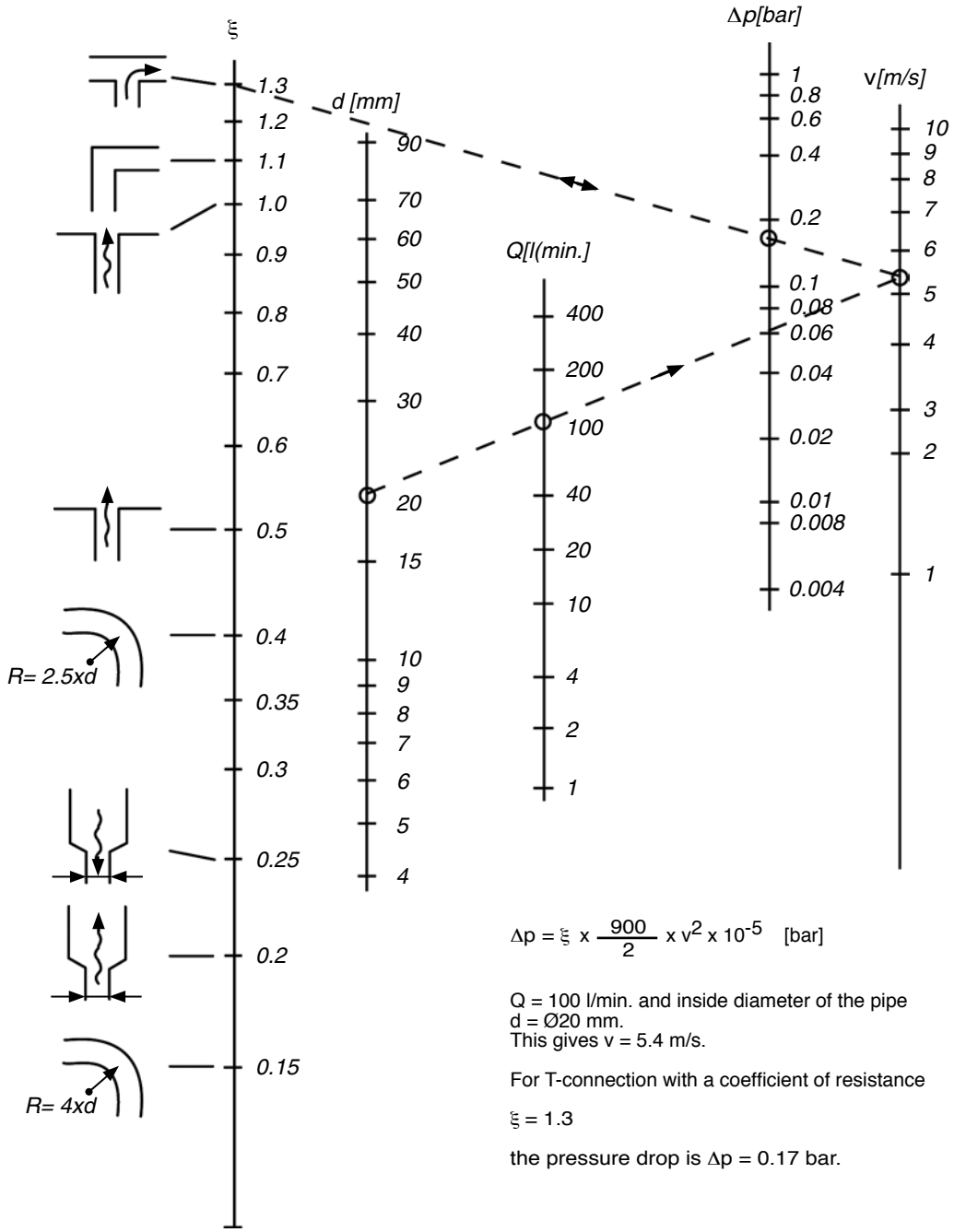
Correction at another density is:

$$\Delta p = \frac{\varrho}{\varrho_{nomoger}} \cdot \Delta p_{nomoger}$$

ϱ = oil density [kg/m³]
v = oil viscosity [cSt]

Attachment 4. Pressure drop in bends, couplings etc.

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



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

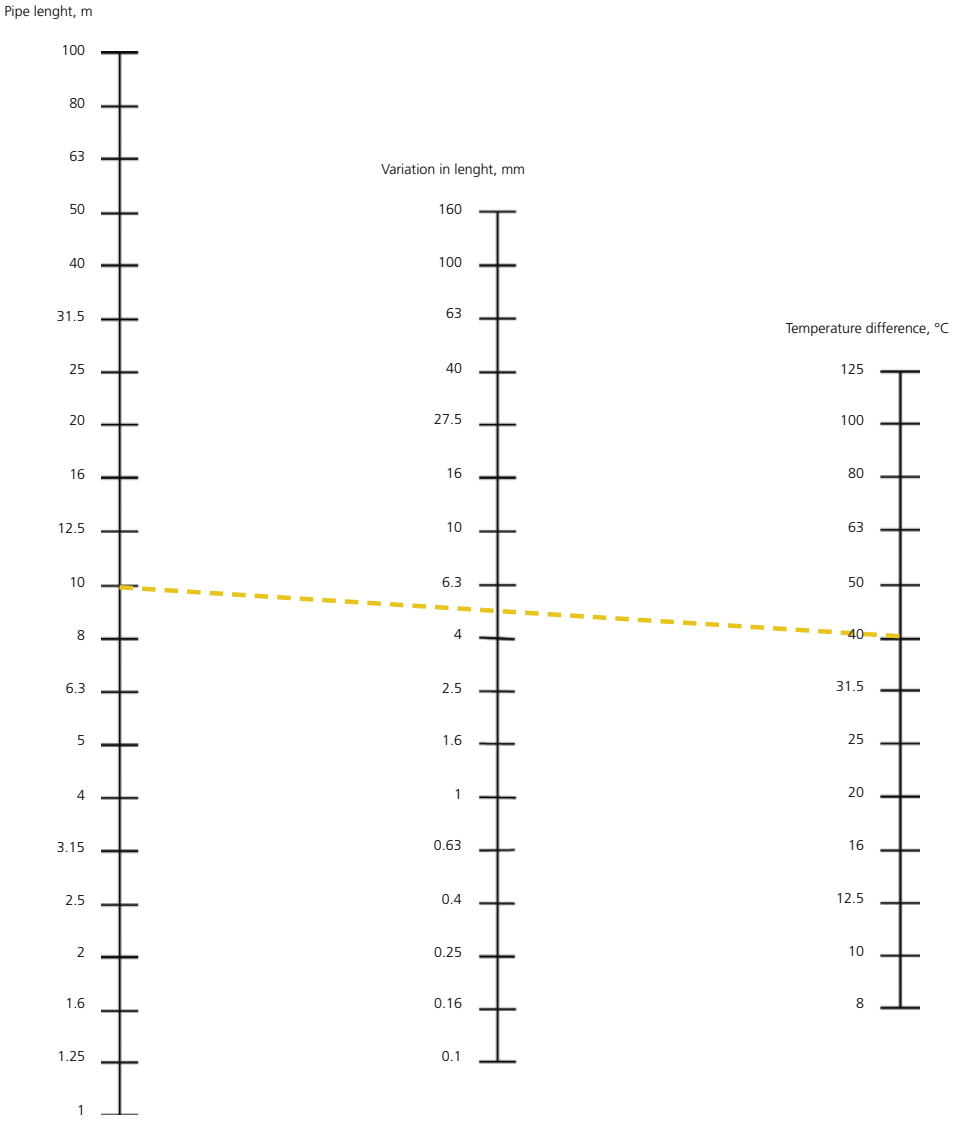
Q = 100 l/min. and inside diameter of the pipe
d = Ø20 mm.
This gives v = 5.4 m/s.

For T-connection with a coefficient of resistance

$\xi = 1.3$

the pressure drop is $\Delta p = 0.17$ bar.

Attachment 5. Thermal expansion of steel pipes



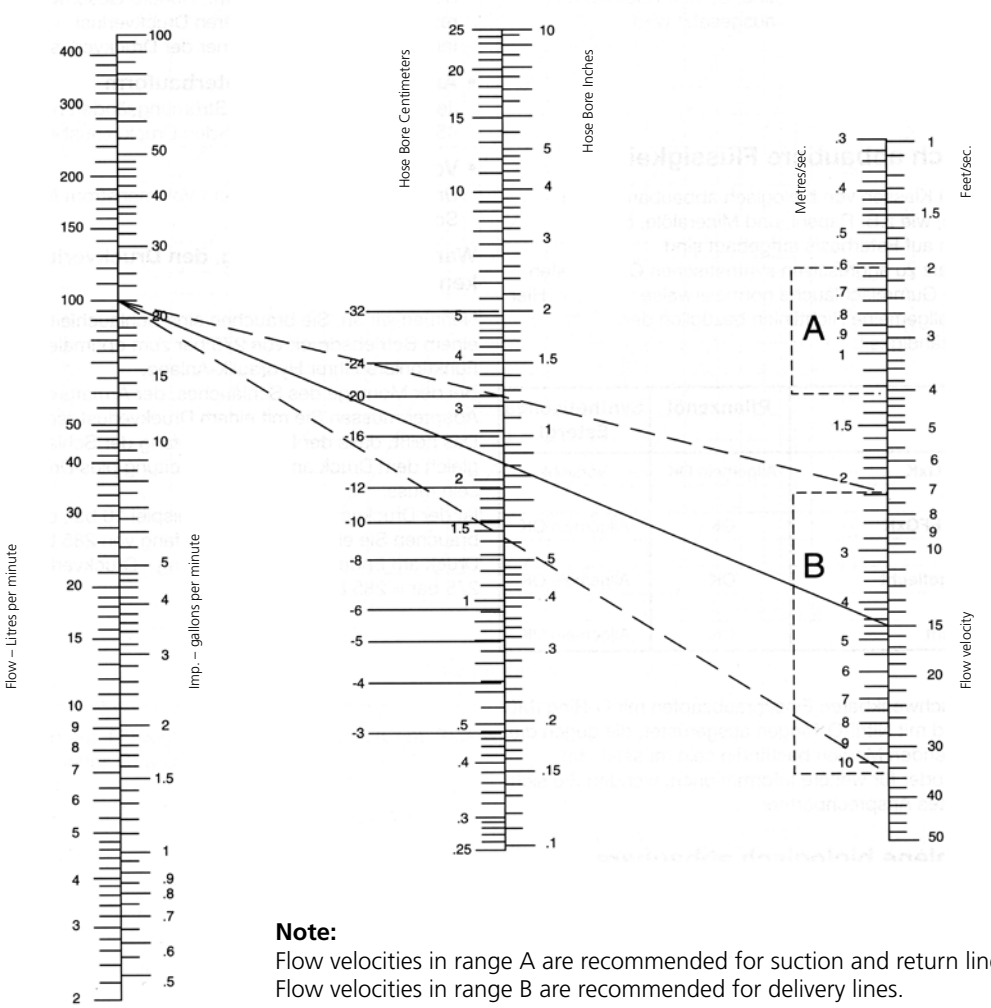
Attachment 6. Hose types in hydraulic systems

Hose type	Reinforcement type	Europe	America	International
Low pressure hoses	Textile braid	EN 854-ITE EN 854-2TE EN 854-3TE EN 854-R3 - EN 854-R6	- - - SAE 100R3 SAE 100R5 SAE 100R6	ISO 4079-1 ISO 4079-1 ISO 4079-1 ISO 4079-1 - ISO 4079-1
Medium pressure hoses	Steel braid	EN 853-1ST EN 853-1SN EN 853-2ST EN 853-2SN	SAE 100R1A SAE 100R1AT SAE 100R2A SAE 100R2AT	ISO 1436-1 ISO 1436-1 ISO 1436-1 ISO 1436-1
		EN 857-2SC EN 857-1SC - -	- - SAE 100R16 SAE 100R17	ISO 11237-1 ISO 11237-1 - -
High pressure hoses	Steel spiral	EN 856-4SP EN 856-4SH - - EN 856-R12 EN 856-R13 EN 856-R15	SAE 100R10 - SAE 100R9 SAE 100R11 SAE 100R12 SAE 100R13 SAE 100R15	ISO 3862-1 ISO 3862-1 ISO 3862-1 ISO 3862-1 ISO 3862-1 ISO 3862-1 ISO 3862-1
Suction hose	Textile braid + steel spiral	-	SAE 100R4	-
Thermoplastic hoses	Polyester braid	EN 855-R7 EN 855-R8	SAE 100R7 SAE 100R8	- -
Teflon hose (PTFE)	Stainless steel braid		SAE 100R14	-

Attachment 7. Hose size selection

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.

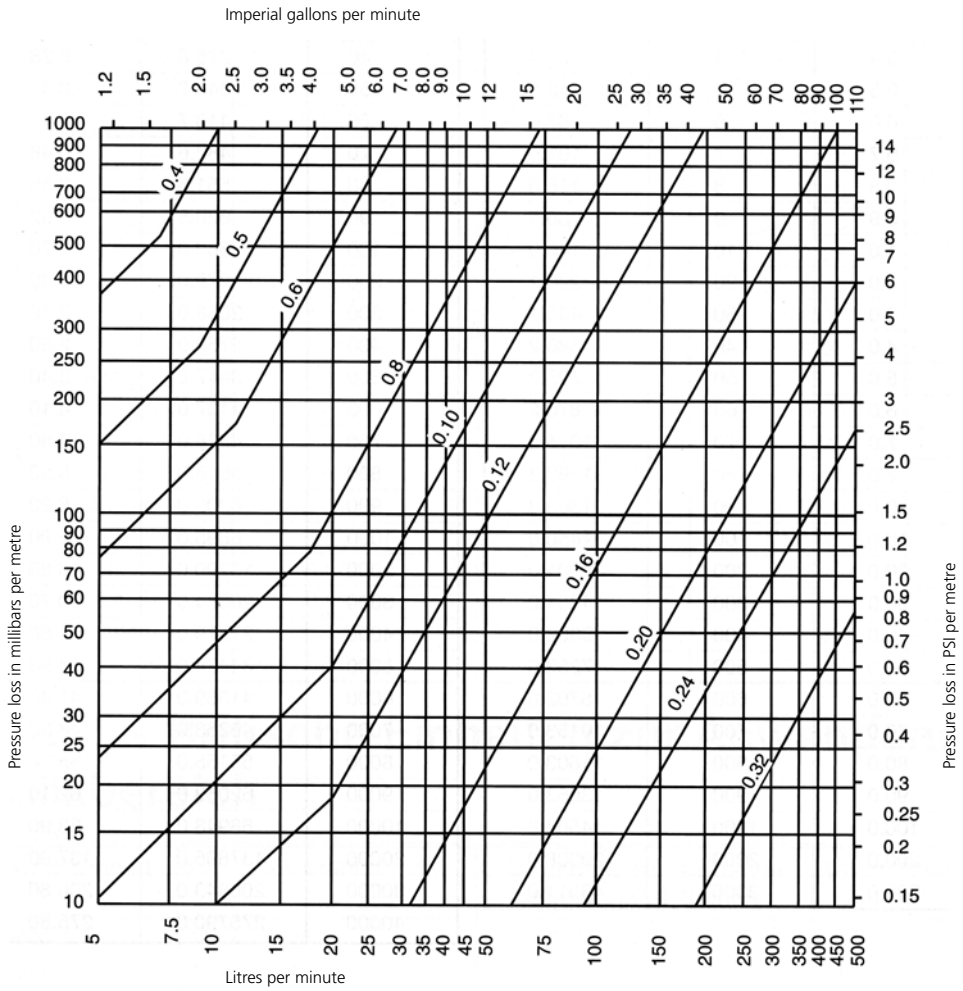


Note:
Flow velocities in range A are recommended for suction and return lines.
Flow velocities in range B are recommended for delivery lines.

Attachment 8. 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.



Attachment 9. 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)

Attachment 10. Notations and ratio factors

Notations:		
q	= Displacement	: cm^3
n	= Rotation speed	: min^{-1} = rpm
p	= Pressure	: bar
Δp	= Pressure drop	: bar
Q	= Flow rate	: l/min = dm^3/min
v	= Velocity	: m/s
L	= Length	: m
D	= Piston diameter	: mm
d	= Piston rod diameter	: mm
D_i	= Inner diameter of pipe	: mm
D_h	= Hydraulic diameter	: mm
A	= Area	: cm^2
a	= Ring area	: cm^2
t	= Time	: s
m	= Mass	: kg
F	= Force	: N
M	= Torque	: Nm
P	= Power	: kW
v	= Kinematic viscosity	: mm^2/s = cSt
ρ	= Oil density	: kg/m^3
η_v	= Volumetric efficiency	
η_m	= Mechanical efficiency	
η_{tot}	= Total efficiency	
Re	= Reynolds number	
λ	= Frictional resistance factor	
ζ	= Individual resistance factor	
V_{ac}	= Accumulator size	: l = dm^3
V_x	= Available oil capacity in accumulator	: l = dm^3
p_1	= Lowest oil pressure	: bar
p_2	= Highest oil pressure	: bar
p_0	= Pre-charge pressure	: bar

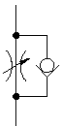
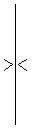
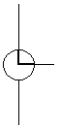
Ratio factors:		
Power	1 kw	= 1,36Hp
	1Hp	= 75 kpm/s
		= 0,736 kw
Torque	1 kpm	= 9,81 Nm
		= 7,233 lbf ft
	1 Nm	= 0,102 kpm
Pressure	1 kp/cm^2	= 98.000 Pa
		= 0,981 bar
		= 9,81 N/cm^2
		= 14,22 psi
	1 psi	= 0,06895 bar
		= 0,0703 kp/cm^2
	1 bar	= 1,0194 kp/cm^2
Volume	1 US, gallon	= 3,785 liter
	1 Eng. gallon	= 4,546 liter
	1 in^3	= 16,38 cm^3
	1 liter	= 1,0 dm3
Area	1 in^2	= 645,2 mm^2
	1 $foot^2$	= 92900 mm^2
Speed	1 km/h	= 0,2778 m/s
	1 foot/s	= 0,3048 m/s
	1 mile/h	= 0,447 m/s
Acceleration	1 $foot/s^2$	= 0,3048 m/s^2
Length	1 in	= 25,4 mm
	1 foot	= 0,3048 m
	1 yd	= 0,9144 m

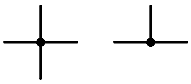
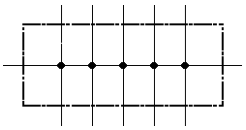
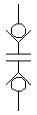
Symbols

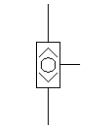
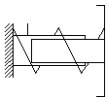
Symbols 190
Main symbols 190
Pumps 191
Oil filters 192
Air coolers 193
Cylinders 193
Motors 193
Hydraulic valves for general use 195
Pressure relief and reducing valves 196
Kind of actuators 196
Measuring instruments. 197
Electric sensors, switches 197
Brakes 197

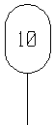
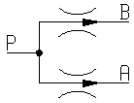
SYMBOLS

1. MAIN SYMBOLS

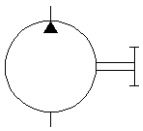
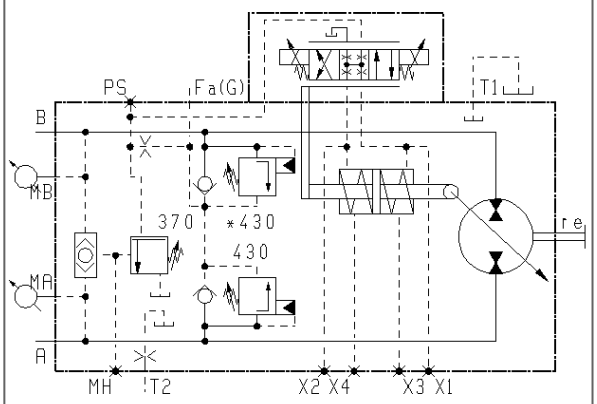
	**Check valve, non return valve**
	**Non return valve** spring loaded
	**Non return valve** with adjustable flow restriction
	**Flow control valve - nozzle** adjustable
	**Orifice**
	**Shut off valve** manual operated
	**3-way change over valve** manual operated
	**Tank**

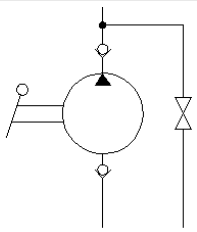
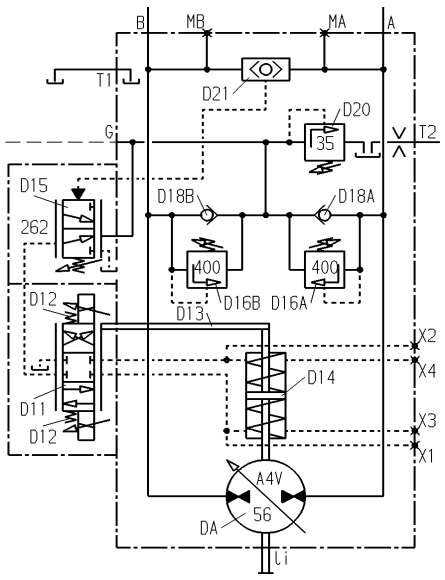
	Work line
	Pilot line
	Drain line
	**Flexible line**
	**Line connections**
	**Enclosure for several components in one unit**
	**Distribution block**
	**Quick release coupling**

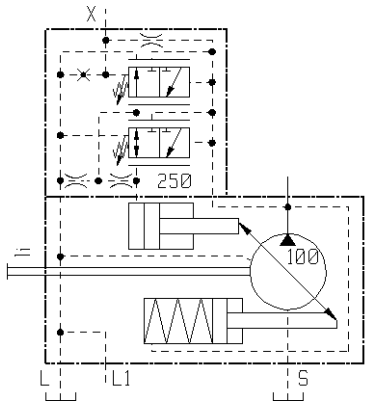
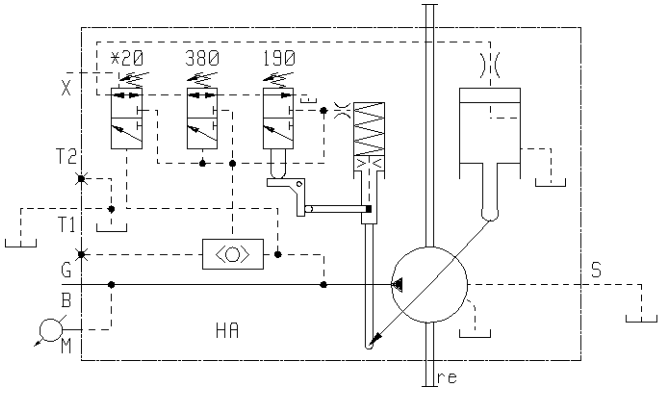
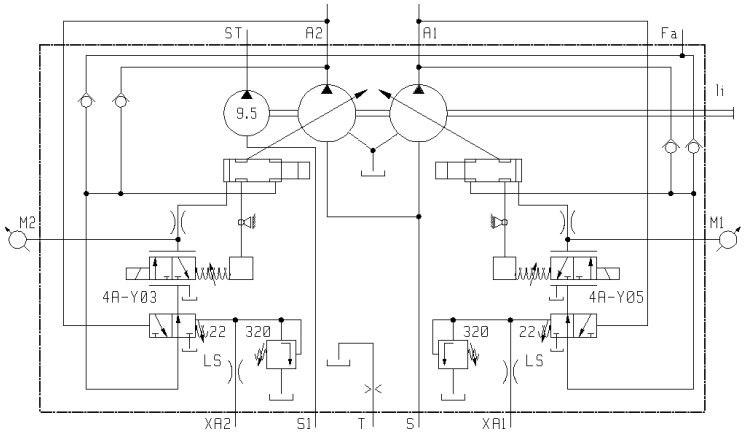
	**Shuttle valve**
	**Cartridge valve** 2/2-way valve, hydraulically operated
	**Hydraulically operated air flap**

	**Pressure accumulator**
	**Flow divider**

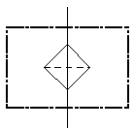
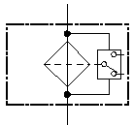
2. PUMPS

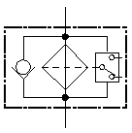
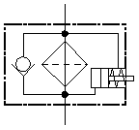
	**Pump**
A4VG-Pump (replacement for A4V Pump) variable delivery in both directions, electrically controlled with internal pressure relief and pressure cut off valve used for closed circuits	
	

	**Handpump**
A4V-Pump (replaced by A4VG pump) variable delivery in both directions, electrically controlled with internal pressure relief and pressure cut off valve used for closed circuits	
	

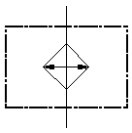
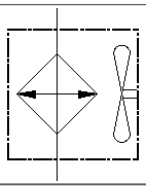
	**A10VO-Pump** one flow direction with variable delivery for open circuits, hydraulically (X) controlled, with flow control valve and pressure relief valve (250 bar)
	**A11VO-Pump** valiable delivery in one flow direction for open circuits, hydraulically controlled
	**LPVD-Pump** Liebherr double pump for open circuits

3. OIL FILTER

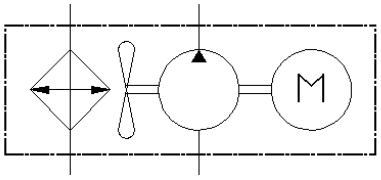
	**Oil filter**
	**Oil filter** with electric change over contact to show if filter is dirty

	**Oil filter** with electric change over contact to show if filter is dirty with security bypass
	**Oil filter** with security bypass valve andmechanic pollution indicatior

4. AIR COOLER

	**Oil cooler**
	**Oil cooler** air cooled by fan

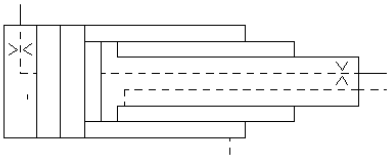
Oil cooler-pump unit
driven from an electric motor



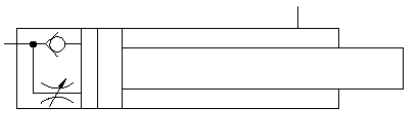
5. CYLINDERS

	**Double acting cylinder**
	**Single acting cylinder** with spring forced retraction
	**Single acting cylinder** with spring forced retraction, used on holding brakes

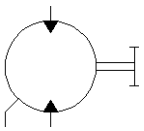
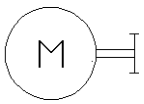
Double acting telescopic cylinder

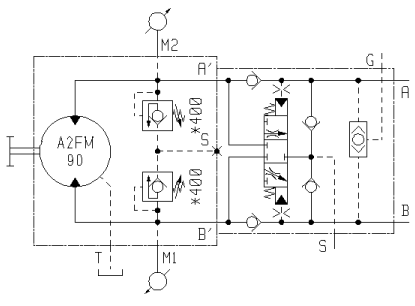


Double acting cylinder
with return flow limitation

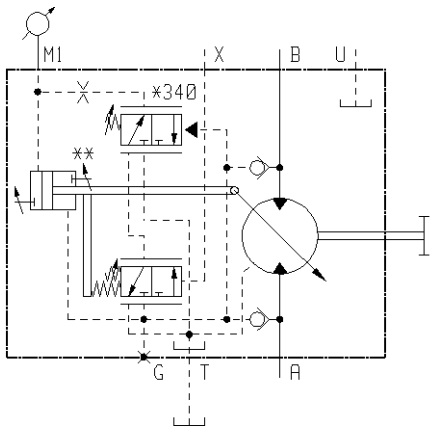
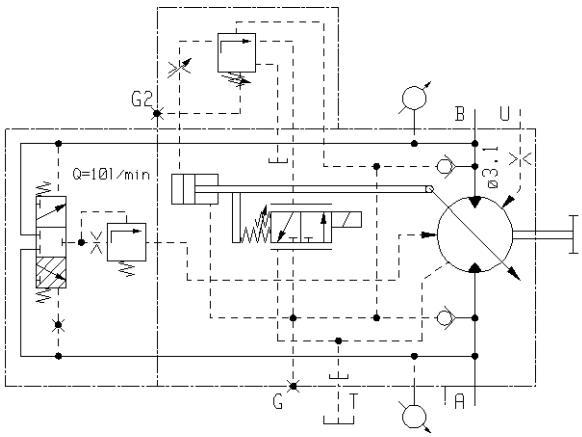
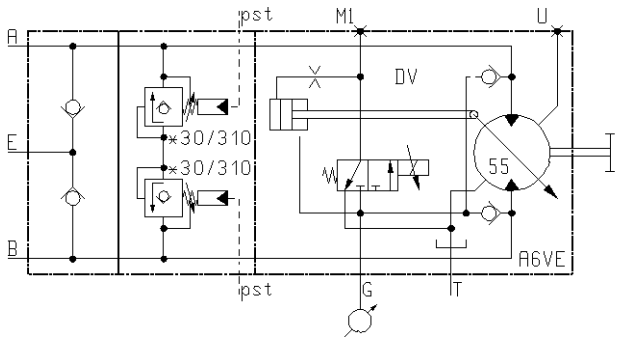


6. MOTORS

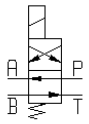
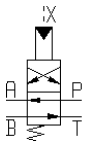
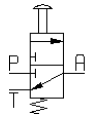
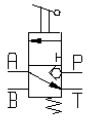
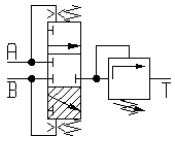
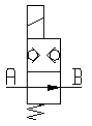
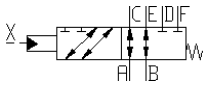
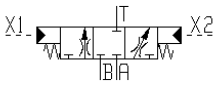
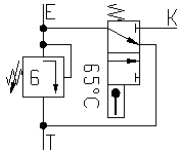
	**Motor** for both directions and leak oil outlet
	**Electric motor**

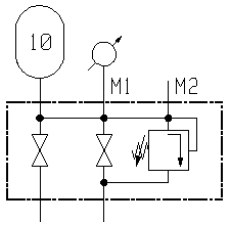
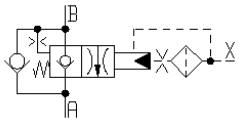
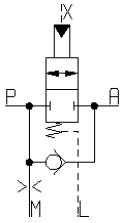
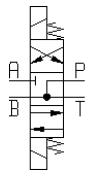
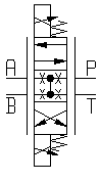
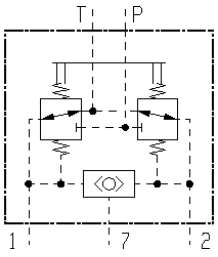


A2FM-Motor
axial piston, constant displacement motor for both directions, with internal pressure limitation for closed circuits

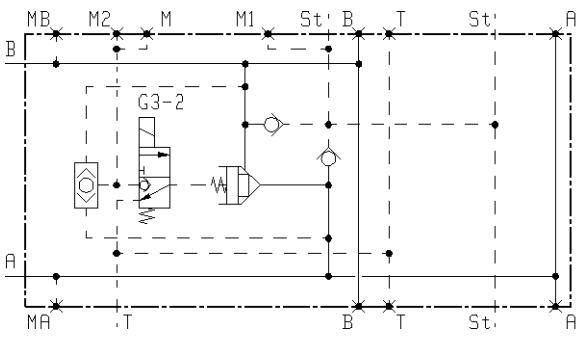
	**A6VM-Motor** variable displacement motor with axial piston rotary group, for both directions, displacement is infinitely variable, hydraulically controlled (connection X) with spring and pressure dependant return
	**A6VM-Motor** variable displacement motor, electrically controlled with spring and pressure dependantreturn
	**A6VE-Motor** variable displacement plug-in motor with standard axial tapered piston rotary group, hydraulically controlled, primarily installed in slewing gears LR/HS

7. HYDRAULIC VALVES FOR GENERAL USE

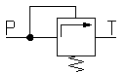
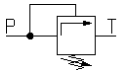
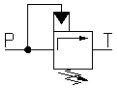
	**4/2-way valve** electrically controlled, spring reset
	**4/2-way valve** hydraulically controlled, spring reset
	**3/2-way valve** manually controlled, spring reset
	**3/2-way valve** manually controlled, spring reset
	**3/3-way valve** (e.g. oil flushing valve used in aclosed circuit) hydraulically controlled, spring reset, with pressure relief valve, side B not used
	**2/2-way valve** electrically controlled, spring reset
	**6/2-way valve** hydraulically controlled, spring reset
	**3/3-way valve** hydraulically controlled
	**3/2-way valve** thermostatically controlled with pressure relief valve to protect the oil cooler

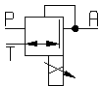
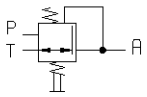
	**Pressure accumulator** with security block
	**Over centre brake** hydraulically controlled 2/2 way valve wit restriction / brake function
	**2/2-way valve, hose fracture safety valve** applied in shipcrane luffing gear cylinder
	**4/3-way valve** electrically controlled, spring reset
	**4/3-way valve, servo control valve** electrically controlled, spring reset
	**Pilot valve** used for complete hydraulic motion drives

Slewing gear safety block

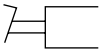


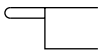
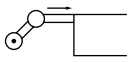
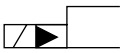
8. PRESSURE RELIEF AND REDUCING VALVES

	**Pressure relief valve** direct controlled, fixed
	**Pressure relief valve** direct controlled, adjustable
	**Pressure relief valve** pilot operated, adjustable

	**Pressure reducing valve** adjustable
	**Pressure reducing valve** adjustable and electrically contolled with release outlet
	**Pressure reducing valve** manually controlled with release outlet

9. KIND OF ACTUATORS

	**Pneumatic**
	**Manual** general
	**Manual** Pedal
	**Hydraulic**
	**Mechanical** sping forced

	**Mechanical** push-button
	**Mechanical** joined push-button
	**Electrical**
	**Electrical Hydraulic**

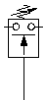
11. MEASURING INSTRUMENTS

	**Pressure gauge connection point**

	**Pressure gauge**

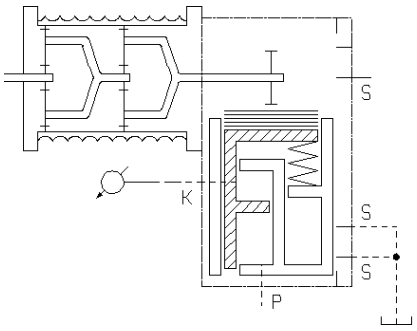
12. ELECTRIC SENSORS, SWITCHES

	**Pressure transducer** pressure to current or voltage
	**Pressure switch** with electric change over contact

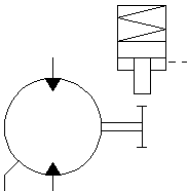
	**Pressure switch** with electric make contact and spring reset

13. BRAKES

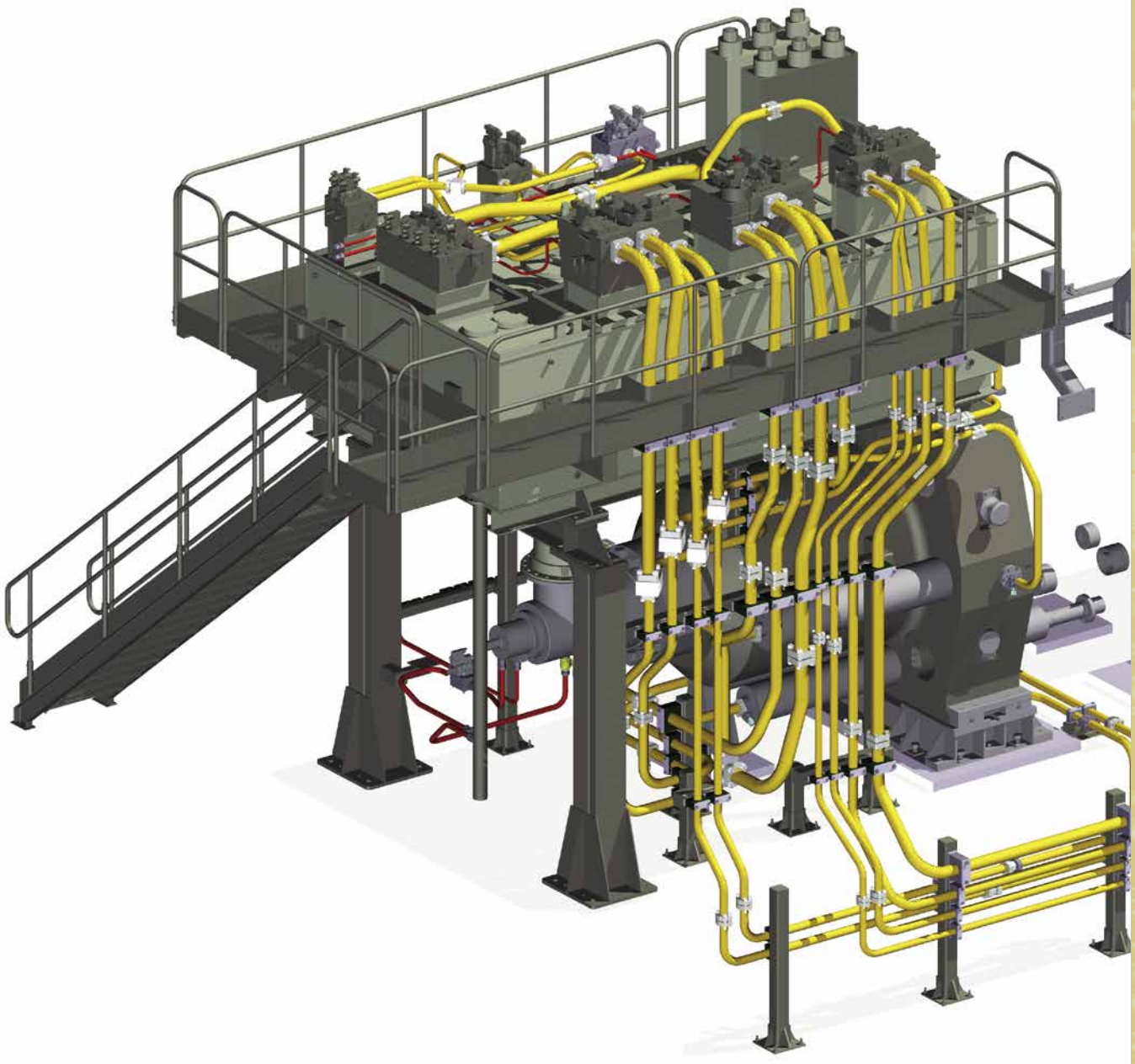
Free fall brake
on the winch



Multiple disk brake
spring loaded and hydraulically released, holds the motor in stand still position



HYDRAULIC PIPING STANDARD HANDBOOK



8990306005 Hydraulic Piping Standard Handbook Revision 1 EN-1 April 2014

GS-Hydro Corporation
Finland
Phone: +358 3 656 41
E-mail: info@gshydro.com
www.gshydro.com

www.kianhydraulic.com

GS-Hydro