EQUIPMENT PIPING

TRAINING COURSE MANUAL

1. THE FUNCTIONS OF PIPING

1.1. INTRODUCTION

The piping or pipe is a network unit which transports a fluid from one type of equipment to another.

The various transported fluids:

- Incompressible fluids (liquid)
- Compressible fluids (gas)
- Fluids under high pressure
- Mixed fluids: liquid gas / slurries / solids

Flow principles

- Difference in pressure between an upstream and a downstream equipment
- Pump (liquid)
- Compressor (gas)
- Gravity flow

1.2. PIPING NETWORK

The piping network is a complete network (pipes, valves and other accessories which are connected to correctly perform a specific job.)

A familiar example of a piping system is the network of water pipes in houses.

This system includes all the components which are needed to bring the water to the house and distribute it to the various places within it.

The piping systems are essential for the successful operation of any industrial plant. There are various systems, each with its own function.

For example, the gas oil storage tanks for boiler burners.

Piping network

1.3. PIPES

Pipes are used mostly to permit fluid flow and must support specifically determined pressure, compression, and tensile stress.

They must also resist buckling.

1.4. FLANGES

The flanges are used to ensure a detachable and leak-proof connection between two piping units (piping section, connection on a rotating machine, on a vessel).

1.5. GASKETS

Placed between 2 flanges, a sealing joint must have the following qualities:

- Be sufficiently plastic to absorb surface irregularities.
- Withstand operating pressures without breaking.
- Have enough spring back to permit the flow of the fluid to the outside (leak)
- Not be attacked by the transported fluid.

1.6. BLINDS

Blind flanges are installed to isolate a piping section or a storage capacity, each time one needs to ensure that no leakage will occur.

When shutting down a unit, the plates provide 3 essential functions:

- Sectional (or isolating) blinds.

  The blinds are placed at the battery limits of a unit upon shutdown, in order to completely isolate the unit from the rest of the installations which are still operating.

- Working blinds

  They are placed as close as possible to the vessels, the apparatus, and the machines, which must be inspected, overhauled, or otherwise worked on.

- Test blinds

  Their purpose is to isolate and resist the test pressures in the apparatus, during the regulation tests ordered by the mining or inspection department.

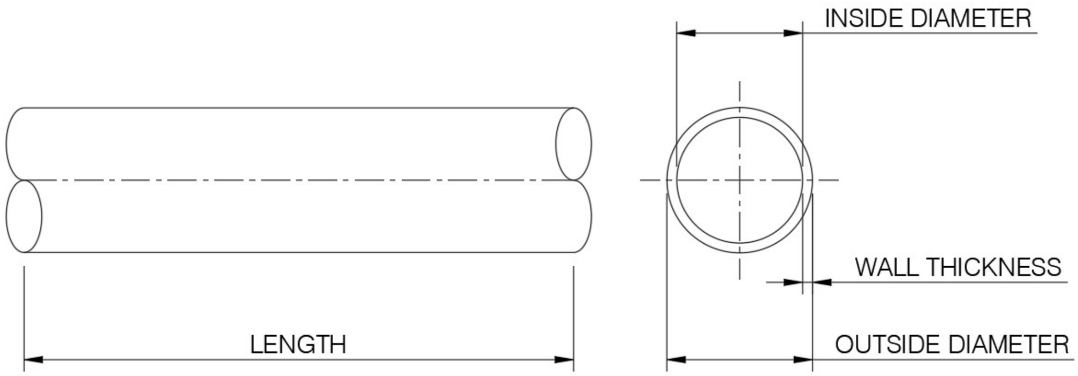
2. PIPING COMPONENTS

2.1. TUBES OR PIPES

2.1.1. CHARACTERISTICS

A tube is defined by its diameter, the thickness of the envelope and the grade of the steel of which it is composed.

The nominal pipe size expressed according to French or American standards is but a simple number used to classify the tubes.



The definitions of a tube

Correspondence in diameters between French standards (AFNOR) and American (ANSI):

• French nominal pipe size	NPS 50	NPS 100
• Diameter in inches	2"	4"
• True outer diameter	60,3	114,3

In the French standard AFNOR, the thickness is expressed in mm.

In the American standard ANSI, the thickness is defined by *the Schedule Number*, (According to the metal) given in the form of a table.

This standard is defined by the American code ANSI B 36-10 for carbon steel according to the internal pressure (P) and to the allowable stress of the metal at the operating temperature.

2.1.2. THE VARIOUS TYPES

Three types are distinguished:

- Welded tubes

Obtained through heat or cold they have a welded joint coefficient. In accordance with the manufacturing process of the envelope, the weld can be longitudinal (butt seam tube) or helicoidal (spiral seam tube).

- Centrifuge tubes

Obtained by means of a metal flow in a rotating cylindrical mould, these tubes are reserved for special steels.

- Seamless tubes

They are mostly used in the oil and petrochemical industry. They are obtained by heating a steel billet up to about 1250°C, then after a piercing made by a metal pear, the obtained tube is laminated and calibrated.

2.1.3. THE VARIOUS CLASSES

API: Mainly used for very high-pressure oil applications.

ASME: Standard, frequently used flanges and tubes.

The wellheads are API equipped.

The manifolds are either API or ASME equipped.

The utilities are usually ASME equipped.

3. ABBREVIATIONS USED

ANSI	American National Standard Institute	MI	Malleable Cast Iron
API	American Petroleum Institute	Mo	Molybdenum
ASTM	American Society for Testing and Materials	MSS	Manufacturers Standardization Society
BB	Bolted Bonnet	NPT	Threading as per ANSI B.I.20.1
BE	Beveled End	OS&Y	Outside Screw Spindle and Yoke
Br	Bronze	PE	Plain End
BW	Butt Welding	PTFE	Teflon
CAS	Cast Alloy Steel	RF	Raised Face
CCS	Cast Carbon Steel	RJ	Machined Face for Ring Joint
CS	Carbon Steel	SAW	Submerged Arc Welded
CuNi	Copper-Nickel	SB	Screwed Bonnet
Cr	Chromium	SF	Small Female Face
EFW	Electric Fusion Welded	SM	Small Male Face
ERW	Extended Resistance Welded	SMLS	Seamless
ES	Extended Spindle	SO	Slip-on
FAS	Forged Alloy Steel	SP	Standard Practice (MSS)
FCS	Forged Carbon Steel	SPB	Split Body
FF	Flat Face	SS	Stainless Steel
F6	Stainless Steel, 13% Cr	STD	Standard
Gr	Grade	SW	Socket Welding
GRP	Glass Reinforced plastic	TE	Threaded End
HCP	Hard Chrome Plated	TM	Trunion Mounted
ISRS	Inside Screw Riser Spindle	TPE	Top Entry
LJ	Lap Joint	WN	Welding Neck
LTCS	Low Temperature Carbon Steel	WB	Welded Bonnet

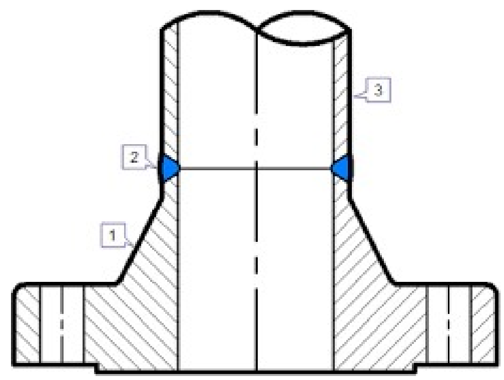
4. FLANGES

4.1. VARIOUS FLANGES

4.1.1. VARIOUS TYPES OF FLANGES

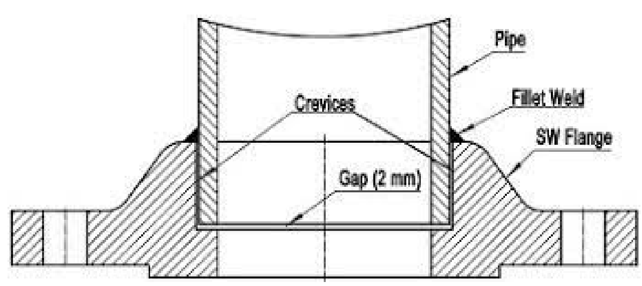
- Welding neck

Used when NPS >= 2” in most cases (the most resistant)



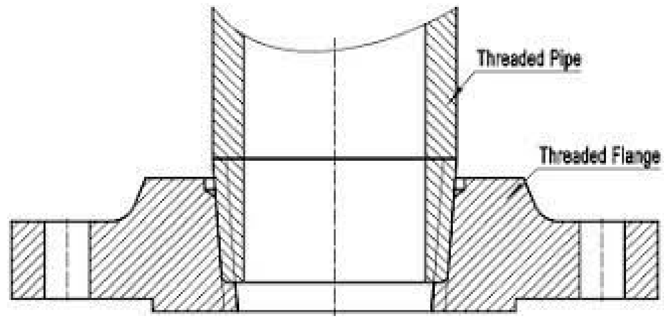
- Socket welding

Only used for classes 150 and 300 (carbon steel)



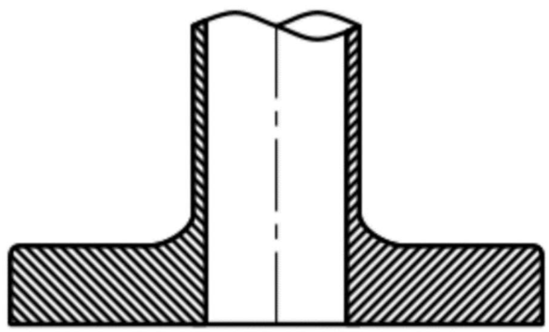
- Threaded

Used for the utility lines, do not use for the process lines.

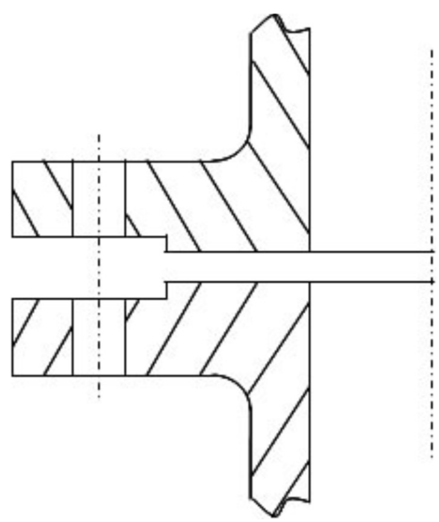


4.1.2. THE VARIOUS TYPES OF FACES

- Flat face (FF)
  Used for flanges in reinforced iron and plastic (SVR)

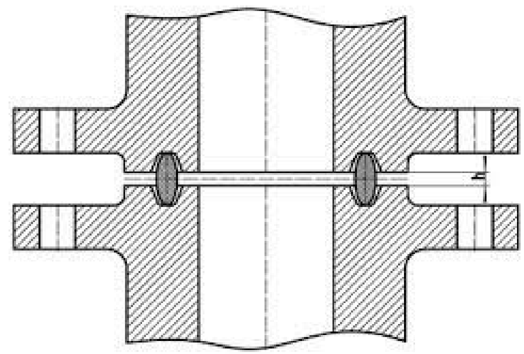


- Raised Face (RF)
  Used for classes 150 to 600.



- Ring Joint (Grooved for Ring Joint RJ)

  Used for classes 900 to 10000.



4.1.3. THE VARIOUS CLASSES

Class	ASME Class	Material (Corrosion in mm)	Fluid	Temperature
B01	150 RF	C.S. (1.27)	Hydrocarbons (corrosion resistant gas or liquid) Pressurized drains Corrosion-resistant flare gas, Fuel gas Gas oil Diesel Nitrogen Oily water Cooling water (corrosion resistant) Tail water (corrosion resistant) Methanol Glycol	-29°C to 220°C
D01	300 RF	C.S. (1.27)	Hydrocarbons (corrosion resistant gas or liquid) Pressurized drains Fuel oil (medium pressure), Nitrogen (medium pressure), Methanol Glycol	-29°C to 220°C
F01	600 RF	C.S. (1.27)	Hydrocarbons (corrosion resistant gas or liquid) Low pressure hydraulic units Methanol Glycol	-29°C to 220°C

Class	ASME Class	Material (Corrosion in mm)	Fluid	Temperature
G01	900 RF	C.S. (1.27)	Hydrocarbons (corrosion resistant gas or liquid) Deacidified gas (HP sweet gas) Methanol Glycol	-29°C to 220°C
H01	1500 RF or Hub Connectors	C.S. (1.27)	Hydrocarbons (corrosion resistant gas or liquid) deacidified gas (HP sweet gas) Injection water (corrosion resistant, degassed sea water) MP hydraulic power unit Methanol Glycol	-29°C to 220°C
J01	2500 RF or Hub Connectors	C.S. (1.27)	Hydrocarbons (corrosion resistant gas or liquid) deacidified gas (HP sweet gas) Injection water (corrosion resistant, degassed sea water) HP hydraulic power unit Methanol Glycol	-29°C to 220°C

4.1.4. CHARACTERISTICS

A flange is defined by various elements:

- **Its type:** is in accordance with the use, the stress and both operating pressure and temperature,
- **Its diameter:** is in accordance with the piping line diameter,
- **Its face:** is in accordance with the sealing joint which will be used,
- **Its series or its class:** it characterizes the capacities to support both pressure and temperature,
- **Its material**: is in accordance with pressure, temperature and with the resistance to the corrosion of the transported fluid.

4.1.5. AMERICAN STANDARDS

Since the pipes are classified by “Schedule” the flanges are classified according to the following standards, in nominal pressures (NP), class or series.

- API (American Petroleum Institute)
- ASME (American Society of Mechanical Engineers)
- ASME used to be called:
- American Standard Association (ASA ⇒ 1966).
- United States of America Standard (USAS ⇒ 1969)
- American National Standard Institute (ANSI ⇒ 1982).

New names for the ANSI flanges

New name	Old name
NP 20	Class 150#
NP 50	Class 300#
NP 100	Class 600#
NP 150	Class 900#
NP 250	Class 1500#
NP 420	Class 2500#

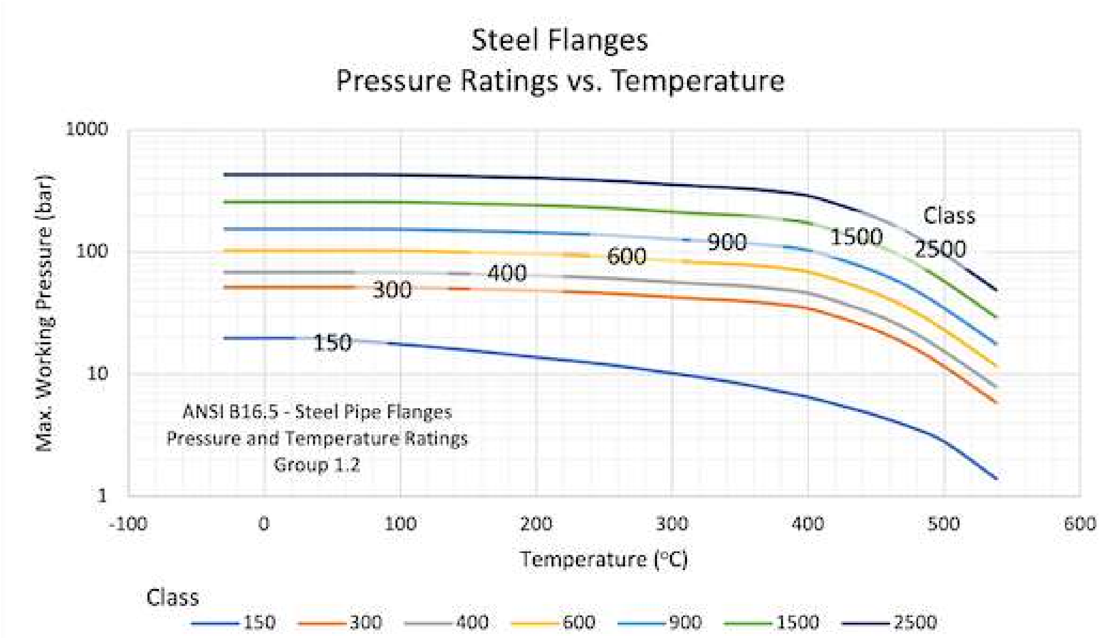
Maximum pressure allowed according to ASME standard B16.5

Class	Temperature		
Psi	-29°C to 38°C	260°C	454°C
150	19 bars	10.35 bars / 150psi	
300	49.6 bars		20.70 bars / 300 psi
400	66.2 bars		27.60 bars / 400 psi
600	99.3 bars		41.40 bars / 600 psi
900	148.9 bars		62.10 bars / 900 psi
1500	248.4 bars		103.45 bars / 1500 psi
2500	414 bars		172.40 bars / 2500 psi

The use of the various classes

Value in lbs	Use
150	Low pressure
300	Intermediate pressure
600	High pressure
900	Very high pressure
1500	Extremely high pressure
2500	Maximum pressure

Pressure curve according to the series



4.1.6. THE FRENCH STANDARDS AFNOR

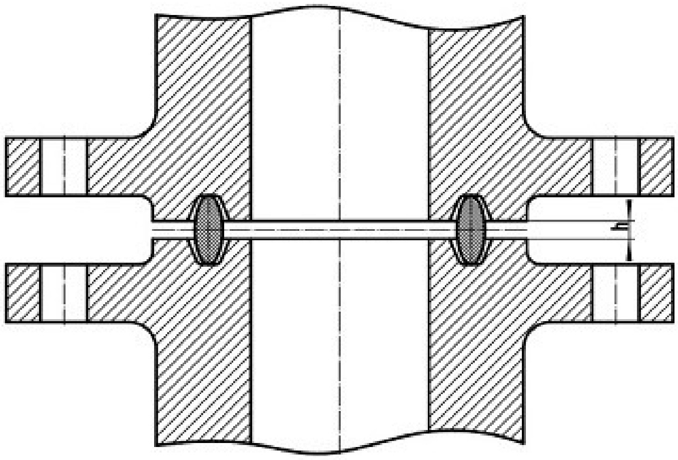
In the beginning, taking in account the material of the flanges, the series were expressed in NP (nominal pressure given in bar) in correspondence with the maximum pressure that the assembly could support, up to a limited temperature of 110 °C.

The values of the standardized NP series were the following:

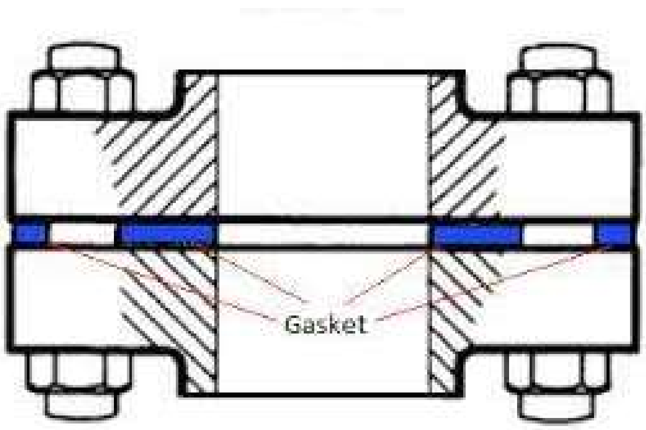
NP: 2.5 – 6 – 10 – 16 – 25 – 40 – 64 – 100 – 160 – 250 – 320 – 400 – 640 – 1000

4.1.7. THE VARIOUS TYPES OS ASSEMBLING

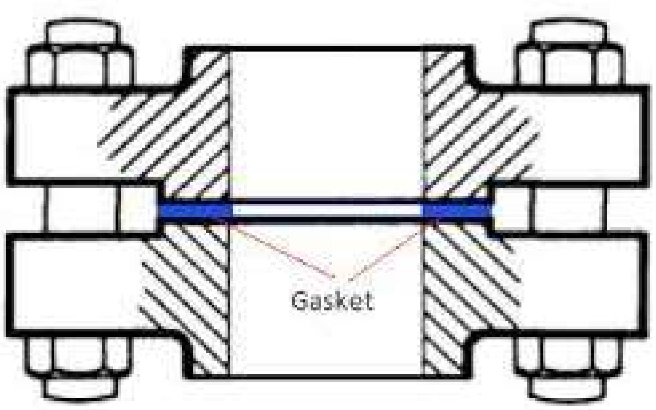
Ring type joint facing



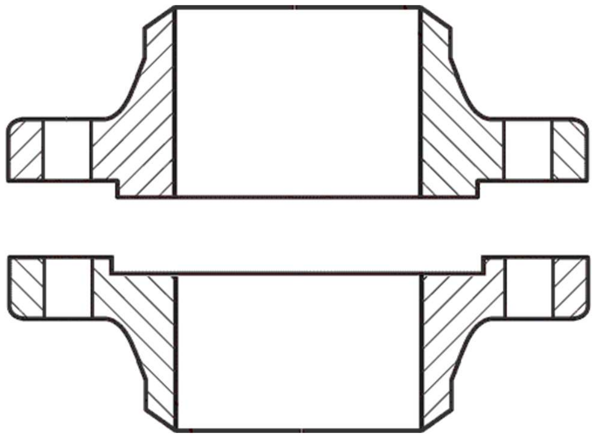
Flat face



Raised Face



Male and female facing



4.1.8. TIGHTENING THE FLANGES

The flanges must be tightened in a very specific order, for good alignment between the two flanges and for equal squeezing of the gasket, resulting in a tight seal.

4.1.9. TIGHTENING TORQUE

A torque wrench is an adjustable tool, which limits the tightening torque of the screw and nut so that they may be installed optimally.

The oldest models are fully mechanical and emit a click when the torque (adjustable by means of a cursor on the wrench) has been reached. The wrench must absolutely be reset before tightening each time.

Current models no longer need to have the wrench reset.

They now have an electronic part, with a display and a keypad, connected to a strain gauge which triggers a buzzer to warn the operator when the tightening is sufficient. No need to reset the wrench, you only need to change the batteries once they are flat.

Example: Usually a tightening torque is expressed in daN.m (1 decaNewton.m = 10 Newton.m). The nuts of a cylinder head will, for example, be tightened at 9 daN.m

Example of a table with tightening torques.

COUPLES DE SERRAGE POUR BOULONNERIE METRIQUE — 80% de la limite élastique (Sy)

MÉTRIQUE	ABMS Conception et calculs mécaniques			Diamètre (mm)	6	8	10	12	14	16	18	20	22	24	27	30	33	36	39	42	45	48	52	56	60	64	68
					M6	M8	M10	M12	M14	M16	M18	M20	M22	M24	M27	M30	M33	M36	M39	M42	M45	M48	M52	M56	M60	M64	M68
				PAS (mm)	1	1,25	1,5	1,75	2	2	2,5	2,5	2,5	3	3	3,5	3,5	4	4	4,5	4,5	5	5	5,5	5,5	6	6
	SECTION RÉSISTANTE (As) en mm²				20	37	58	84	115	157	192	245	303	353	459	561	694	817	976	1121	1306	1473	1758	2030	2362	2676	3055
	MATÉRIAU	Sy (MPa)	ÉTAT	μ	COUPLE DE SERRAGE en N·m														Multipliez par 0.7376 pour obtenir des Lbs*Ft								
PAS NORMAL	CLASS 4.6	240	NL	0,20	5	11	22	39	62	96	133	188	256	325	476	646	879	1129	1461	1808	2257	2715	3510	4365	5442	6576	7978
		240	L	0,15	3	8	17	29	47	72	100	141	192	244	357	484	659	847	1096	1356	1693	2036	2633	3274	4082	4932	5983
	CLASS 8.8	640	NL	0,20	12	30	59	104	165	257	355	501	683	866	1270	1722	2344	3011	3897	4821	6018	7241	9360	11641	14512	17537	21275
		640	L	0,15	9	22	45	78	124	193	266	376	513	650	953	1292	1758	2258	2923	3616	4514	5431	7020	8731	10884	13153	15956
	INOX Class 50	210	NL	0,20	4	10	19	34	54	84	116	165	224	284	417	565	769	988	1279	1582	1975	2376	3071	3820	4762	5754	6981
		210	L	0,15	3	7	15	25	41	63	87	123	168	213	313	424	577	741	959	1166	1481	1782	2303	2865	3571	4316	5236
	INOX Class 70	450	NL	0,20	9	21	42	73	116	180	249	353	N/A, See note 1														
		250	NL	0,20	N/A, Voir note 1								267	338	496	673	915	1176	1522	1883	2351	2828	3656	4547	5669	6850	8310
		450	L	0,15	7	16	31	55	87	135	187	264	N/A, See note 1														
		250	L	0,15	N/A, Voir note 1								200	254	372	505	687	882	1142	1412	1763	2121	2742	3410	4252	5138	6233
	INOX Class 80	600	NL	0,20	12	28	56	97	155	241	333	470	641	812	1191	1614	2197	2823	3653	4520	5642	6788	8775	10913	13605	16441	19945
		600	L	0,15	9	21	42	73	116	180	249	353	481	609	893	1211	1648	2117	2740	3390	4231	5091	6581	8185	10204	12331	14959
	ASTM A36	250	NL	0,20	5	12	23	40	65	100	139	196	267	338	496	673	915	1176	1522	1883	2351	2828	3656	4547	5669	6850	8310
		250	L	0,15	4	9	17	30	48	75	104	147	200	254	372	505	687	882	1142	1412	1763	2121	2742	3410	4252	5138	6233
	AISI 1045	310	NL	0,20	6	15	29	50	80	124	172	243	331	420	615	834	1135	1458	1887	2335	2915	3507	4534	5639	7029	8495	10305
		310	L	0,15	4	11	22	38	60	93	129	182	248	315	461	626	851	1094	1416	1751	2186	2630	3400	4229	5272	6371	7729
	AISI 4140	420	NL	0,20	8	20	39	68	109	168	233	329	449	569	834	1130	1538	1976	2557	3164	3949	4752	6143	7639	9524	11509	13961
		420	L	0,15	6	15	29	51	81	126	175	247	336	426	625	848	1154	1482	1918	2373	2962	3564	4607	5730	7143	8632	10471
	CLASS 10.9	940	NL	0,20	18	44	87	152	243	377	521	736	1004	1272	1866	2529	3442	4422	5723	7081	8839	10635	13748	17098	21315	25758	31247
		940	L	0,15	14	33	65	114	182	283	391	552	753	954	1399	1897	2582	3317	4293	5310	6629	7976	10311	12823	15986	19318	23435
	CLASS 12.9	1100	NL	0,20	21	52	102	178	284	441	610	862	1175	1489	2183	2960	4028	5175	6698	8286	10344	12445	16088	20008	24943	30142	36566
		1100	L	0,15	16	39	77	133	213	331	457	646	881	1117	1637	2220	3021	3881	5023	6214	7758	9334	12066	15006	18707	22607	27424
				PAS (mm)	0,75	1	1	1,25	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1.5	1,5	2	4	4	4
	SECTION RÉSISTANTE (As) en mm²				22	39	64	92	125	167	216	272	333	401	514	642	784	940	1110	1294	1493	1705	2010	2301	2485	2851	3242
	MATÉRIAU	Sy (MPa)	ÉTAT	μ	COUPLE DE SERRAGE en N·m														Multipliez par 0.7376 pour obtenir des Lbs*Ft								
PAS FIN	CLASS 4.6	240	NL	0,20	5	12	25	42	67	103	149	209	281	369	533	740	993	1299	1662	2087	2579	3143	4014	4947	5725	7006	8465
		240	L	0,15	4	9	19	32	50	77	112	156	211	277	400	555	745	974	1247	1565	1934	2357	3011	3711	4294	5255	6349
	CLASS 8.8	640	NL	0,20	14	32	66	113	179	274	399	556	750	985	1422	1973	2649	3465	4433	5566	6878	8380	10705	13193	15267	18683	22574
		640	L	0,15	10	24	50	85	134	206	299	417	563	739	1067	1479	1987	2599	3324	4174	5158	6285	8028	9895	11450	14012	16930
	INOX Class 50	210	NL	0,20	4	11	22	37	59	90	131	182	246	323	467	647	869	1137	1454	1826	2257	2750	3512	4329	5009	6130	7407
		210	L	0,15	3	8	16	28	44	67	98	137	185	242	350	485	652	853	1091	1370	1693	2062	2634	3247	3757	4698	5555
	INOX Class 70	450	NL	0,20	10	23	46	80	126	193	280	391	N/A, See note 1														
		250	NL	0,20	N/A, Voir note 1								293	385	556	771	1035	1353	1732	2174	2687	3274	4181	5154	5964	7298	8818
		450	L	0,15	7	17	35	60	94	145	210	293	N/A, See note 1														
		250	L	0,15	N/A, Voir note 1								220	289	417	578	776	1015	1299	1631	2015	2455	3136	3965	4473	5474	6613
	INOX Class 80	600	NL	0,20	13	30	62	106	167	257	374	521	703	924	1333	1849	2483	3248	4156	5218	6448	7857	10036	12369	14312	17515	21163
		600	L	0,15	10	23	46	80	126	193	280	391	528	693	1000	1387	1863	2436	3117	3914	4836	5893	7527	9277	10734	13136	15872
	ASTM A36	250	NL	0,20	5	13	26	44	70	107	156	217	293	385	556	771	1035	1353	1732	2174	2687	3274	4181	5154	5964	7298	8818
		250	L	0,15	4	9	19	33	52	80	117	163	220	289	417	578	776	1015	1299	1631	2015	2455	3136	3865	4473	5474	6613
	AISI 1045	310	NL	0,20	7	16	32	55	86	133	193	269	363	477	689	955	1283	1678	2147	2696	3331	4059	5185	6390	7395	9050	10934
		310	L	0,15	5	12	24	41	65	100	145	202	273	358	517	717	962	1259	1610	2022	2498	3044	3889	4793	5546	6787	8201
	AISI 4140	420	NL	0,20	9	21	43	74	117	180	262	365	492	647	933	1294	1738	2274	2909	3653	4513	5500	7025	8658	10019	12261	14814
		420	L	0,15	7	16	33	56	88	135	196	274	369	485	700	971	1304	1705	2182	2739	3385	4125	5269	6494	7514	9195	11111
	CLASS 10.9	940	NL	0,20	20	47	97	166	262	402	585	817	1102	1447	2089	2897	3891	5089	6510	8175	10101	12309	15722	19378	22423	27441	33156
		940	L	0,15	15	35	73	125	197	302	439	613	827	1085	1567	2173	2918	3817	4883	6131	7576	9232	11792	14533	16817	20580	24867
	CLASS 12.9	1100	NL	0,20	23	55	114	194	307	471	685	956	1290	1693	2445	3390	4553	5955	7619	9566	11821	14404	18399	22676	26240	32111	38799
		1100	L	0,15	17	41	85	146	230	353	514	717	967	1270	1833	2543	3415	4466	5714	7175	8866	10803	13799	17007	19680	24083	29099

État : NL = Non-lubrifié L = Lubrifié ou Neuf

As = 0.25 * Pi * (D - (0.9382 * Pas))^2

D = diamètre nominal du boulon, en mm

F = % * Sy * As (% = % de la limite élastique, généralement 80%)

C = F * μ * D = % * Sy * As * μ * D / 1000

Sy = limite élastique, en MPa

Note 1 : Inox, classe 70, Sy=250 MPa lorsque D > 22mm

As = section résistante du boulon, en mm²

P = Pas des filets en mm

F = la force en tension, en N

C = LE COUPLE DE SERRAGE, EN N*m

μ = Coefficient de frottement

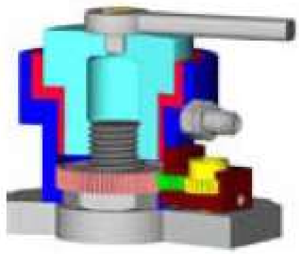
\\HO-PAU-FIL01.hq.ad.ep.corp.local\UserData-2\L0044290\PersonalData\Couple de serrage.xls, 03.05.23 par A.S.

4.2. TOOLS FOR TIGHTENING BY HYDRAULIC TENSIONING.

The hydraulic bolt tensioning cylinders are described as tools for tightening by means of hydraulic pull as they tighten the screw without any interference fit stress (friction or torsion).

The operating principle of the hydraulic bolt tensioning cylinder (tensioning method) is briefly explained, along with its advantages, and compared to tightening with a conventional torque.

The use of the tensioning method allows for large tightening reproducibility from one screw to the other (tolerance close to ±2, 5%).

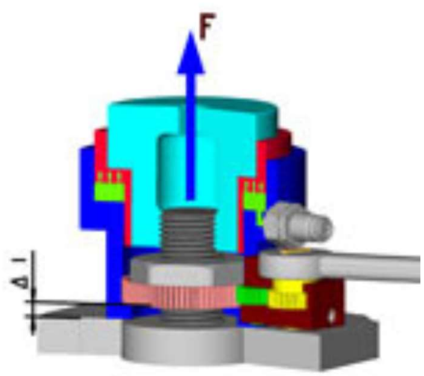


The hydraulic bolt tensioning cylinder is placed on the external thread (passing above the nut).

Positioning the hydraulic bolt tensioning cylinder on the screw

The hydraulic pressure is provided by a hydraulic power pack pulls on the screw without exerting any torsional or frictional stress.

There is a linear relationship between the hydraulic pressure transmitted to the hydraulic bolt tensioning cylinder and the tension force of the screw, thereby ensuring a high degree of precision.



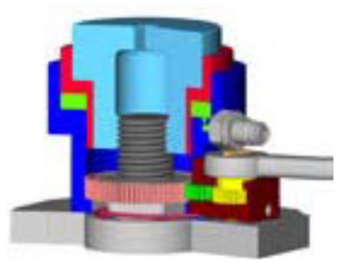
Drawing of the screw

Once the required pressure has been reached, the nut is put in contact with the bearing surface, without any frictional stress, using a hand torque wrench.

Thanks to this principle, and in the absence of all interference fit stress (torsion and friction), it is possible to tighten screws up to 98% of the elastic limit.

Place the hydraulic bolt tensioning cylinder on the screw, using a spanner wrench or an electric screwdriver. When the selected hydraulic pressure has been reached, the screw is pulled without any frictional or torsional stress.

Place the nut on the contact surface using a spanner wrench. The screw is tight.



Positioning the nut

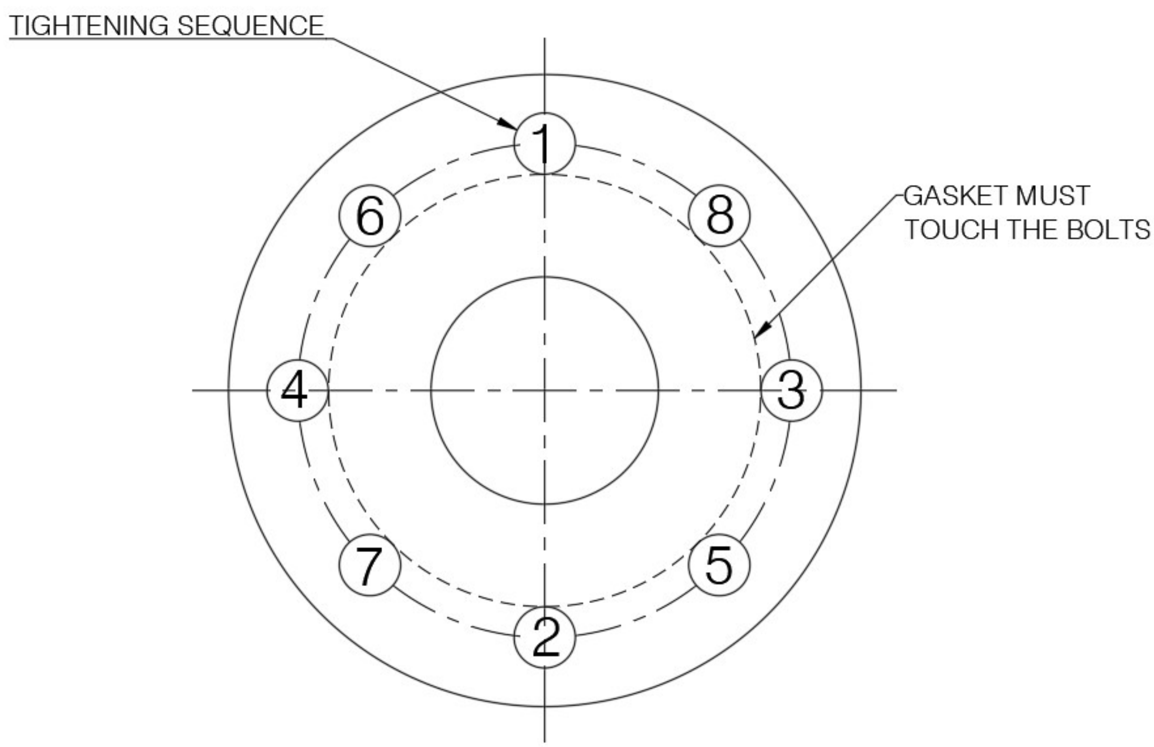
Advantages:

- Great tightening force achieved with small sized tools (Thread W 510 or M340: 45,000 kN)
- No torsional stress in the screw
- Only tensile stress in the screw
- Tightening of several screws simultaneously (multi-tensioning system)
- A hydraulic bolt tensioning cylinder can be used for several screw sizes.
- Perfect use for stainless steel as there is no risk of cold junction (seizing) of the thread.
- The sealing surfaces, subject to high temperatures (example: in gas turbines), can be disassembled even after long periods of time.
- The linear relationship between the tension force of the hydraulic bolt tensioning cylinder and the hydraulic pressure, ensures significant reproducibility.

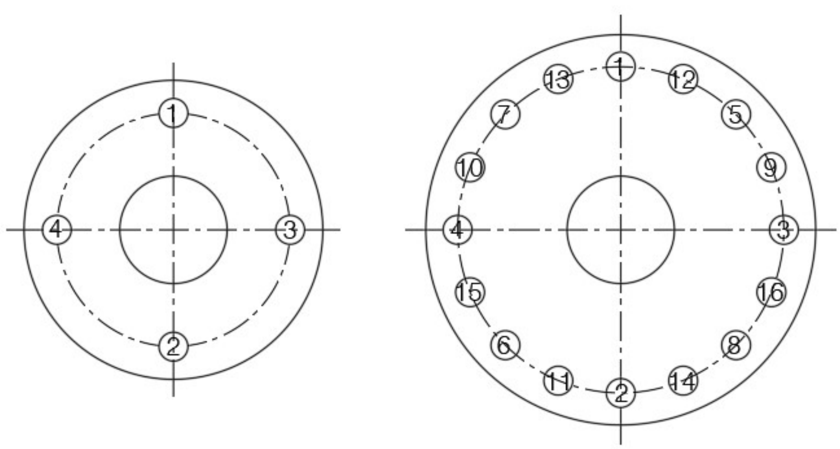
4.2.1. INSTALLING A NEW GASKET

- Visually examine and clean the flanges, the bolts, the nuts and the washers
- Lubricate the bolts and the nuts.
- Make sure that the gasket is in accordance with the characteristics (type, material, ND, the class…)
- Install the gasket and the bolts; use your hands to tighten the nuts and examine the space to ensure the uniformity.

- Pre-tighten the nuts to a torque of 10/20 ft.lbs, do not exceed 20 % of the end Torque.
- Proceed to the final tightening using the model below, while tightening in the indicated order and checking each of the bolts
- Retighten after 24h or with every rise in temperature of the pipe.



Tightening sequence of the bolts



Tightening sequence for various types

4.2.2. THE MAIN FITTING USED

Name	Description and use
Fitting	A male and female fitting which connects two straight pipes
Union	A female fitting which can be unscrewed
Elbow (angle of 45° or 90°)	Used to change the direction of a pipe
Sleeve	With a different internal and external thread. It joins one pipe to another, smaller pipe
Tee (T)	Joins 3 pipes together in a T
Y gasket	Joins 3 pipes together in a Y
Cross / + gasket	Joins 3 pipes together in a +
Plug	Solid male thread to temporarily (un)plug a pipe
Cap	Solid plug with internal thread to temporarily (un)plug a pipe
Nipple	A male fitting of a small section often used to fit other fittings
Reducing sleeve	Serves to reduce the diameters of a pipe

5. GASKETS

5.1 THE VARIOUS TYPES

Gaskets can be classified into three large families which comprise:

- The soft gasket
- The metallic gaskets
- The metal-asbestos gaskets

Remark:

- Gaskets containing asbestos are prohibited.
- Flat gaskets in PTFE (Polytetrafluoroethylene) or containing PTFE are not accepted.
- Graphite-impregnated flat gaskets must not be used with anticorrosion alloys when they used in contact with salt water.

5.1.1 SOFT GASKETS

- The most used are soft fibrous gaskets composed of a mixture of elastomers.
- The elastomer provides the mechanical resistance.
- To improve the mechanical resistance, a very fine metal screen can be imbedded in the middle during manufacturing.
- Numerous elastomers can make up the composition of these gaskets: Viton, rubber …
- Some gaskets are coated with PTFE.

Soft gasket

- Synthetic rubber gaskets

  Thickness:

  3mm for NPS < 6”
  5mm for NPS > 8”

Synthetic rubber gasket

- Synthetic fibre gaskets (klinger type)

  Must be impregnated with a non-stick coating on both faces.

5.1.2 METALLIC GASKETS

They are used for operating conditions with very severe pressures and temperatures.

There are three main types:

- The ring type joints RTJ with oblong or trapezoidal section.
- The flat gaskets: smooth, ribbed or corrugated.
- The slim corrugated gasket with or without packing.
- The lens-shaped gaskets

Their low elasticity demands evenly distributed tightening (tightening sequence of the heads, extent of their pull during tightening, flatness, and alignment of the flanges).

Otherwise, occurrence of a leak is highly probable.

- Spiral wound gaskets
- The spiral part must be made of stainless steel.
- The fitting can be made of a material based on PTFE or graphite, with a corrosion inhibitor.
- The two rings are made of epoxy-coated carbon steel or in stainless steel.

Spiral wound gasket

- Ring joint gaskets

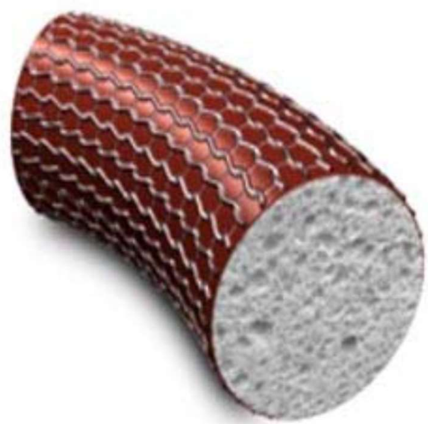
  The section can be oval or octagonal shaped.

  The gaskets must have a hardness (HB) < to the flanges in order to guarantee a tight sealing.

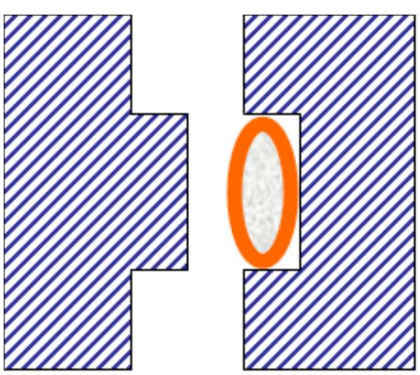
Ring joint gaskets

5.1.2.1. THE METAL-ELASTOMER GASKETS

A metal covering (copper, aluminum, stainless steel …) coats an elastomer compound forming the gasket core.



Metal-elastomer gasket



When placed in a groove, these gaskets must have the crimped side facing the bottom of the groove.

Positioning a metal-elastomer gasket

5.1.3 USING GASKETS.

The gaskets must be fully adapted to the operating conditions (diameter, series, and quality).

The gaskets are **not reusable** with exception of some metallic gaskets which can be reused provided they are not deformed or scratched.

The flange faces must not have deteriorations such as: scratches, corrosion, substantial pitting …

The gaskets must be perfectly centered between the flanges.

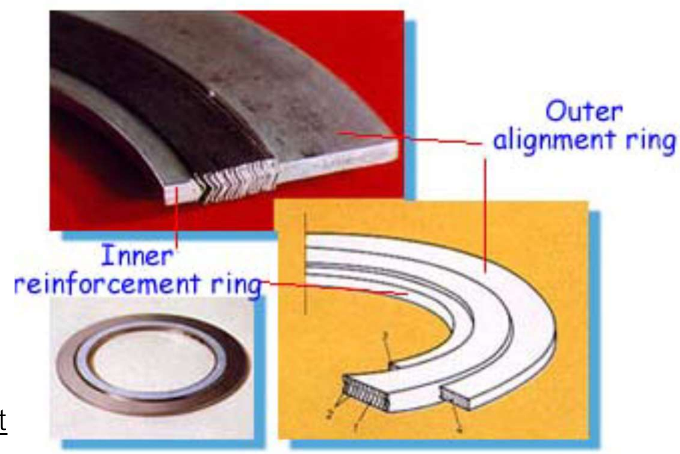
The tightening technique must ensure regular gradual squeezing over the whole surface of the gasket.

The metal coverings are sensitive to various types of corrosion. It is good to verify the state of the gaskets after use.

A strip, of PTFE, expanded graphite and ceramic fibers is wound in a spiral together with a metal strip in the form of a V. This type of gasket is called a spiral wound gasket.

When used with raised face flanges, they are fitted with an outer alignment ring.

To prevent the metal spiral from deteriorating on the fluid side, they can be equipped with an internal ring.



Gasket with inner reinforcement and alignment

Type of material according to the fuel

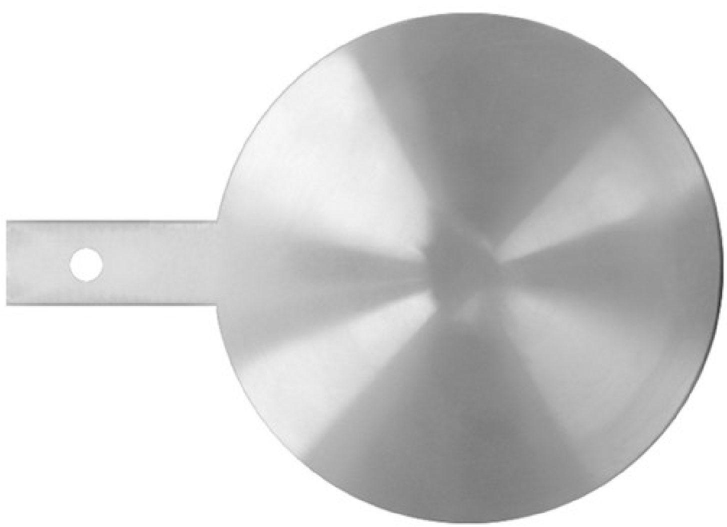
FLUID	MATERIAL
WATER	RUBBER
COLD OIL	NEOPRENE
HOT OIL	INGOT IRON
LOW TEMPERATURE GAS	RUBBER
HIGH TEMPERATURE GAS	ELASTOMER
ACIDS	METAL RESISTANT TO CORROSION

5.2 BLINDS

5.2.1 THE VARIOUS TYPES

5.2.1.1 FLUSH JOINTS

They are simple metal discs with a tail and are inserted in case of need.



5.2.1.2 THE REVERSIBLE BLINDS

The spectacle blinds are permanently installed.

In open position they let the fluid pass; in closed position they stop the circulation.

They are placed between two flanges.

5.2.1.3 BLIND FLANGES

Blind flanges are installed to close the ends of the pipes, the valves, or the equipment.

The bolts pass through the blind flanges and the equipment flanges.

After the placing of a gasket the bolts must be tightened according to specifications.

ATTENTION

FLANGES, GASKETS AND BOLTING MUST CORRESPOND TO THE CLASS OF THE INITIAL FLANGE

5.2.2 GASKET BRACKETS

The pipes are submitted to stress from:

- Their own weight
- Vibrations
- Dilatation

It is therefore imperative that they be supported to maintain the network in good operating condition.

The various types of brackets:

- Fixed clamp type, or well welded
- Gliding bracket, permitting a liberty to move in an axis, or a design to permit the dilatation of the pipe.
- Special bracket of a spring box type

5.3 ADVANTAGES AND DRAWBACKS OF THE VARIOUS TYPES

5.3.1. CARBON STEEL

Advantages:

- Price of the raw material
- Easy to weld.
- Good resistance to pressure

Drawbacks:

- Sensitive to corrosion

5.3.2. STAINLESS STEEL

There are various qualities of stainless steel; example: 304/ 316 / 316L

The 304 being at the bottom-of-the-line; used in places which demand a simple corrosion protection.

The more sophisticated 316L is used in more corrosive sectors.

The numbers correspond with the various percentages of Nickel which are employed during manufacturing.

Advantages

- Resists corrosion.

Drawbacks

- Difficult to weld.
- Galvanic cell formation with the carbon steel from the structures
- Price

5.3.3. SYNTHETIC MATERIALS

Advantages

- Corrosion resistant
- Lightness
- Easy to apply.
- Does not need hot working (except for some thermoplastic components)

Drawbacks

- Hardly withstands pressure.
- Fragile to shock
- Poor fire resistance

6. REPRESENTATION AND DATA

This chapter describes …

6.1. TUBES OR PIPES

6.1.1. PIPE CLASSIFICATION

Networks are classified as process or service lines.

Service pipes transport water, steam, gas and air which is needed for the process utility systems.

Most of the pipes are color-coded.

The transported fluid is identified by the color and the code.

For example, the pipe which transports the water for the fire-fighting facilities is usually painted red and is also identified with white lettering.

6.1.2. PIPE IDENTIFICATION PRINCIPLE ACCORDING TO TOTAL SPECS

The class is identified by a code, composed of 1 letter and 3 numbers

Example:

- B 511

B ⇒ Class = 150 lbs (pounds or 1lbs is equal to 453 gr) ASME class

51 ⇒ Liquid or hardly corrosive gas hydrocarbons

1 ⇒ Corrosion thickness = 1.5 mm

Classes:

A	B	C	D	E	F	G	H	J
125	150	300	600	900	1500	2500	TUBING	10 000

Corrosion thicknesses:

- 0 ⇒ 0.0 mm
- 1 ⇒ 1.5 mm
- 2 ⇒ 3.0 mm
- 3 ⇒ 6.0 mm

Material Property	Letter Color on Field Color	Example
Single Gases		
Oxygen USP†	White on Green	OXYGEN 50-55 PSI
Carbon Dioxide†	White on Gray	CARBON DIOXIDE
Nitrous Oxide†	White on Blue	NITROUS OXIDE
Cyclopropane‡	Black on Orange	CYCLOPROPANE
Helium USP†	White on Brown	HELIUM 50-55 PSI
Nitrogen NF†	White on Black	NITROGEN 160-200 PSI
Medical Air USP†	Black on Yellow	MEDICAL AIR
Instrument Air†	White on Red	INSTRUMENT AIR
Waste Anesthetic Gas Disposal†	White on Purple	WASTE ANESTHETIC
Laboratory Air†	Black on White/Yellow Checkerboard	LABORATORY AIR
Laboratory Vaccum†	Black on Black/White Checkerboard[2]	LABORATORY VACUUM
Medical-Surgical Vaccum†	Black on White	MEDICAL VACUUM

FRESH WATER *(blue)*

- Fresh Water
- Condensate from heating system
- Fresh water - sanitary
- Cooling fresh water
- Feed water
- Distillate
- Potable water
- Chilled water
- Condensate

WASTE MEDIA *(black)*

- Waste media
- Black water
- Waste oil
- Bilge water
- Exhaust gas
- Sewage

OILS OTHER THAN FUEL *(orange)*

- Waste media
- Black water
- Waste oil
- Bilge water
- Exhaust gas
- Sewage

STEAM *(silver)*

- Steam
- Steam for heating
- Bleeder steam
- LP drains
- Supply steam
- Exhaust steam
- HP drains

MASSES (DRY & WET) *(copper)*

- Masses

ACIDS AND ALKILIS *(violet)*

- Acids and Alkilis

FLAMMABLE GASES *(yellow)*

- Flammable gases
- Hydrogen
- Acetylene
- Mixture of Propane/Butane

NON-FLAMMABLE GASES *(gray)*

- Non-flammable gases
- Oxygen
- Breathing Gas
- Nitrogen
- Refrigerant
- Pressure air HP
- Breathing air

FIRE FIGHTING *(red)*

- Fire fighting
- Fire-fighting fresh water
- Fire-fighting sea water
- Fire-fighting CO2 gas
- Sprinkler water
- Fire-fighting powder
- Fire-fighting foam

FUEL *(brown)*

- Fuel
- Heavy fuel
- Liquid gas
- Petrol
- Diesel fuel

SEA WATER *(green)*

- Sea water
- Ballast water
- Cooling sea water
- Sanitary sea water

AIR IN VENTILATION SYSTEMS *(white)*

- Air in ventilation systems
- Natural exhaust air
- Supply air, atmospheric
- Natural supply air
- Mechanical exhaust air

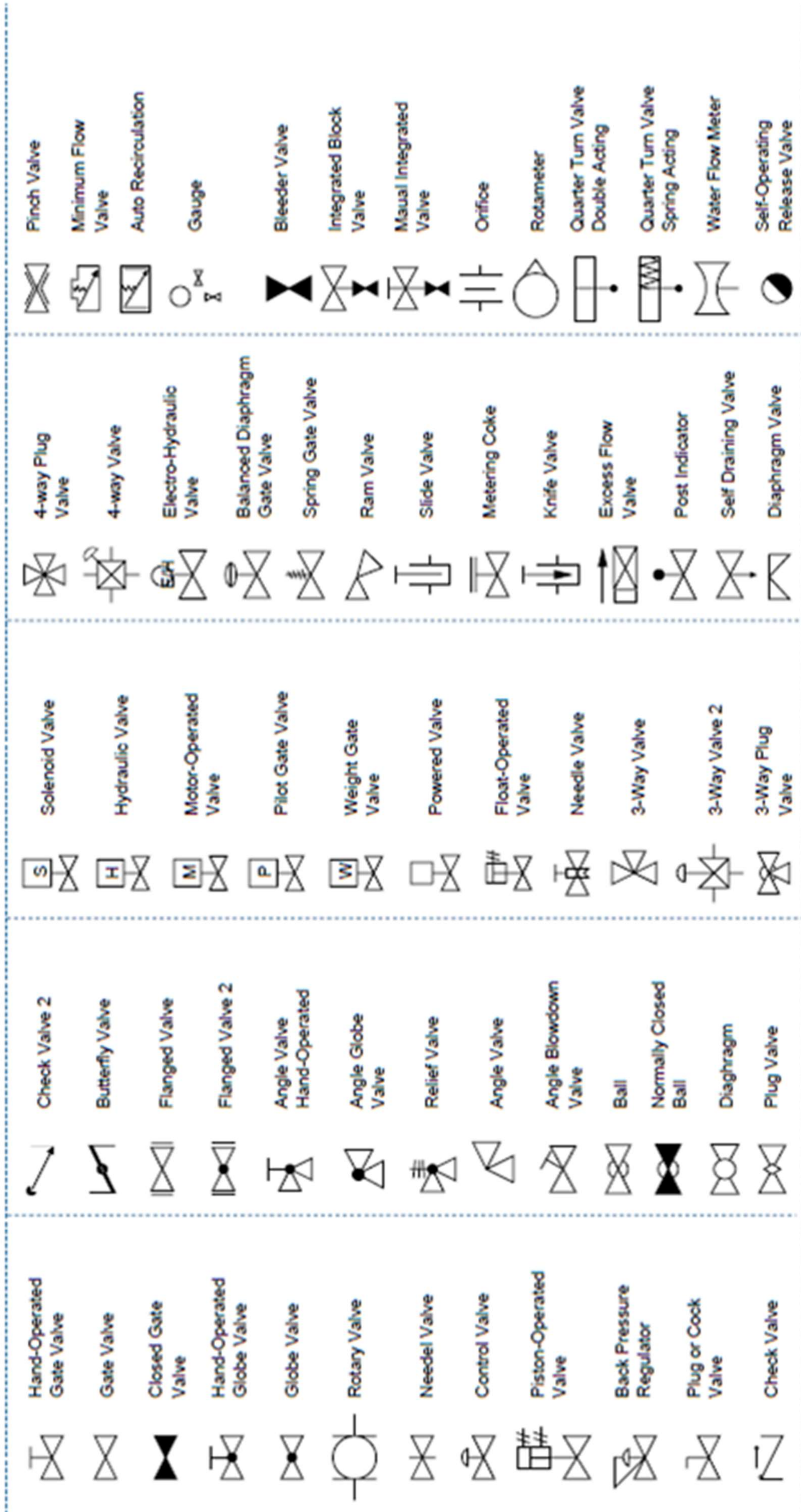
6.2. REPRESENTATION ON P&ID

To be able to read the various documents at our disposal on the oil sites, especially concerning the piping, it is necessary to KNOW how to recognize and interpret the symbols, lines and other information found on the PFD and P&ID.

A PID (Piping & Instrumentation Diagram) usually offers a minimum amount of information on the pipe (this is especially important when making modifications to the lines)

- The pipelines with their symbols
- The valves with their system for opening and closing.
- The plugs

Valves


Hand-Operated Gate Valve
Gate Valve
Closed Gate Valve
Hand-Operated Globe Valve
Globe Valve
Rotary Valve
Needel Valve
Control Valve
Piston-Operated Valve
Back Pressure Regulator
Plug or Cock Valve
Check Valve
Check Valve 2
Butterfly Valve
Flanged Valve
Flanged Valve 2
Angle Valve Hand-Operated
Angle Globe Valve
Relief Valve
Angle Valve
Angle Blowdown Valve
Ball
Normally Closed Ball
Diaghragm
Plug Valve
S
Solenoid Valve
H
Hydraulic Valve
M
Motor-Operated Valve
P
Pilot Gate Valve
W
Weight Gate Valve
Powered Valve
Float-Operated Valve
Needle Valve
3-Way Valve
3-Way Valve 2
3-Way Plug Valve
4-way Plug Valve
4-way Valve
E-H
Electro-Hydraulic Valve
Balanced Diaphragm Gate Valve
Spring Gate Valve
Ram Valve
Slide Valve
Metering Coke
Knife Valve
Excess Flow Valve
Post Indicator
Self Draining Valve
Diaphragm Valve
Pinch Valve
Minimum Flow Valve
Auto Recirculation
Gauge
Bleeder Valve
Integrated Block Valve
Maual Integrated Valve
Orifice
Rotameter
Quarter Turn Valve Double Acting
Quarter Turn Valve Spring Acting
Water Flow Meter
Self-Operating Release Valve

Symbol Name	Symbol
One to Many	
Multi-lines	
Mid-arrow	
Butt Weld	×
Sonic Signal	
Nuclear	
Pneumatic	//
Hydraulic Signal line	L
Mechanical Link	●
Soldered/Solvent	○
Flange	
Rotary Valve	

Symbol Name	Symbol
End Cap	
End Cap 2	
Breather	
Electronically Insulated	
Reducer	
In Line Mixer	
Separator	
Bursting Disc	
Flame Arrester	F
Detonation Arrester	D
Drain Silencer	
Triangle Separator	

Symbol Name	Symbol
Tundish	
Open Vent	
Siphon Drain	
Removable Spool	
Y Type Strainer	
Diverter Valve	
Pulsation Dampener	
Duplex Strainer	
Basket Strainer	
Vent Silencer	S
Inline Silencer	S
Steam Trap	T
Eject or Eductor	

6.3. DIMENSIONING

6.3.1. THE DIMENSIONING CRITERIA

The dimensioning of a pipe and of the associated elements is determined by what it will be used for (flow rate, velocity, pressure, location)

There are formulas which provide the correct dimensions.

Efforts are made not to oversize the tubes because of problems with weight, price and excessive thickness.

6.3.2. DIMENSIONS OF THE PIPES

Pipe dimensions are standardized in inches and also in the metric system.

The most used are the measurements in inches:

½”	¾”	1”	1½”	2”	4”	6”	8”	10”	12”	14”
16”	18”	20”	24”	30”	36”	42”	48”	56”	60”	64”

Example :

A pipe with a nominal pipe size of 4” (100 mm) is available in the thicknesses and diameters below:

OUTER DIAMETER IN mm	INTERIOR DIAMETER IN mm	THICKNESS IN mm	SCHEDULE
114.3	102.3	6.00	40
114.3	97.2	8.55	80
114.3	87.3	13.50	160

Various thicknesses of a 4” carbon steel pipe

IMPORTANT: For each material the Schedule changes

After construction and assembly, the pipes are submitted to a radiographic check of the weldings and a hydrostatic test.

The tests may be conducted on part or all of the network in compliance with the specifications.

To consider the corrosive or erosive effect of the fluids, a supplemental thickness, called a corrosion allowance, is generally defined at 1.5 mm for slightly corrosive services or 3mm for the other services.

Nominal Pipe Size		Outside Diameter (mm)	Nominal Wall Thickness Schedule																
NPS	DN	OD	SCH 5s	SCH l0s	SCH 10	SCH 20	SCH 30	SCH 40s	SCH STD	SCH 40	SCH 60	SCH 80s	SCH XS	SCH 80	SCH 100	SCH 120	SCH 140	SCH 160	SCH XXS
1/8	6	10.3		1.24				1.73	1.73	1.73		2.41	2.41	2.41					
1/4	8	13.7		1.65				2.24	2.24	2.24		3.02	3.02	3.02					
3/8	10	17.1		1.65				2.31	2,31	2.31		3.20	3.20	3.20					
1/2	15	21.3	1.65	2.11				2.77	2.77	2.77		3.73	3.73	3.73				4.78	7.47
3/4	20	26.7	1.65	2.11				2.87	2.87	2.87		3.91	3.91	3.91				5.56	7.82
1	25	33.4	1.65	2.77				3.38	3.38	3.38		4.55	4.55	4.55				6.35	9.09
1 1/4	32	42.2	1.65	2.77				3.56	3.56	3,56		4.85	4.85	4.85				6.35	9.70
1 1/2	40	48.3	1.65	2.77				3.68	3.68	3.68		5.08	5.08	5.08				7.14	10.15
2	50	60.3	1.65	2.77				3.91	3.91	3.91		5.54	5.54	5.54				8.74	11.07
2 1/2	65	73	2.11	3.05				5.16	5.16	5.16		7.01	7.01	7.01				9.53	14.02
3	80	88.9	2.11	3.05				5.49	5.49	5.49		7.62	7.62	7.62				11.13	15.24
3 1/2	90	101.6	2.11	3.05				5.74	5.74	5.74		8.08	8.08	8.08					
4	100	114.3	2.11	3.05				6.02	6.02	6.02		8.56	8.56	8.56		11.13		13.49	17.12
5	125	141.3	2.77	3.40				6.55	6.55	6.55		9.53	9,53	9.53		12.70		15.88	19.05
6	150	168.3	2.77	3.40				7.11	7.11	7.11		10.97	10.97	10.97		14.27		18.26	21.95
8	200	219.1	2.77	3.76		6.35	7.04	8.18	8.18	8.18	10.31	12.70	12.70	12.70	15.09	18.26	20.62	23.01	22.23
10	250	273.1	3.40	4.19		6.35	7.80	9.27	9.27	9.27	12.70	12.70	12.70	15.09	18.26	21.44	25.40	28.58	25.40
12	300	323.9	3.96	4.57		6.35	8.38	9.53	9.53	10.31	14.27	12.70	12.70	17.48	21.44	25.40	28.58	33.32	25.40
14	350	355.6	3.96	4.78	6.35	7.92	9.53		9.53	11.13	15.09		12.70	19.05	23.83	27.79	31.75	35.71	
16	400	406.4	4.19	4.78	6.35	7.92	9.53		9.53	12.70	i6.66		12.70	21.44	26.19	30.96	36.53	40.49	
18	450	457.2	4.19	4.78	6.35	7.92	11.13		9.53	14.27	19.05		12.70	23.83	29.36	34.93	39,67	45.24	
20	500	508	4.78	5.54	6.35	9.53	12.70		9.53	15.09	20.62		12.70	26.19	32.54	38.10	44.45	50.01	
22		559	4.78	5.54	6.35	9.53	12.70		9.53		22.23		12.70	28.58	34.93	41.28	47.63	53.98	
24	600	610	5.54	6.35	6.35	9.53	14.27		9.53	17.48	24.61		12.70	30.96	38.89	46.02	52.37	59.54	
26		660			7.92	12.70			9.53				12.70						
28	700	711			7.92	12.70	15.88		9.53				12.70						
30		762	6.35	7.92	7.92	12.70	15.88		9.53				12.70						
32	800	813			7.92	12.70	15.88		9.53	17.48			12.70						
34		884			7.92	12.70	15.88		9.53	17.48			12.70						
36	900	914			7.92	12.70	15.88		9.53	19.05			12.70						
38		965							9.53				12.70						
40	1000	1016						9.53		12.70									
42		1067				12.70	15.88		9.53	19.05			12.70						
44	1100	1118							9.53				12.70						
46		1168							9.53				12.70						
48	1200	1219							9.53			12.70							

6.3.3. CHOICE AND PRINCIPLE OF CHANGING THE CLASS

The choice of the pipes, flanges and gaskets is made during the engineering phase.

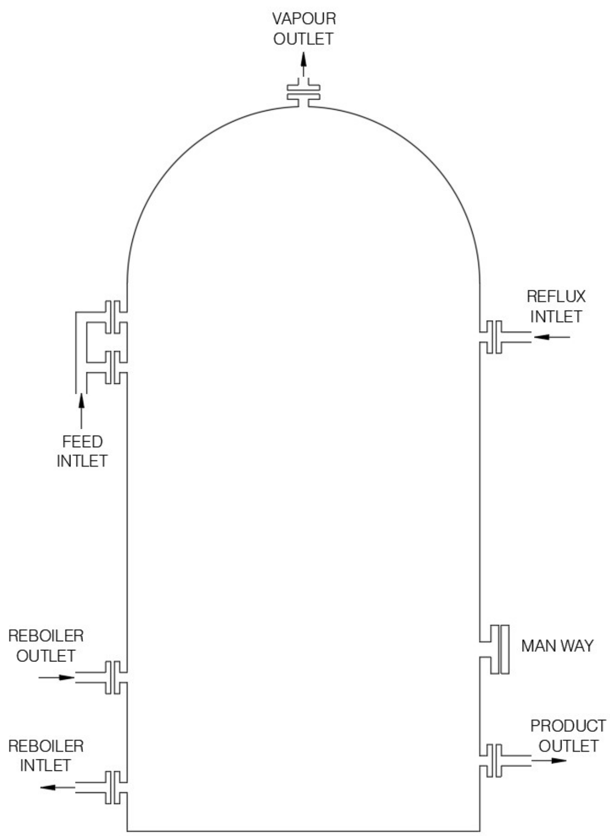
Starting from the wellhead we find a series of pipes destined for high pressure; depending on the equipment that is found downstream, the series will evolve towards much more conventional one.

7. PIPING OPERATIONS

The operator has a certain number of responsibilities, especially when concerning interventions on lines or equipment.

He is responsible for the observance of the isolation procedures before all work.

In addition to his knowledge of the site, he must, during start-up or shutdown, sign a document specifying the positions and the types of blinds which have been placed for works.



Example of blinding

Before and afterwards, he must ABSOLUTELY verify the list of blinds.

He has the following document at his disposal:

Process Line	Blind in operator initials	Blind out operator initials
Feed inlet (1)		
Feed inlet (2)		
Reboiler outlet		
Reboiler inlet		
Vapour inlet		
Product inlet		

<u>Document with positions of the blinds</u>

7.1. PRECAUTIONS BEFORE START-UP

Before signing the blind removal list the operator must:

- Ensure that the whole of the work is finished.
- Check the inside of the storage capacity to see if everything is clean and free of all waste.
- Check that all the blinds have been removed.
- Check that the new gaskets have been installed.

It is also necessary to clean the inside of the pipe to eliminate the debris or other waste which could be found inside, either by blowing or by rinsing.

The leak tests help check the pipe sealing by increasing the pressure in the pipe usually to 1.5 times the design pressure (providing the pipe has been calculated for such a pressure).

7.2. PRECAUTIONS TO TAKE BEFORE SHUTDOWN OR INTERVENTIONS

- Depressurization
  Before any intervention, it is imperative to depressurize the pipes; an intervention on a pressurized pipe must in NO CASE be attempted.
- Drainage
  Thoroughly verify the drainage at the low points.
- Inserting
  Necessary for any intervention on the line (opening of a flange, replacement of a gasket)

Notes: Embrittlement problems on a line require specific precautions.

In case of welding, verify the residual thickness of the pipe, (see chapter corrosion)

7.3. 1st DEGREE MAINTENANCE

Pipes are usually not submitted to preventive maintenance as are safety valves and other equipment. As we have seen they are nevertheless subjected to corrosion or shocks which sometimes damage a part of the line.

In this case the intervention is obligatory and the actions to be carried out are even the more dangerous as the transported fluid is either a gas, or a fluid under pressure or temperature.

The type of intervention on a pipe is either a temporary light repair (fiber glass, collars, or insulation) or a heavy reparation, demanding welding or other technical intervention.

Maintenance consists of:

- Monitoring the sealing (check the tightening of the flanges)
- Outer protection with paint
- Monitoring of internal corrosion (measurement of the thickness with ultrasound, corrosion coupon)

8. TROUBLESHOOTING

8.1. PIPING PROBLEMS

8.1.1. EXTERNAL CORROSION

Corrosion is the deterioration of a substance due to a chemical reaction to its environment.

The substance does not necessarily have to be a metal. Wood, ceramics, plastic and other materials can also be corroded.

If a material becomes corroded its properties will change and it will no longer correspond to its characteristics.

Generally speaking, no corrosion occurs in a vacuum.

- Salt water is more corrosive than soft water.
- Hot water is more corrosive than cold water.
- Hot air is more corrosive than cold air. (if T° C < 80 °C)
- Humid air is more corrosive than dry air.

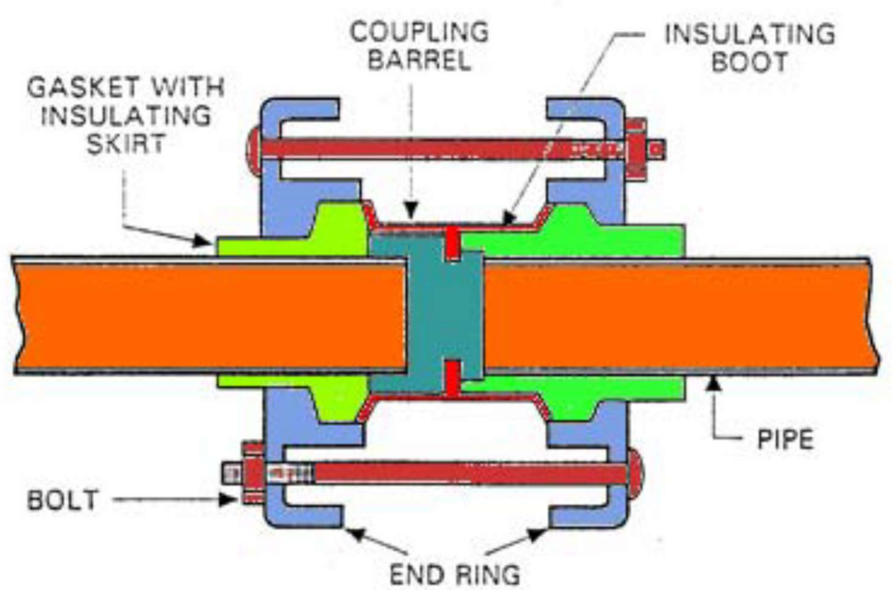
- Polluted air is more corrosive than clean air.
- Acids are more corrosive than alkaline compounds.

Important, this information consists of generalities which must be checked according to the sites!

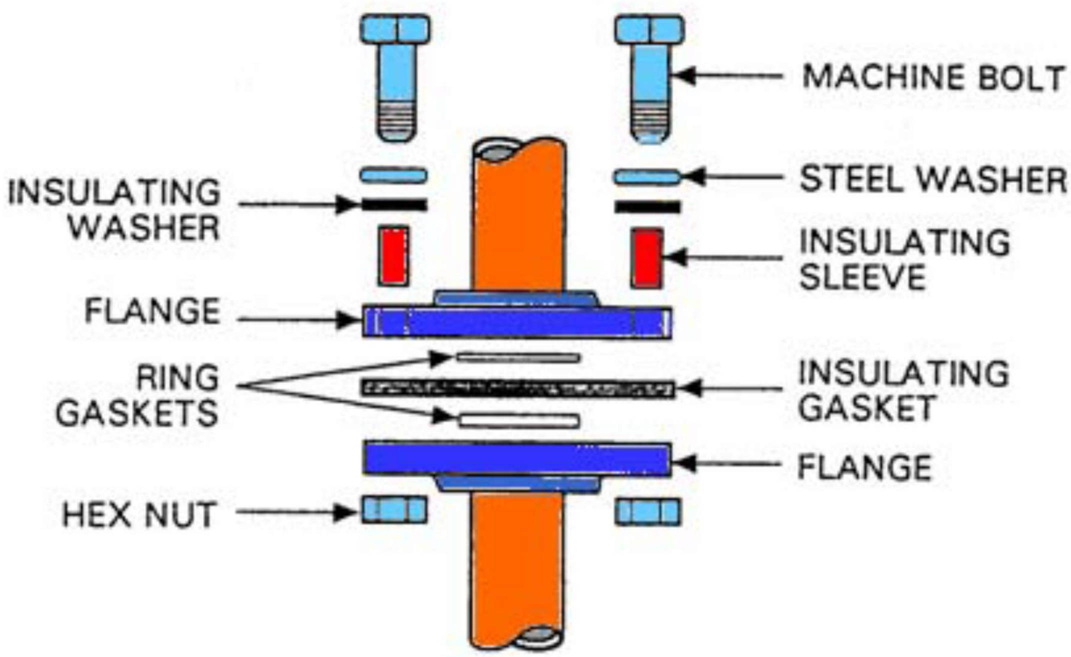
Most of the corrosion which develops on the metals is electrochemical. This corrosion can develop on the inside or outside of a piece of metal equipment.

To protect our equipment, various solutions are placed on or in the pipes.

The pipes deteriorate mainly because of corrosion and erosion.



Coupling of insulated pipes



Insulator for flanges

Protective coatings can also be used to protect the systems. The outside of the pipe can be painted with special protective paints.

Special coatings are usually used on the subterranean systems. Plastics and epoxy are some of the newest coatings used for protection against corrosion.

8.1.2. INTERNAL CORROSION

Piping networks and static equipment can be affected by both external and internal corrosion.

It is much more difficult to detect the internal corrosion. It can decompose the inner surface causing a corrosion accumulation.

To eliminate internal corrosion, or to slow down its progression, special coatings are used.

Certain chemicals are also used and injected into the pipes in order to inhibit the action of the corrosion or other fluids.

In case of internal corrosion, it is vital to eliminate the source of the corrosion and to determine the extent of the problem, allowing adapted repair.

Wear is greatest at the elbows owing to liquid friction from the changes in direction at the low part of their section.

8.1.3. OTHER CAUSES OF DETERIORATION

It is dangerous, because of risks of rupture:

- To use a pipe as support without careful consideration
- To exert a force on small-diameter pipes
- To walk on a pipe

Furthermore, walking on a pipe constitutes a dangerous act (fall, deterioration of the insulation materials of the heat-proof pipes).

Finally, leaks from petroleum products comprise risks. It is prudent to foresee clamp collars of various diameters to rapidly seal a leak.

Take into account the corrosion to the support-flanges, thermal insulation and welded tapping.

They are actually zones where the corrosion spreads due to the friction or the movements of the pipes.

8.1.4. PROTECTIONS

There are three main types of protection.

- Thermal protection
- Personnel protection
- Protection against shocks

The piping receives:

- A cathodic protection, when the nature of the environment suggests a corrosive action because of an electrolysis effect.
- A thermal insulation, when it transports hot substances (heat reduction, protection against fire and the burning).
- An electrical continuity between flanges (put in the ground).
- A corrosion-protective covering and an outer paint (traditional shades).

8.2. NOTES