

BASIC CONCEPT OF PIPING ENGINEERING

N.RAMAKRISHNA



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PIPING DESIGN FUNCTION IN ORGANIZATION

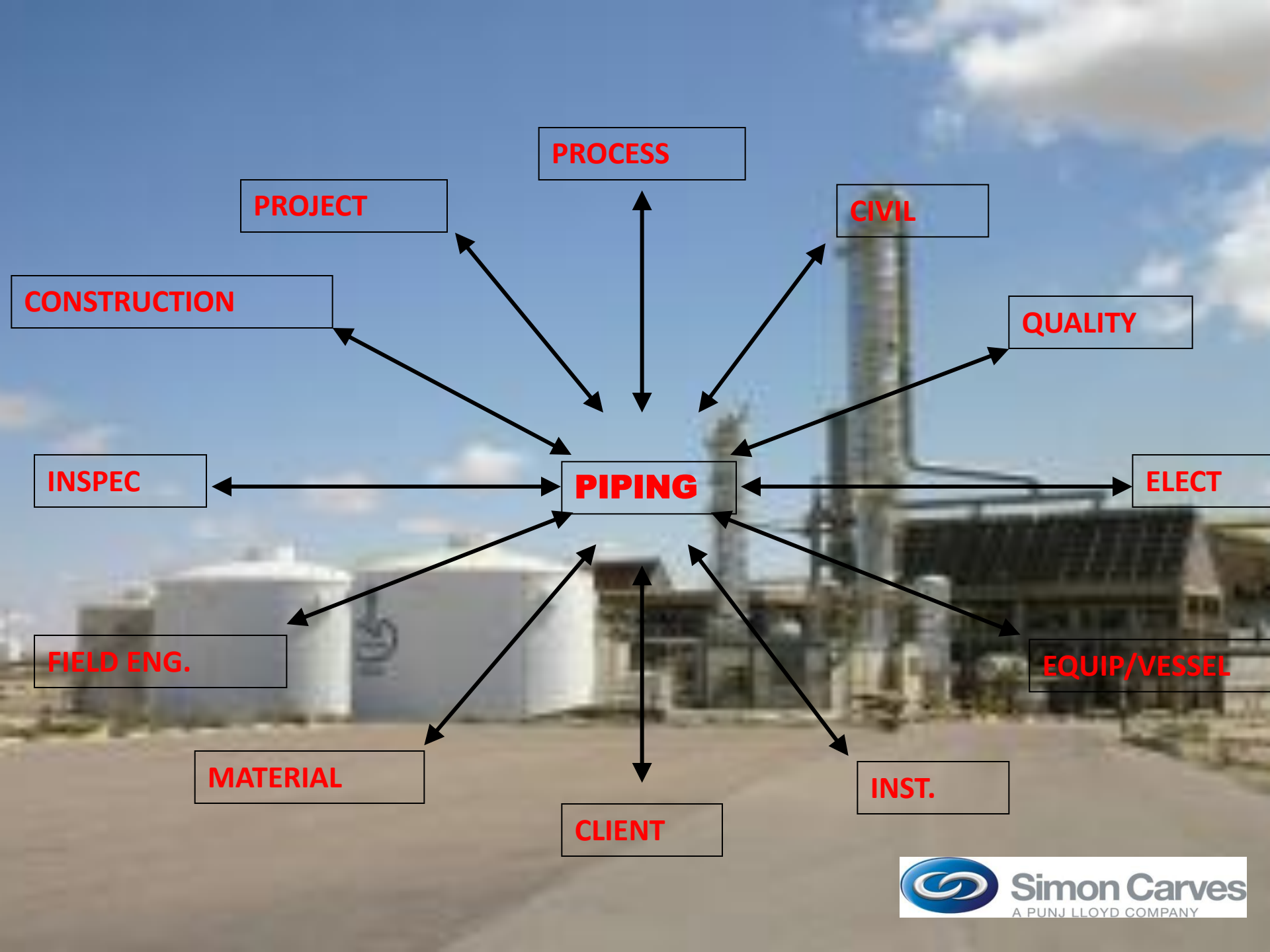
The size and scale of company or design office do not change either the basic piping design requirements or the underlying design principles and practices.

As the volume of piping design work and the number of projects executed increases, so also does the degree of specialization increase.

Functions such as Piping layout, Piping Specifications, Detail Drafting, 3D Modeling and Material Take Off (MTO) emerges as separate departments within the design office.



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PIPING

PIPING includes pipe, flanges, fittings, bolting, gasket, valves and the pressure containing portion of other piping components. It also includes Pipe hangers and supports and other items necessary to prevent over-pressurization and over stressing of the pressure-containing components. When the pipe sections joined with fittings, valves and other mechanical equipment and properly supported by supports are called **PIPING**.

PIPE Pipe having round cross section confirming to the dimensional requirement according to

- ASME B 36.10 Welded and Seamless Wrought Steel Pipe
- ASME B 36.19 Stainless Steel Pipe

PIPE SIZE

Initially a system known as **Iron Pipe Size (IPS)** was established to designate the pipe size. Size represents the approx. inside dia. Of pipe in inches. In the beginning each pipe size was produced to have one thickness, which later was termed as **Standard (STD)** or **Standard Weight(STD WT.)**

As the industrial requirements demanded the handling of higher-pressure fluids, pipes were produced having thicker wall, which came to be known as **Extra Strong (XS)**, **double extra strong (XXS)** walls while the standardized out side diameters are unchanged

PIPE SIZE Con.

With the development, stronger and corrosion-resistance piping materials, the need for thinner wall pipe resulted in new method of specifying pipe size and wall thickness. The designation known as **Nominal pipe Size (NPS)** replaced **IPS** term **schedule (SCH)** was invented to specify the nominal wall thickness of pipe.

Nominal pipe Size (NPS) is a dimensionless designator of pipe size. It indicates standard pipe size when followed by the specific size designation number without an inch symbol. The NPS 12 and small pipe has out side diameter greater than the size designator. However, the outside diameter of NPS14 and large pipe is the same as the size designator in inch.

Diameter Nominal (DN) is also a dimensionless designator of pipe size in the metric unit system, developed by the International Standards Organization (ISO). It indicates standard pipe size when followed by the specific size designation number.



PIPE SIZE Cont.

Pipe Size Designators NPS and DN

NPS	DN	NPS	DN	NPS	DN	NPS	DN
1/8	6	3 1/2	90	22	550	44	1100
1/4	8	4	100	24	600	48	1200
3/8	10	5	125	26	650	52	1300
1/2	15	6	150	28	700	56	1400
3/4	20	8	200	30	750	60	1500
1	25	10	250	32	800	64	1600
1 1/4	32	12	300	34	850	68	1700
1 1/2	40	14	350	36	900	72	1800
2	50	16	400	38	950	76	1900
2 1/2	65	18	450	40	1000	80	2000
3	80	20	500	42	1050		

For sizes larger than NPS 3, determine the DN equivalent by multiplying NPS by 25

- **Components include ...**

1. Pipes

2. Fittings

3. Flanges

4. Gaskets

5. Bolting

6. Valves



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CODE

A group of general rules or systematic procedures for design, fabrication, installation and inspection prepared in such a manner that it can be adopted by legal jurisdiction and made into law.

STANDARDS

Documents prepared by a professional group or committee which are believed to be good and proper engineering practice and which contain mandatory requirements.



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RECOMMENDED PRACTICES

Documents prepared by professional group or committee indicating good engineering practices but which are optional. Companies also develop Guides in order to have consistency in the documentation. These cover various engineering methods which are considered good practices, without specific recommendation or requirements.

Codes and standards as well as being regulations, might be considered as “design aids” since they provide guidance from experts. Each country has its own Codes and Standards. On global basis, American National Standards are undoubtedly the most widely used and compliance with those

requirements are accepted world over. In India, other than American Standards, British Standards and Indian Standards are also used for the design and selection of equipment and piping systems.



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MAJOR ORGANIZATION FOR STANDARDS

<u>Sr. No.</u>	<u>Country</u>	<u>Organization</u>	<u>Abbreviation</u>
1.	USA	American National Standards Institute	ANSI
2.	Canada	Standards Council of Canada	SCC
3.	France	Association Francaise	AFNOR
4.	United Kingdom	British Standards Institute	BSI
5.	Europe	Committee of European Normalization	CEN
6.	Germany	Deutsches Institute fur Normung	DIN
7.	Japan	Japanese Industrial Standards Committee	JISC
8.	India	Bureau of Indian Standards	BIS
9.	Worldwide	International Organization for Standards	ISO

- **ISO is a worldwide federation of national standards bodies from some 100 countries, one from each country.**



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The American National Standards Institute's standards used in the design of the Piping System are as listed. ASME B 31. Code for Pressure piping is at present a non-mandatory code in USA, though they are adopted as legal requirement.

- 1)ASME B 31.1 - Power Piping**
- 2)ASME B 31.2 - Fuel Gas Piping**
- 3)ASME B 31.3 - Process Piping**
- 4)ASME B 31.4 - Pipeline Transportation
System for liquid hydrocarbon
and other Liquids**
- 5)ASME B 31.5 - Refrigeration Piping**



- 6)ASME B 31.8 - Gas Transmission and Distribution Piping Systems.
- 7)ASME B 31.9 - Building Services Piping
- 8)ASME B 31.11 - Slurry Transportation Piping Systems
- 9)ASME B 31.G - Manual for determining the remaining strength of corroded piping -A supplement to ASME B31.

Of the above, the most commonly used code is ASME B31.3. Refineries and chemical plants are designed based on the same. All power plants are designed as per ASME B31.1.



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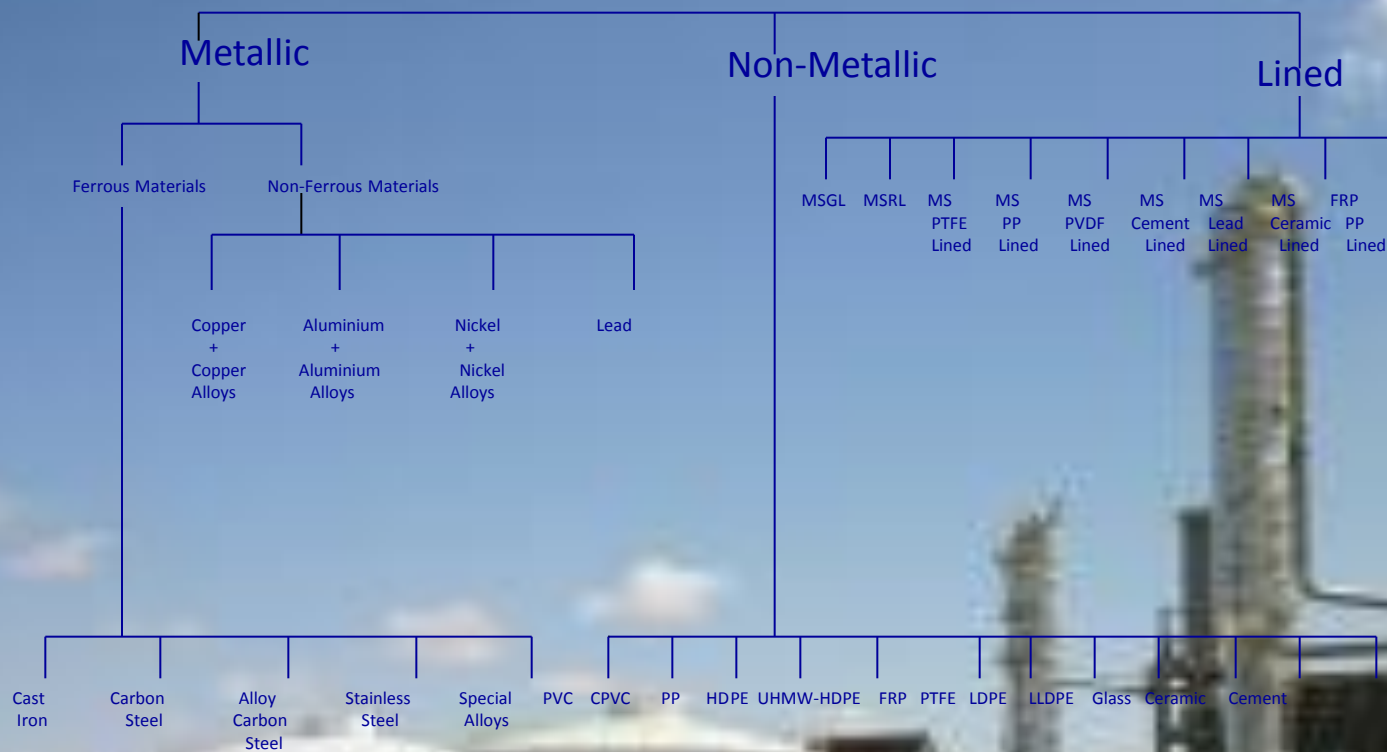


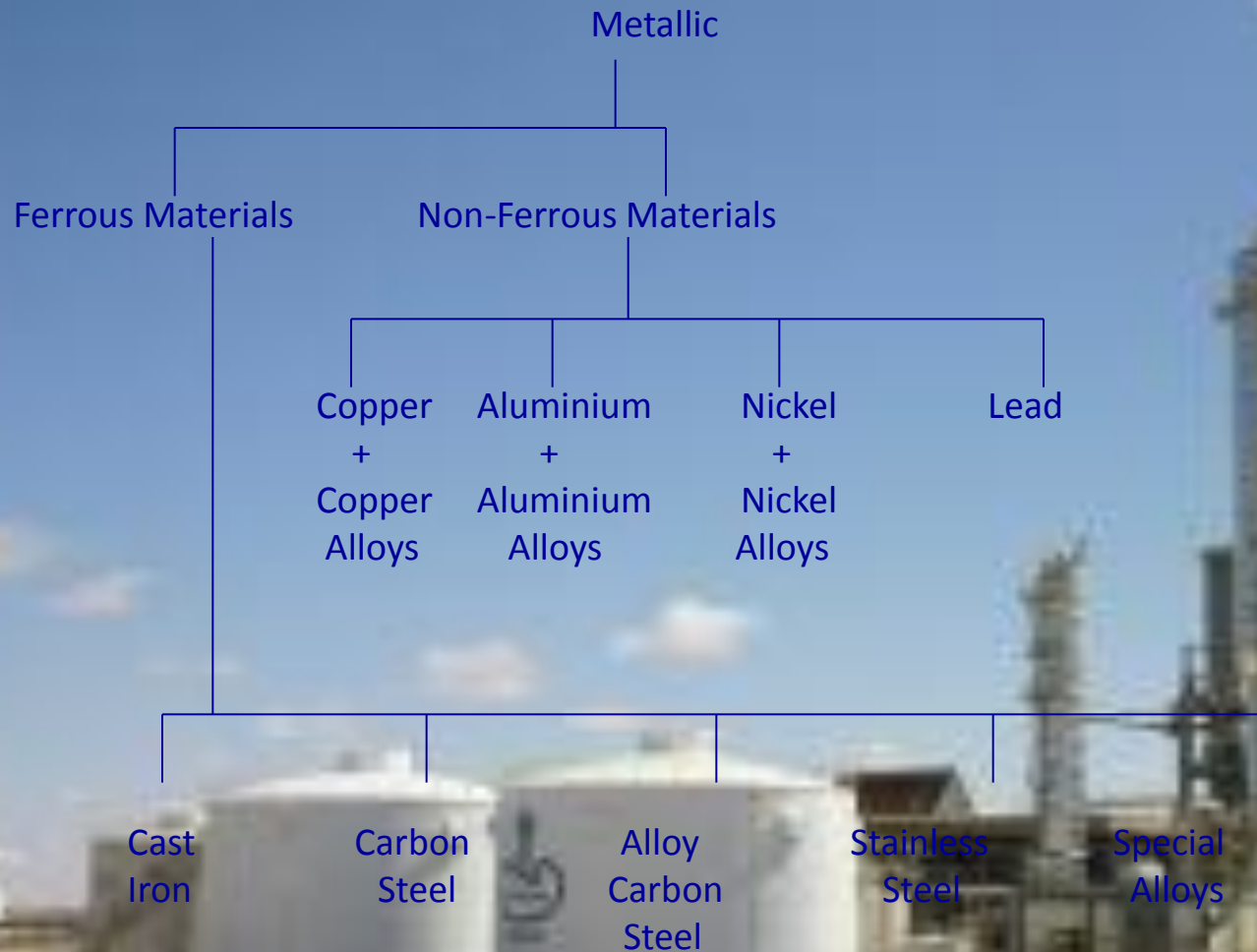
FIGURE 1.1

PIPING ELEMENTS

CLASSIFICATION BASED ON MATERIAL OF CONSTRUCTION



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Pipe Ends

Based on the material of construction and the pipe to pipe joint, the ends of the pipes are specified as follows.

Bevelled ends

Plain ends

Screwed ends

Flanged ends

Spigot/Socket ends

Buttress ends

Types Of Pipes

Based on the method of manufacture pipes could be classified as;

- Seamless
- Welded
 - Electric Resistance Welded (ERW)
 - Electric Fusion Welded (EFW)
 - Spiral Welded
 - Furnace Butt welded
 - Double Submerged Arc Welded
- Forged and Bored



Pipe Materials

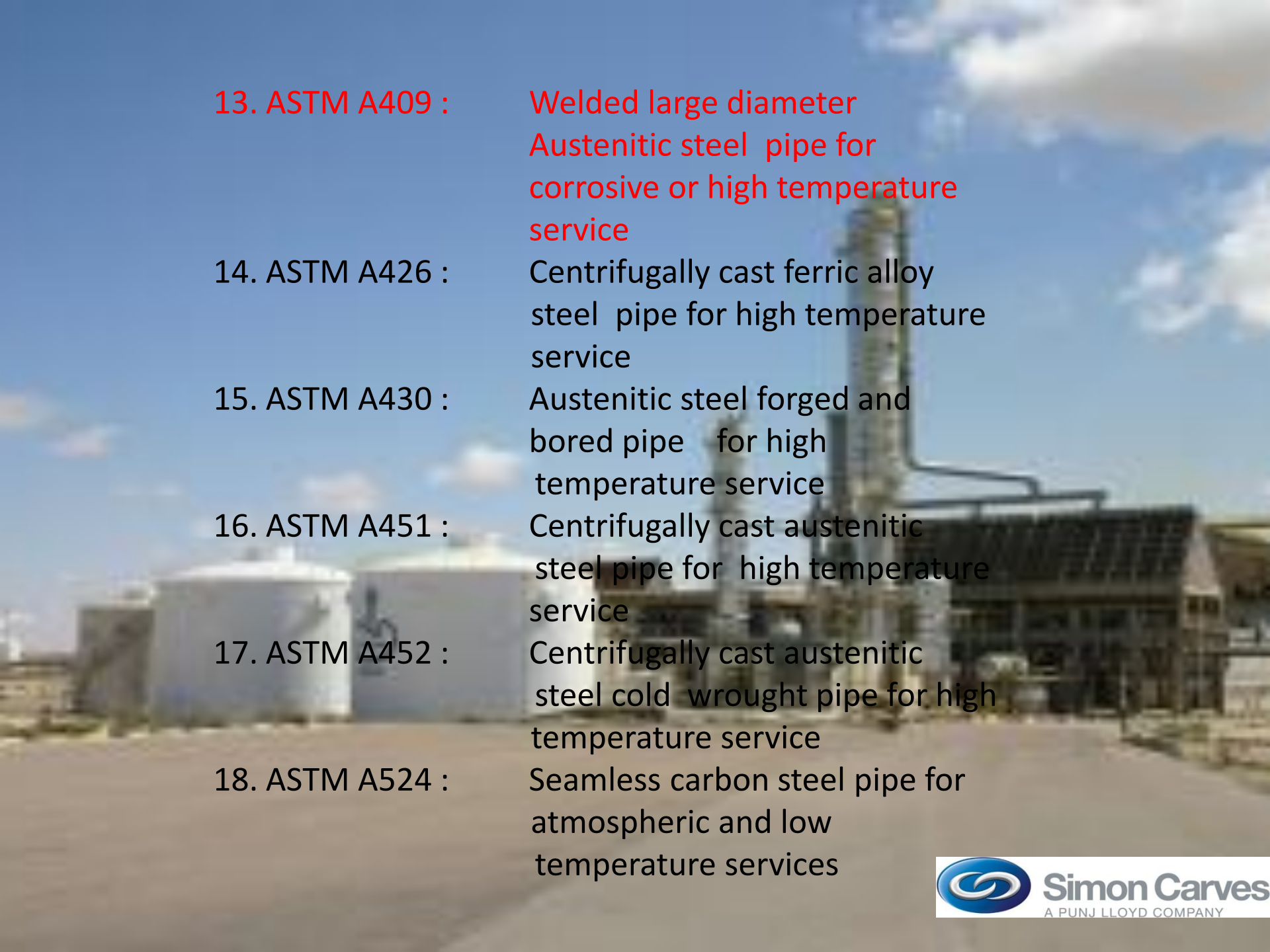
1. ASTM A53 : Welded and Seamless Steel Pipe Black and Galvanized
2. ASTM A106 : Seamless CS Pipe for High Temp. Services
3. ASTM A120 : Black and Hot Dipped Zinc coated (Galvanized) welded and seamless pipe for ordinary use
4. ASTM A134 : Electric fusion welded steel plate pipe (Sizes $\geq 16''$ NB)
5. ASTM A135 : Electric resistance welded pipe
6. ASTM A155 : Electric fusion welded steel pipe for high temperature service
7. ASTM A312 : Seamless and welded Austenitic stainless steel pipes



- 
8. ASTM A333 :Seamless and welded steel pipe for low temperature service
 9. ASTM A335 :Seamless ferric alloy steel pipe for high temperature service
 10. ASTM A358 : Electric fusion welded Austenitic chrome-nickel steel pipe for high temperature service
 11. ASTM A369 : Carbon and ferric alloy steel forged and bored for high temperature service
 12. ASTM A376 : Seamless austenitic steel pipe for high temperature central station service



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13. ASTM A409 : Welded large diameter Austenitic steel pipe for corrosive or high temperature service
14. ASTM A426 : Centrifugally cast ferric alloy steel pipe for high temperature service
15. ASTM A430 : Austenitic steel forged and bored pipe for high temperature service
16. ASTM A451 : Centrifugally cast austenitic steel pipe for high temperature service
17. ASTM A452 : Centrifugally cast austenitic steel cold wrought pipe for high temperature service
18. ASTM A524 : Seamless carbon steel pipe for atmospheric and low temperature services



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- 
- A background image of an industrial facility, likely a refinery or chemical plant. It features several large white storage tanks in the foreground, a tall distillation column in the center, and various pipes and structural elements. The sky is blue with some clouds.
1. IS 1239 : Steel pipes for general purposes
(Sizes $\leq 6''$ NB)
 2. IS 1536 : Centrifugally cast iron pipe
 3. IS 1537 : Vertically cast iron pipe
 4. IS 1978 : Line pipe
 5. IS 1979 : High test line pipe
 6. IS 3589 : Steel pipe for general services
 7. IS 4984 : HDPE pipe
 8. IS 4985 : PVC pipe



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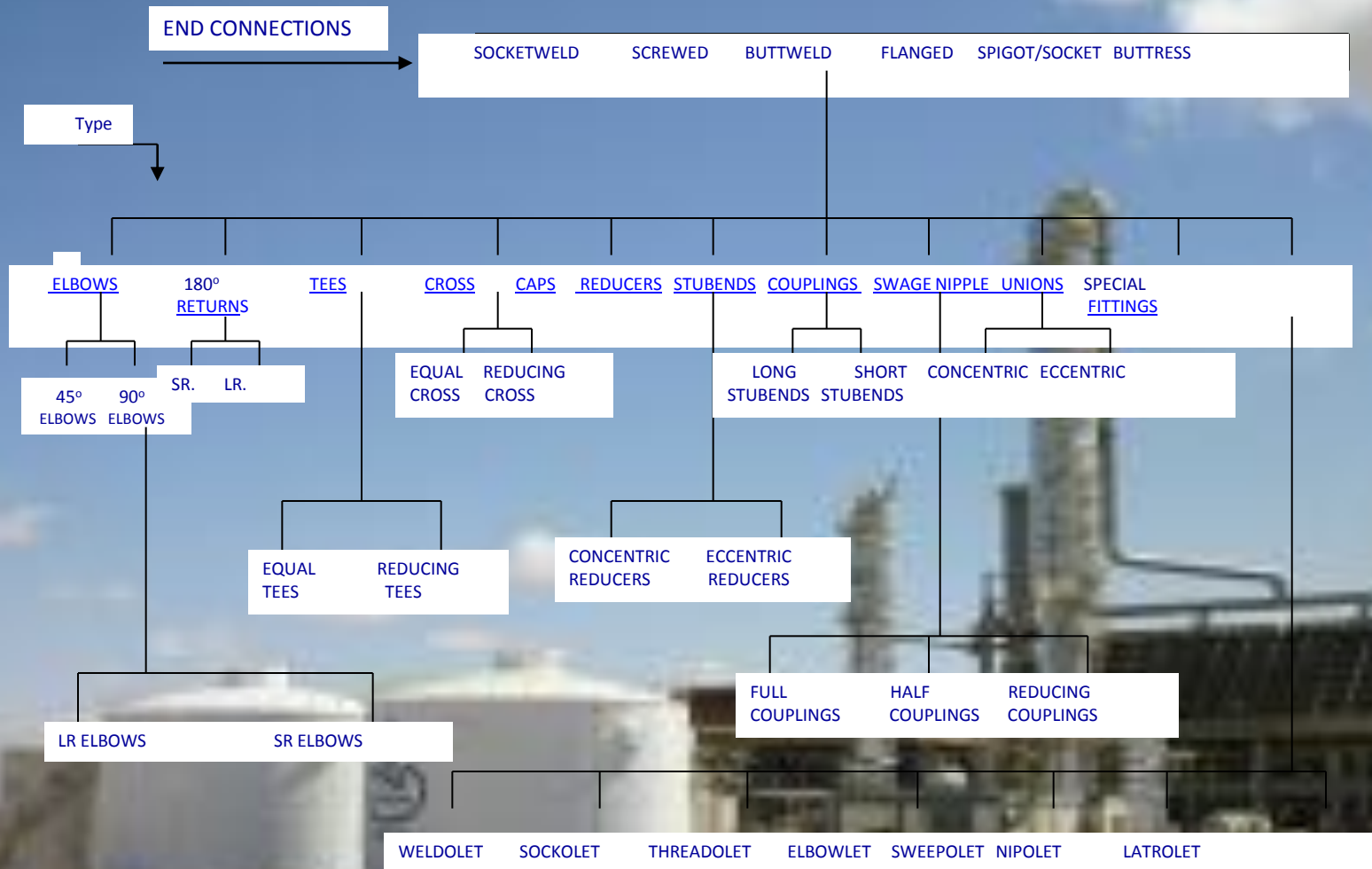


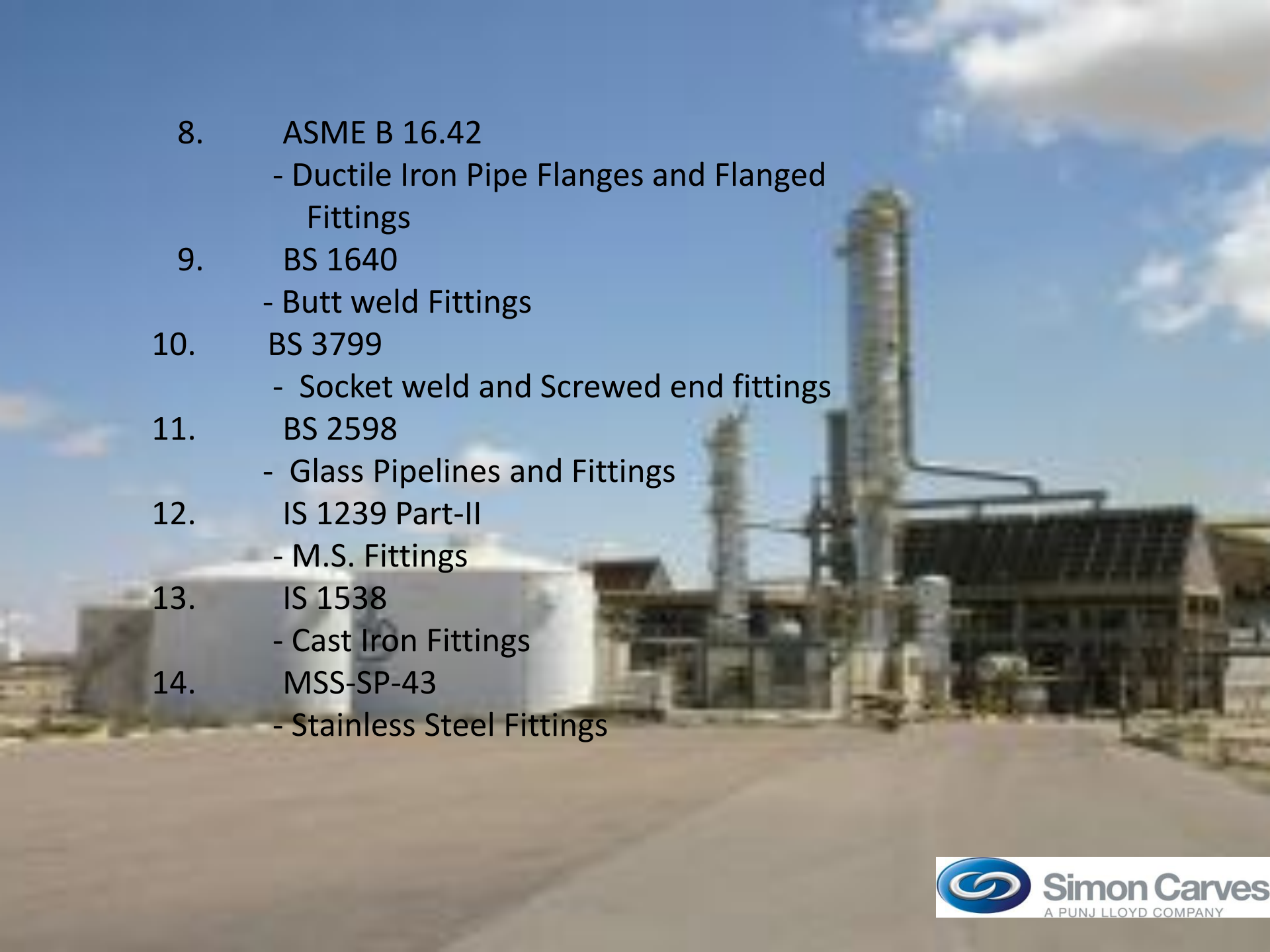
FIGURE 2.1
STANDARD PIPE FITTING

PIPE FITTINGS

DIMENSIONAL STANDARDS

1. ASME B 16.1
 - Cast Iron Pipe Flanges and Flanged Fittings
2. ASME B 16.3
 - Malleable-Iron Threaded Fittings
3. ASME B 16.4
 - Grey Iron Threaded fittings
4. ASME B 16.5
 - Pipe Flanges and Flanged Fittings
5. ASME B 16.9
 - Factory-Made Wrought Steel Butt welding Fittings
6. ASME B 16.11
 - Forged Fittings, Socket welding and Threaded
7. ASME B 16.28
 - Wrought Steel Butt welding Short Radius Elbows and Returns



- 
- A blurred background image of an industrial facility, likely a refinery or chemical plant, featuring tall distillation columns, storage tanks, and complex piping under a blue sky with scattered clouds.
8. ASME B 16.42
 - Ductile Iron Pipe Flanges and Flanged Fittings
 9. BS 1640
 - Butt weld Fittings
 10. BS 3799
 - Socket weld and Screwed end fittings
 11. BS 2598
 - Glass Pipelines and Fittings
 12. IS 1239 Part-II
 - M.S. Fittings
 13. IS 1538
 - Cast Iron Fittings
 14. MSS-SP-43
 - Stainless Steel Fittings



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PIPE FITTINGS

CLASSIFICATION BASED ON END CONNECTIONS - SOCKET
WELD/SCREWED FITTINGS

(DIMN STD ASME B16.11/BS 37 99)

Classification based on the maximum Cold non-shock
Working pressure.

- a. 2000 # Class – only for SCRD fittings
- b. 3000 # Class
- c. 6000 # Class
- d. 9000 # Class – only for SW fittings



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Class Designation of fitting	Type of fitting	Pipe used - Rating based	
		SCH No	Wall Designation
2000	Threaded	80	XS
3000	Threaded	160	--
6000	Threaded	--	XXS
3000	Socket Welding	80	XS
6000	Socket Welding	160	--
9000	Socket Welding	--	XXS



Class Designation of fitting	Type of fitting	Pipe used - Rating based	
		SCH No	Wall Designation
2000	Threaded	80	XS
3000	Threaded	160	--
6000	Threaded	--	XXS
3000	Socket Welding	80	XS
6000	Socket Welding	160	--
9000	Socket Welding	--	XXS



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Beveled end fittings are covered under ASME B 16.9, B16-28 and BS 1640. Thickness to suit pipe thickness.

BW FITTING MATERIALS

1. ASTM A 234 - Carbon Steel and Alloy steel pipe fittings
2. ASTM A 403 - Austenitic Stainless Steel fittings
3. ASTM A 420 - Alloy Steel for low temperature Services

Flanged fittings are covered under ASME B 16.5 and BS 1650 for carbon and alloy steel piping and ASME B 16.1 for cast iron fittings.

FLANGED END FITTING MATERIALS

1. ASTM A 216 - Carbon Steel Castings
2. ASTM A 351 - Stainless Steel Castings
3. ASTM A 352 - Alloy Steel Castings
4. ASTM F 1545 - Plastic Lined Fittings
5. IS 1538 - CI Fittings

ELBOWS

45°

90°

ELBOWS

ELBOWS

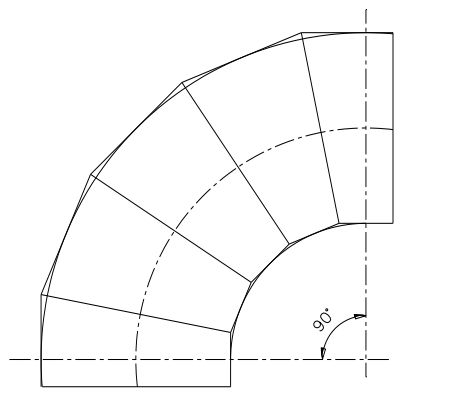
LR ELBOWS

SR ELBOWS

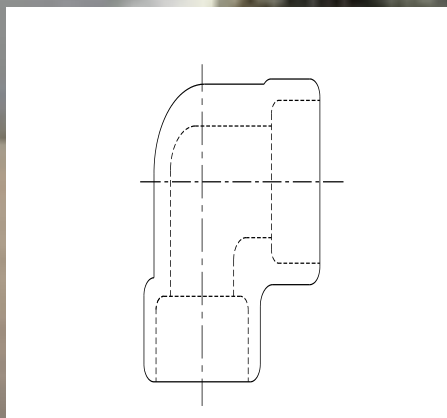
Long Radius Return

Short Radius 90 degree Elbow
($R=1D$)

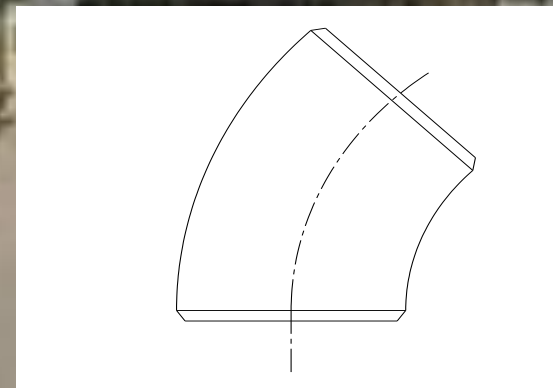
Fig.2.3 : Long Radius 90 degree Elbow
($R=1.5D$)



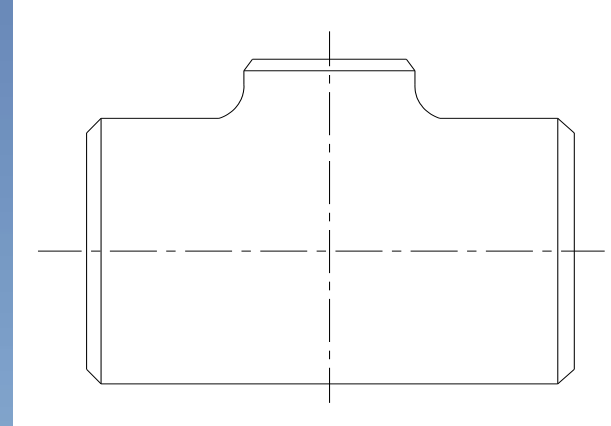
Mitre Bend 90°



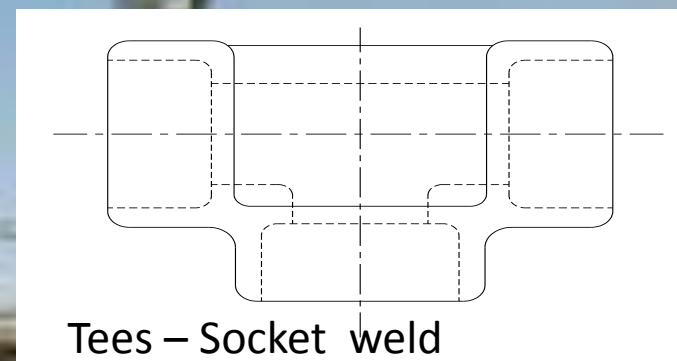
90 deg Elbows – Socket weld



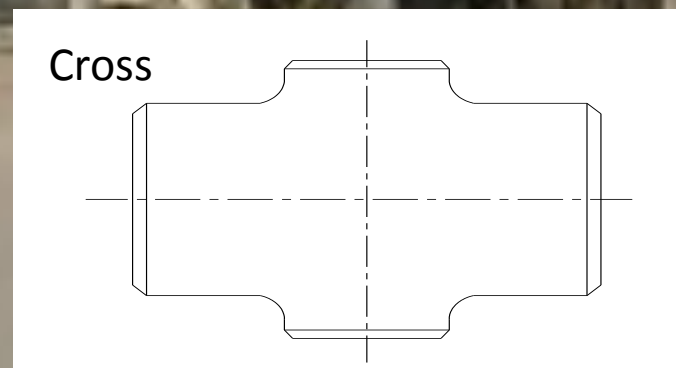
Elbows - 45°



Tees – Butt weld



Tees – Socket weld

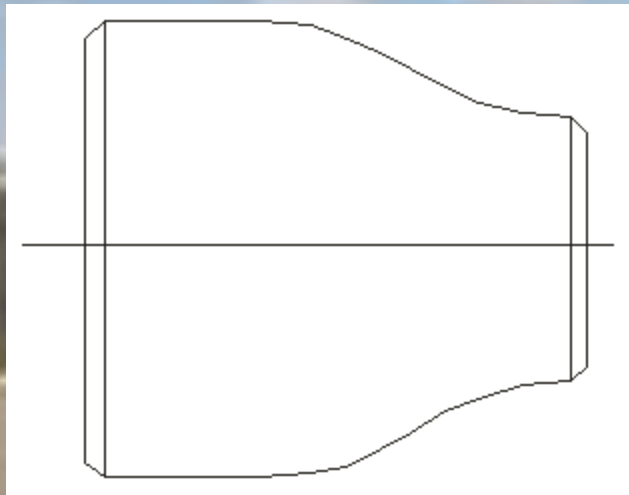


Cross

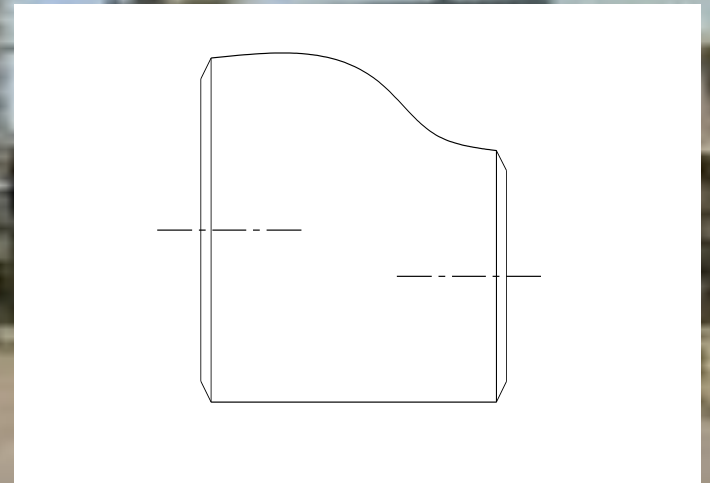
REDUCERS

CONCENTRIC
REDUCERS

ECCENTRIC
REDUCERS



Concentric Reducer



Eccentric Reducer



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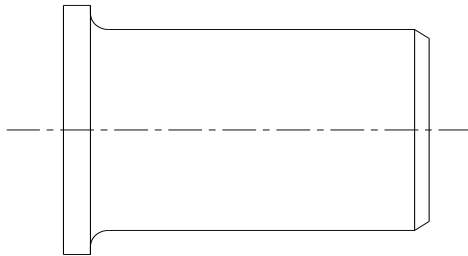
STUBENDS

LONG
STUBENDS

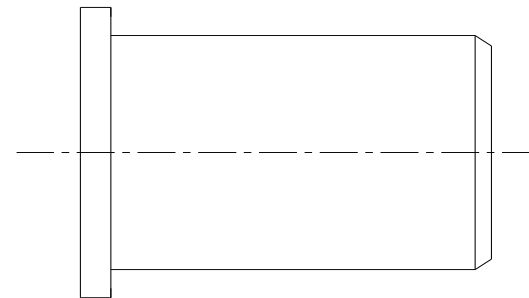
SHORT
STUBENDS

CLASS A

CLASS B



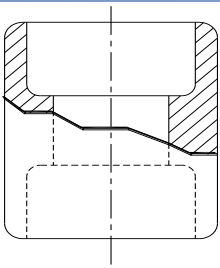
Stub End – Class A



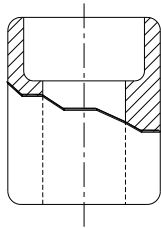
Stub End – Class B

COUPLINGS

FULL COUPLINGS



HALF COUPLINGS

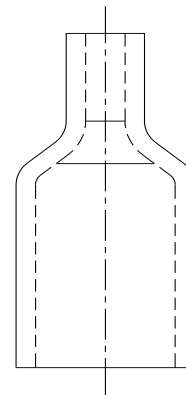


REDUCING COUPLINGS

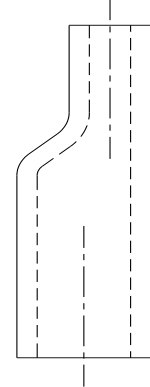
SWAGE NIPPLE

CONCENTRIC

ECCENTRIC



Plain



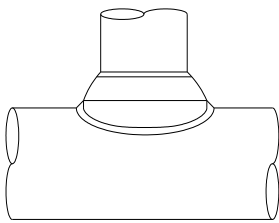
Plain

Concentric Swage Nipple

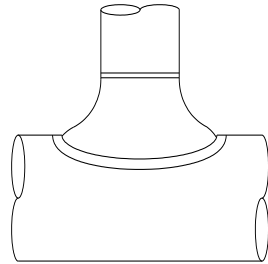
Eccentric Swage Nipple

SPECIAL FITTINGS

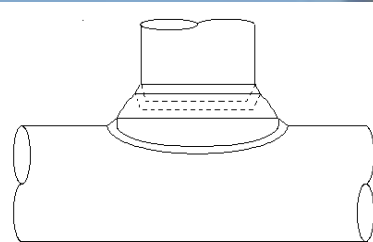
WELDOLET SOCKOLET THREDOLET ELBOWLET SWEEPOLET NIPOLET LATROLET



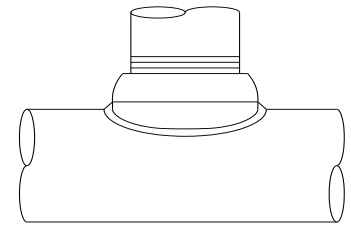
Weldolet



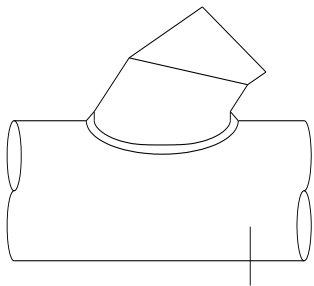
Sweepolet



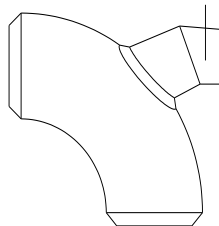
Sockolet



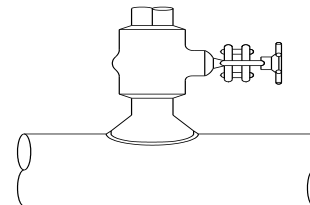
Thredolet



Latrolet



Elbowlet



Nipolet

3.0 FLANGES

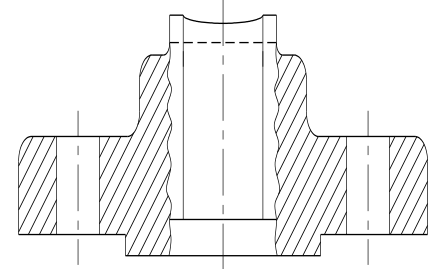
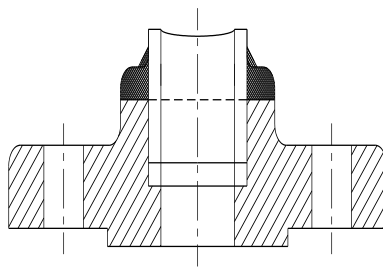
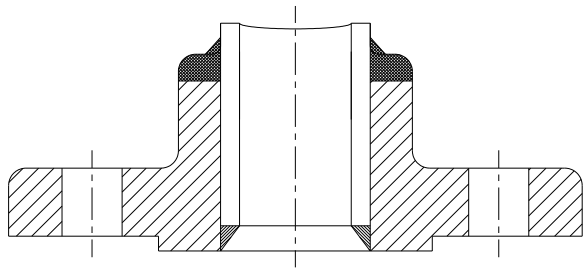
CLASSIFICATION - BASED ON

3.1 BASED ON ATTACHMENT TO PIPE

- 3.1.1 SLIP-ON
- 3.1.2 SOCKET WELD
- 3.1.3 SCREWED ON
- 3.1.4 LAP JOINT
- 3.1.5 WELDING NECK
- 3.1.6 BLIND



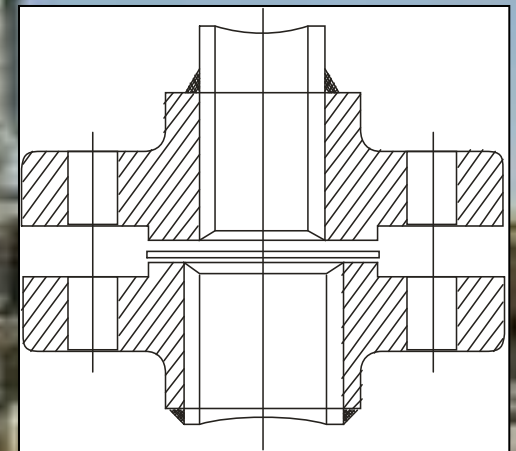
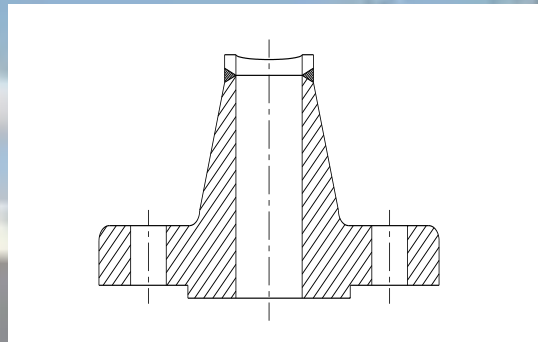
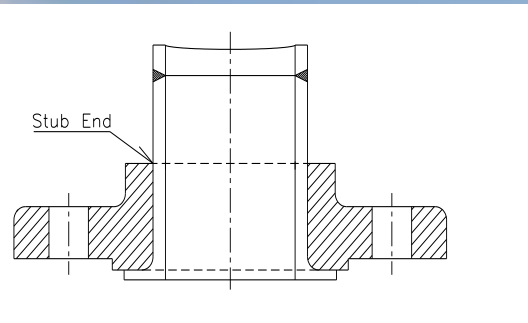
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Slip-on Raised Face Flange

Socket Welded Raised Face Flange

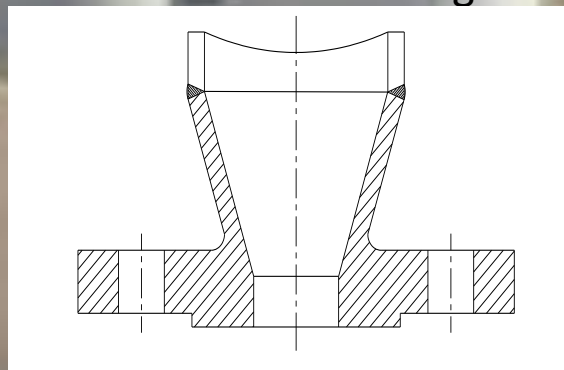
Threaded Raised Face Flange



Lap Joint Flange with Stub End

Welding Neck Raised Face Flange

Reducing Slip-on Flange



Expander or Reducer Flange

3.2 Based On Pressure-temperature Rating

The flanges are also classified by the pressure temperature rating in ASME B 16.5 as below :

3.2.1	150 #
3.2.2	300 #
3.2.3	400 #
3.2.4	600 #
3.2.5	900 #
3.2.6	1500 #
3.2.7	2500 #



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3.3 BASED ON FACING

3.3.1 FLAT FACE

3.3.2 RAISED FACE

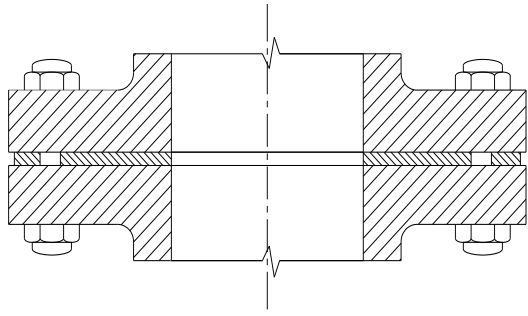
3.3.3 RING TYPE JOINT

3.3.4 TONGUE AND GROOVE

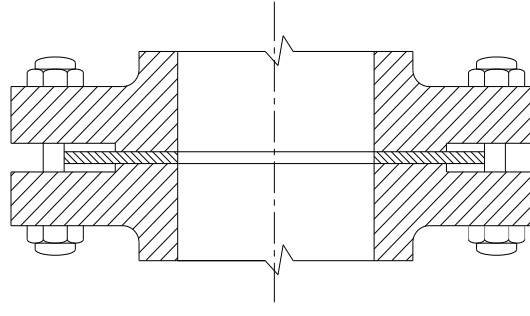
3.3.5 MALE AND FEMALE



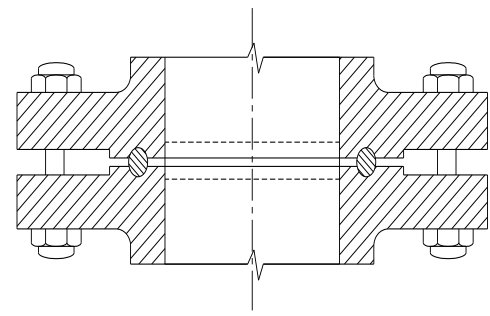
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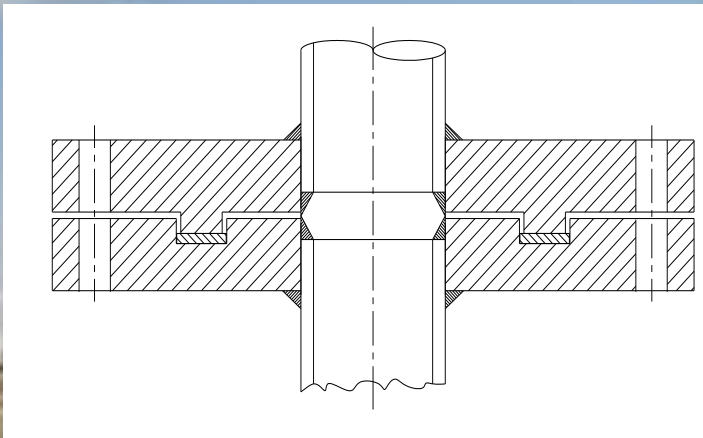
Flat Face



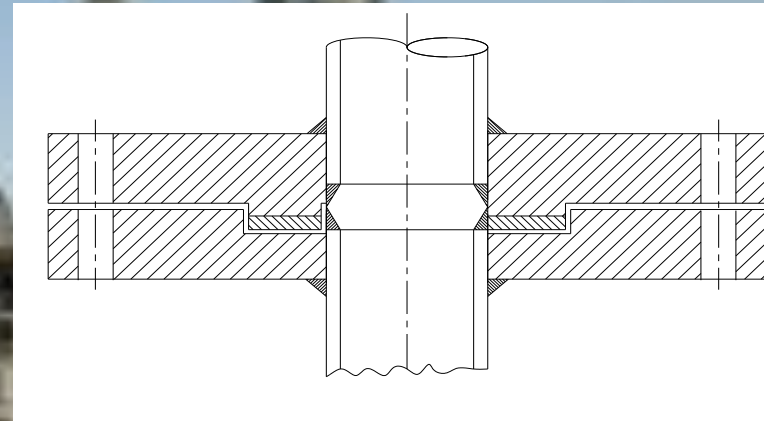
Raised Face



Ring Joint



Tongue and Groove Joint



Male / Female Joint

3.4 Based On Face Finish

- Smooth finish
- Serrated finish.

The serrations are specified by the number which is the Arithmetic Average Roughness Height (AARH).

3.5 Based On Material Of Construction

Flange Materials :

3.5.1 ASTM A105 - Forged Carbon Steel

3.5.2 ASTM A181 - Forged Carbon Steel for
General Purpose

3.5.3 ASTM A182 - Forged Alloy Steel and
Stainless Steel

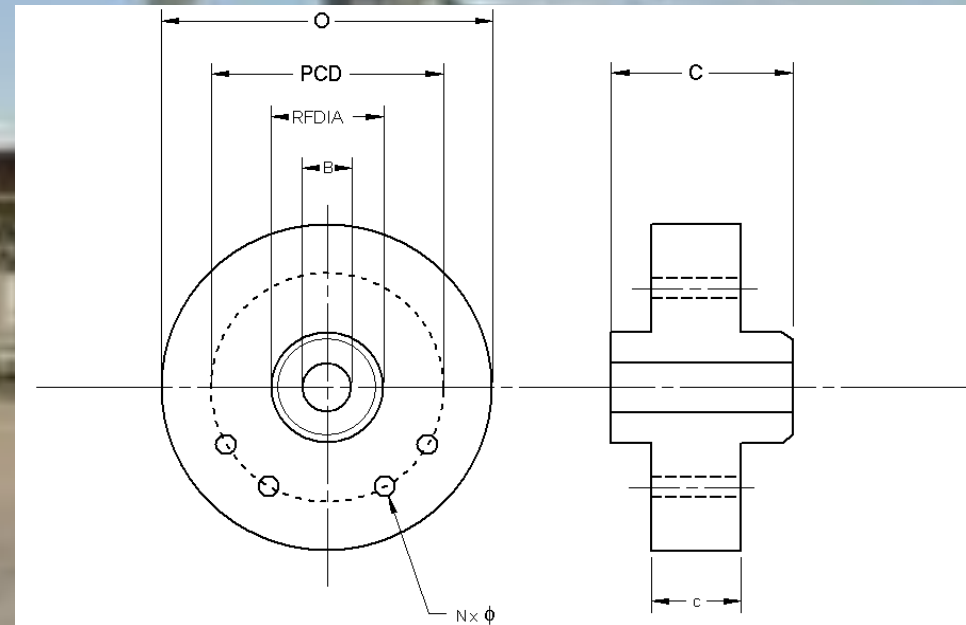
3.5.4 ASTM A350 - Forged Alloy Steel for low
temperature services



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PARAMETERS FOR SPECIFICATION

- 1 BORE/INSIDE DIAMETER - ID - B
- 2 OUTSIDE DIAMETER - OD - O
- 3 BOLT CIRCLE/PITCH CIRCLE DIAMETER - BCD/PCD
- 4 No OF BOLT HOLES - N
- 5 BOLT HOLE DIAMETER - ϕ
- 6 RAISED FACE DIAMETER
- 7 HUB DIAMETER - X
- 8 LENGTH THROUGH HUB - Y
- 9 THICKNESS OF FLANGE - C
- 10 THICKNESS OF RAISED FACE



GASKETS

Proper selection of gasket depends upon following factors.

- Compatibility of the gasket material with the fluid.
- Ability to withstand the pressure-temperature of the system.

Based on the type of construction, gaskets are classified as:

- Full Face
- Inside bolt circle
- Spiral wound metallic
- Ring type
- Metal jacketed



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The material which is most commonly used is the Compressed Asbestos Fibre.

Indian Standard IS 2712 specifies three different materials at three different grades.

- IS 2712 Gr W/1, W/2 and W/3 - for Steam, Alkali and general applications.
- IS 2712 Gr A/1 - for Acid applications.
- IS 2712 Gr O/1, O/2, O/3 - for Oil applications.

Asbestos free gaskets are also available for above applications. For very corrosive applications, PTFE or PTFE enveloped gaskets are used.



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For high temperature and high pressure applications, spiral wound metallic gaskets are used.

ASME B 16.5 does not recommend the use of 150# rating gaskets on flanges other than welding neck and lapped joint type.

The spiral wound gasket will perform when the flange face is 125-250 AARH finish.

Dimensional Standards

- API 601 - Metallic Gasket for Refinery Piping
- BS 3381 - Metallic Spiral Wound Gaskets
- ASME B16.20 - Metallic Gaskets for pipe flanges
- ASME B16.21 - Non-metallic Gaskets for pipe flanges



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GASKET APPLICATION

Based on Manufacturer's Technical Publication the following Rule of Thumb is used for selection of Gasket material.

MATERIAL	MAXIMUM P x T (PSI x °F)	MAXIMUM TEMP (T) (°F)
Rubber Sheet	15,000	300
Woven Asb- Rubberized Sheet	1,25,000	400
Compressed Asbestos sheet	2,50,000	850
Metal Gasket	2,50,000	Depends on type



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This Table does not imply that none of these materials listed have ever been used above the Pressure Temp. value shown.

The designer should refer Manf. Cat. for the recommended upper temp. limits.

The thickness normally selected by piping engineers – 2mm for rubber. 2mm for CAF. For 150 & 300 lb flanges.

The installation bolt force must seat the gasket properly to withstand the effect of internal pressure. Bolt stress value depend upon the material of constn. of bolt Flange finish could be suitable for the gasket selected.

Please find herewith given below cost comparison of various ring gaskets used. As 11/2 "size is the most used size, it has been considered for comparison.

Sr. No.	Type	Cost/No.
1.	Acid proof gasket	Rs. 13.00
2.	Permanite gasket	Rs. 13.00
3.	Ammonia gasket	Rs. 10.00
4.	Virgin Teflon gasket	Rs. 161.00
5.	Spiral wound (asb.) gasket	Rs. 14.00
6.	Spiral wound (grph) gasket	Rs. 38.00
7.	Teflon envelope gasket	Rs. 110.00

Rate excludes taxes (15.3% ST and 4% octroi)



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BOLTING

For low pressure, low temperature services, machine bolts are used and studs are used otherwise.

Flanged joints using low strength carbon steel bolts shall not be used above 200 °C or below –29 °C

Material Of Construction For Bolting

Bolting materials normally used are

- ASTM A 307 - Low Carbon Steel Bolting Material
- ASTM A 320 - Alloy Steel Bolting material for low temperature service
- ASTM A 563 - Carbon and alloy steel nuts
- ASTM A 193 - Alloy Steel Bolting Material for high temperature service
- ASTM A 194 - Alloy Steel nut material for high temperature service
- IS 1367 - Threaded steel fasteners



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