Manual

on

Pipe Fabrication

Prepared by

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Department of Mechanical Engineering (UGV)

COURSE INFORMATION			
Course Title	**Pipe Fabrication**	Lecture Contact Hours	85
Covered Lab	Mechanical Engineering Drawing-II Sessional, Machine Tools Sessional, Welding Shop, Machine Shop, Fluid Mechanics-I & II Sessional	Credit Total Marks	01 50
PRE-REQUISITE		CIE SEE	20 30
Fluid Mechanics-I,II & Fluid Machinery, Welding and Machine Shop Practice			

Course Learning Outcomes (CLOs): after completion of this course

successfully,the students will be able to……

CLO1	**Understand** the P&ID, PFD, Piping System and Pipe Fittings.
CLO2	**Analyze** both the Process flow diagrams and Piping and Instrumentation diagrams
CLO3	**Apply** the Fabrication knowledge to maintain smooth commissioning
CLO4	**Improve** efficiency and cost effectiveness

Sl. No.	Course Content	Hrs	CLOs
1	Understanding and Design P&ID and PFD	20	CLO1
2	Understanding Pipe Scheduling, Pipe fittings Selection	20	CLO1, CLO2, CLO 3
3	Pipe joining (Bolting, Welding), Piping alignment	15	CLO3, CLO4
4	Pipe leakage Inspection, Pipe Flushing	15	CLO3, CLO 4
5	Pressure drop, Flow type, Reynolds number Calculation	5	CLO2, CLO3, CLO 4
7	Lab Test, Viva, Quiz, Overall Assessment, Practice Session	10	

REFERENCE BOOKS

"Piping Handbook (Mechanical Engineering)" by Mohinder L Nayyar
"Handbook of Piping Design" by G K Sahu
"Perfect Knowledge of Piping Engineering: Piping Engineering Handbook" by Sanjay Kumar Gupta

ASSESSMENT PATTERN
CIE- Continuous Internal Evaluation (20 Marks)
SEE- Semester End Examination (30 Marks)

SEE- Semester End Examination (50 Marks) (should be converted in actual marks (30)

Bloom's Category Cognitive	**Tests (20)**
Remember	**05**
Understand	**07**
Apply	**08**
Analyze	**07**
Evaluate	**08**
Create	**05**

Bloom's Category Psychomotor	**Practical Test (30)**
Imitation	10
Manipulation	5
Precision	5
Articulation	5
Naturalization	5

CIE- Continuous Internal Evaluation (40 Marks) (should be converted in actual marks (20)

Bloom's Category Marks (out of 60)	**Lab Report (10)**	**Continuous lab performance (10)**	**Presentation & Viva (10)**	**External Participation in Curricular/Co-Curricular Activities (10)**
Remember			02	Attendance 10
Understand	05	04	03	
Apply		02		
Analyze		02		
Evaluate	05	02		
Create			05	

	Course Plan Specifying Content, CLOs, Teaching Learning Strategy and Assessment Strategy			
Week	Topics	Teaching Learning Strategy	Assessment Strategy	Corresponding CLOs
1	Understanding P&ID and PFD	Lecture, Oral Presentation	viva, Lab Test, Quiz, Lab Report	CLO1, CLO2
2	Design P&ID and PFD	Lecture, discussion, Video Presentation, Experiment	viva, Lab Test, Quiz, Lab Report	CLO1, CLO2
3	Practice on P&ID and PFD	Group Discussion, Experiment Practice	Skill Development Test	CLO1, CLO2
4	Practice on P&ID and PFD	Group Discussion, Experiment Practice	Skill Development Test	CLO1, CLO2
5-6	Pipe Scheduling	Lecture, discussion, Video Presentation, Experiment	Lab Report Assessment, viva, Lab Test, Quiz	CLO2, CLO3
7-8	Pipe Fittings Study and Selection	Lecture, discussion, Video Presentation, Experiment	Lab Report Assessment, viva, Lab Test, Quiz	CLO2, CLO3
9	Pipe joining Bolting,	Group Discussion, Experiment Practice	Skill Development Test	CLO3

	Course Plan Specifying Content, CLOs, Teaching Learning Strategy and Assessment Strategy			
Week	Topics	Teaching Learning Strategy	Assessment Strategy	Corresponding CLOs
10	Pipe joining Welding, Piping alignment	Lecture, discussion, Video Presentation, Experiment	Lab Report Assessment, viva, Lab Test, Quiz	CLO3,
11	Pipe joining Welding, Piping alignment	Lecture, discussion, Video Presentation, Experiment	Lab Report Assessment, viva, Lab Test, Quiz	CLO3
12	Pipe leakage Inspection,	Group Discussion, Experiment Practice	Skill Development Test	CLO2, CLO 4
13-14	Pipe Flushing	Lecture, discussion, Video Presentation, Experiment	Lab Report Assessment, viva, Lab Test, Quiz	CLO2, CLO 4
15	Pressure drop, Flow type, Reynolds number Calculation	Lecture, Field Visit, Lab experiment	Skill Development Test	CLO 2 CLO 4
16-17	Lab Test, Viva, Quiz, Overall Assessment, Skill Development Test (Competency)	Group Discussion, Experiment Practice	Skill Development Test	

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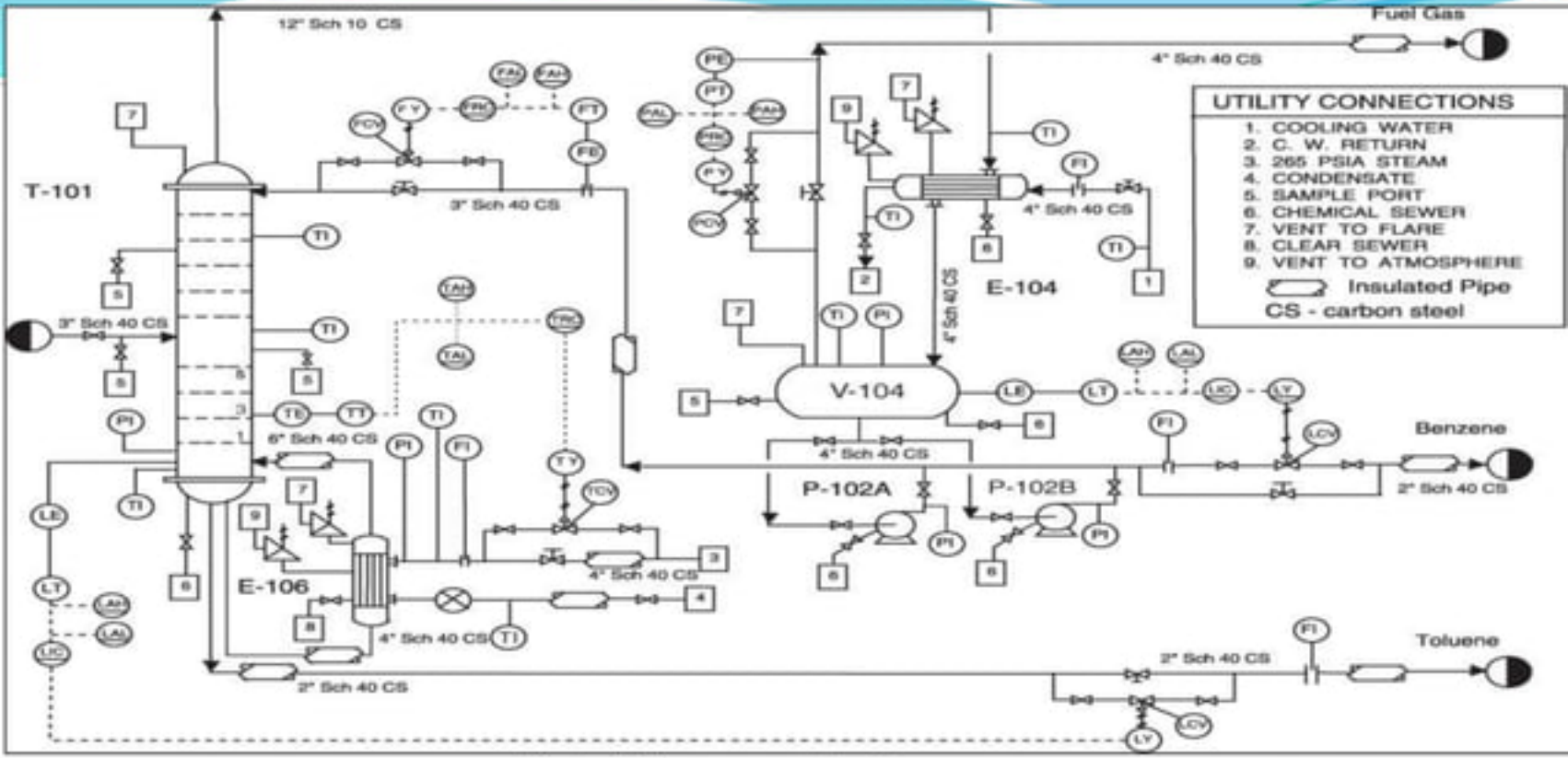
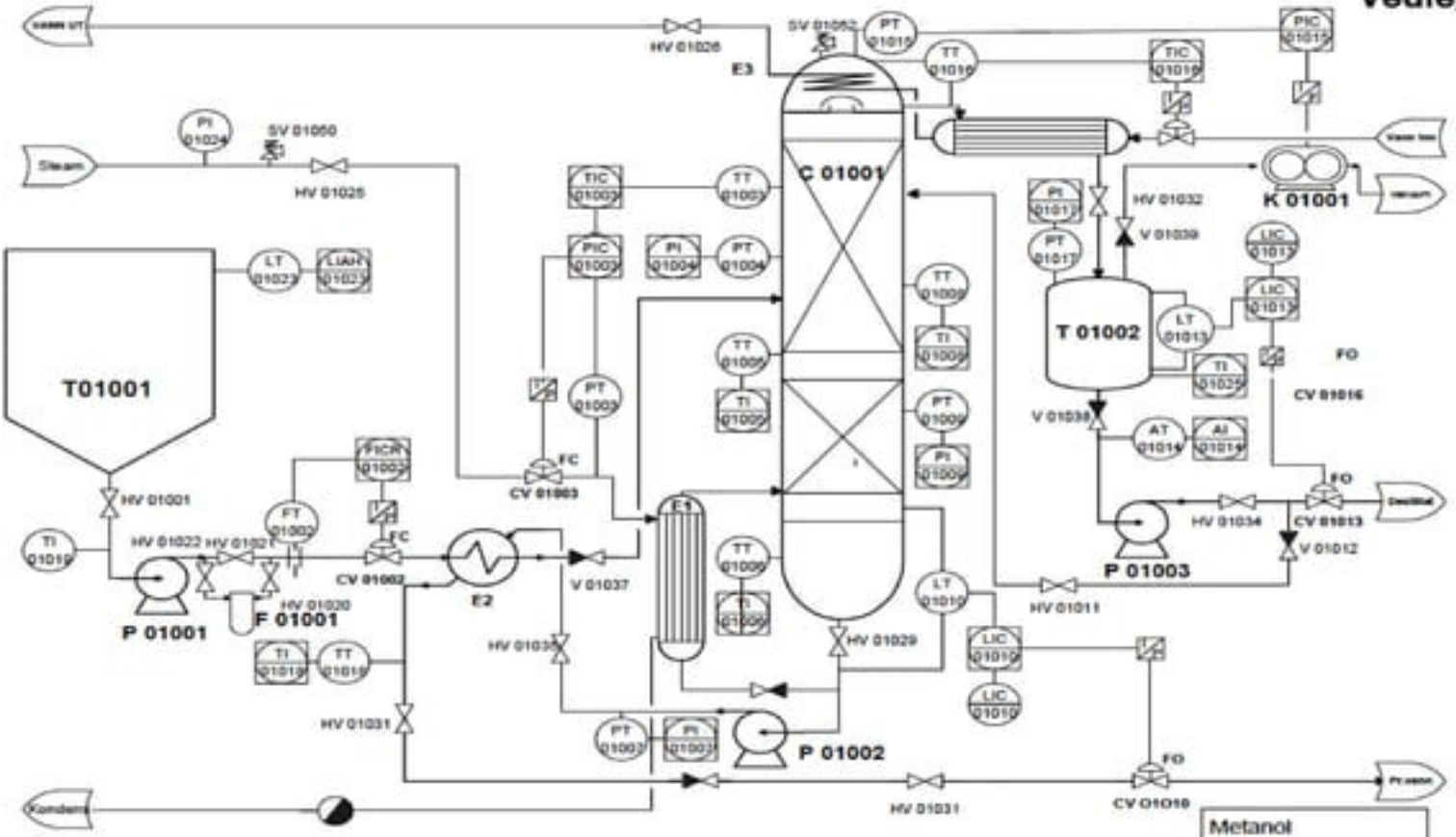
P&ID, PFD Manual

Week (01-04)



Piping & Instrumentation Diagram

Vedlegg 1


T01001
P 01001
F 01001
E2
E1
C 01001
E3
P 01002
T 01002
K 01001
P 01003
HV 01001
HV 01002
HV 01003
HV 01004
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CV 01001
CV 01002
CV 01003
CV 01004
CV 01005
CV 01006
CV 01007
CV 01008
CV 01009
CV 01010
CV 01011
CV 01012
CV 01013
CV 01014
CV 01015
CV 01016
SV 01050
SV 01051
SV 01052
Steam
Kondens
Metanol gjenvinningsanlegg
Anl. 01000

P&ID can be divided into 3 parts:

- Equipment Specification
- Instrument Specification
- Piping specification

P&ID takes different form depending on:

- Nature of the Process
- Firm performing the design work
- Design Philosophy
- Intended Audience

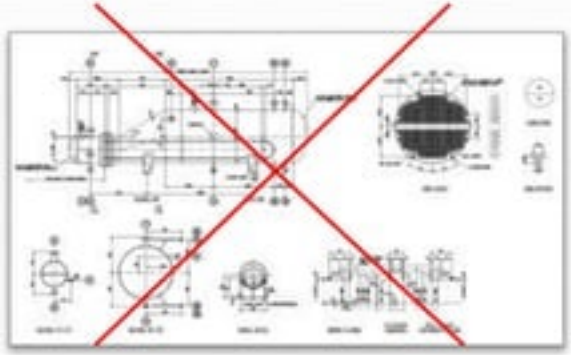
Purpose of P&ID

To show –

- ✓ Material Flow
- ✓ Piping between various sections
- ✓ Major pieces of mechanical Equipments
- ✓ Valves and directions of process flow
- ✓ Field Mounted instruments
- ✓ Electrical Equipments
- ✓ Communication Links

Not to show-

- ⊘ Process Information
- ⊘ Physical dimensions of equipment
- ⊘ Piping Details
- ⊘ Control Logic



P&ID Symbology

Standards and Codes used in Instrumentation-

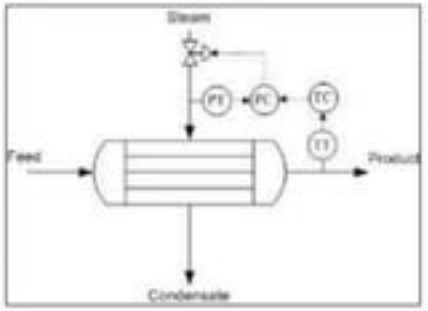
- American National Standards Institute (ANSI)- All Products & Services
- American Petroleum Institute (API)- Oil & Natural Gas
- American Society for Testing Materials (ASTM)- All Products & Services
- American Society of Mechanical Engineers (ASME)-Pressure vessels & Pipes
- American Institute of Chemical Engineers (AIChE)- Manufacturing Processes
- Deutsches Institut für Normung (DIN)- Rules and symbols for flow-sheet
- International Society of Automation (ISA)- Process control

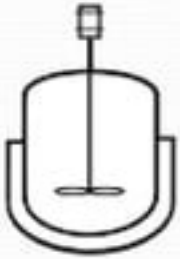
➡ **ANSI/ISA-S5.01-2009**

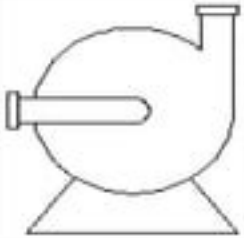
" **Goal of uniformity in the field of Instrumentation** "

P&ID Symbol Contents

- **Equipment Symbology**
  - Equipment Layout
  - Equipment Identification & Numbering
  - Nozzles
  - Miscellaneous
- **Piping Symbology**
  - Piping Layout
  - Line Identification
  - Line Continuation
  - Piping Components
  - Utility Piping
- **Instrument Symbology**
  - Instrument Layout
  - Instrument Identification
  - Interconnecting Piping
  - Instrument Piping
  - Instrument Control







Equipment Symbology

I) Equipment Layout

- **Relative Shape**

e.g. Spheres, Tanks, Columns, Pumps

- **Relative Orientation**

e.g. Horizontal, Vertical, Sloped

- **Relative Position**

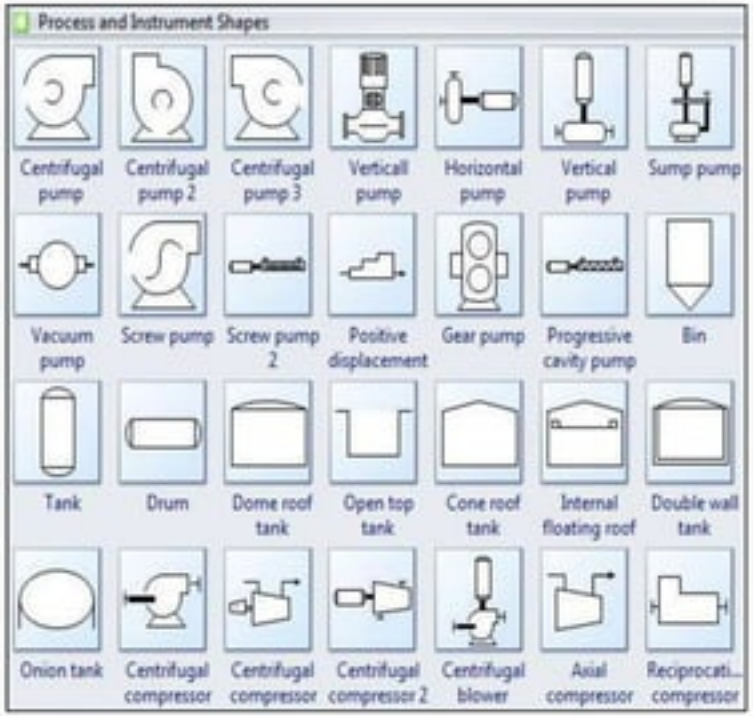
Location relative to other equipment

- **Relative Size**

Size relative to other equipment

- **Equipment Status**

e.g. New, Existing, Relocated, Future, Vendor S.



II) Equipment Identification-1

a) Tag Prefix :

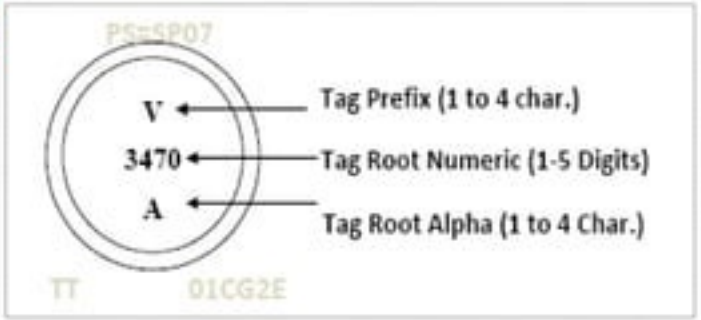
Shows type of the equipments
e.g. V- Storage tanks, P- Pump, FL- Filter ,CT- Cooling Tower

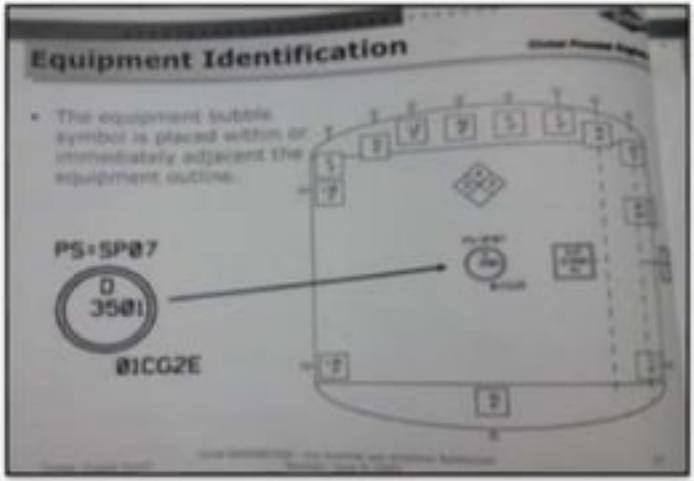
b) Tag Root Numeric :

Gives typical number to the equipment - Equipment Number
e.g. V-405, D-220

c) Tag Root Alphabetic:

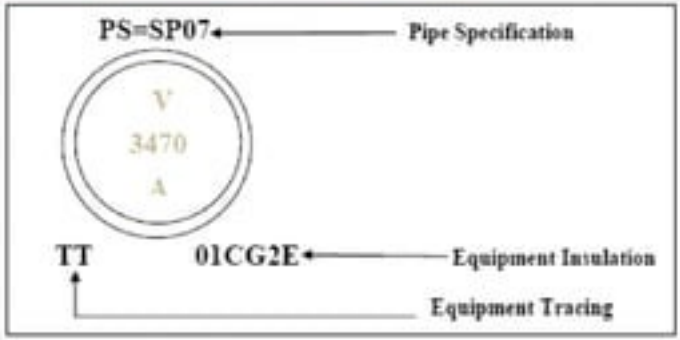
When there are more than 1 equipment is used in single operation then it is given by 1-5 alphabetic letters.
e.g. V-405.A, V-405.B





III)Equipment Identification-2

- Additional utilities used for its proper working are represented by some additional symbols outside the bubble.
- Equipment insulation and tracing is specified below the equipment bubble.
- Pipe specification to be used for piping trimming is specified above the equipment bubble symbol.
- Codes used to identify insulation, tracing and piping trim should be the same as used on the piping itself.



Equipment Numbering

P-1234

P- Equipment Prefix
1- Train number (optional)
2- Major area
3- Major unit operation in that area
4- Equipment within the unit operation

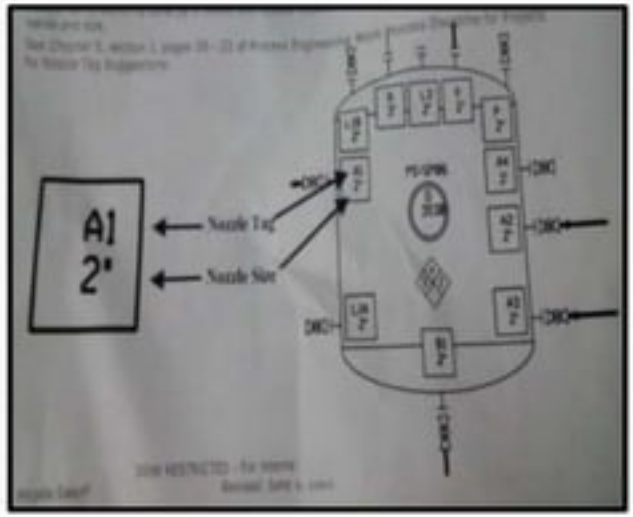
IV)Equipment Nozzles

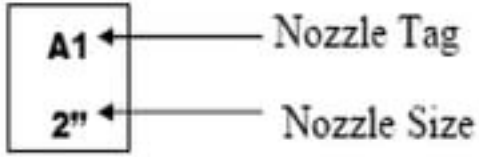
- Nozzle identification is done by a nozzle box located adjacent to the nozzle. It contains a unique name (tag) and size.

- Nozzle tag shows for which purpose the nozzle is used.
  e.g. A- Inlet, B- Outlet, L- Level Switch

- When there are more than 1 nozzles used for similar application, numbers are allocated to nozzles of similar type.
  e.g. L1, L2 - Level switches 1 & 2

- Number written below the nozzle tag inside the box shows size of the nozzle.
  e.g. In given case, size of the nozzle is 2 inches.





Nozzle Prefixes

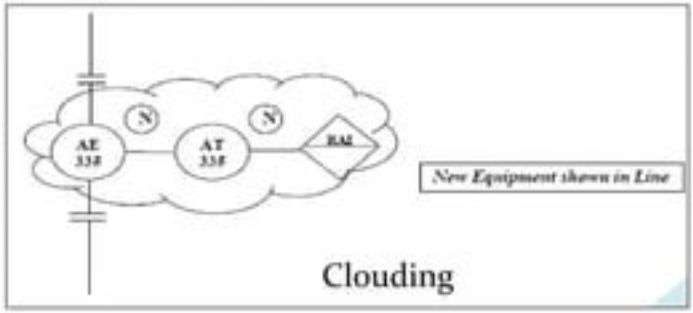
Chapter 5, section J, pages 20 - 22 of Process Engineering Work Process Discipline for Project

Service	Designation	Size
Inlet	A1, A2, A3, etc.	as required
Outlet	B1, B2, B3, etc.	as required
Agitator	C	10" or as required
Relief	R	as required (Consider one size larger)
Manway	M	24" minimum
Hand-hole	H	as required
Removable Baffle	RB (Glass Vessels)	8" minimum
Sample	Z	2"
Spare	S1, S2, S3, etc.	3" or 4" as required
Vent	V	2" minimum
Level Transmitter	L1, L2, L3, etc.	2" with drip ring
Level Trans. w/ 2 taps	L1A, L1B	lower tap A, and the upper tap B
Level Switch	L1, L2, L3, etc.	2" flanged
Pressure	P1, P2, P3, etc.	2" for non-plugging service, 3" w/ diaphragm
Press. Trans. w/ 2 taps	P1A, P1B	lower tap A, and the upper tap B
Temperature	T1, T2, T3, etc.	2"
Jacket Inlet	JA1, JA2, JA3, etc.	as required
Jacket Outlet	JB1, JB2, JB3, etc.	as required
Jacket Vent	JV1, JV2, JV3, etc.	1" flanged
Jacket Drain	JD1, JD2, JD3, etc.	1" flanged

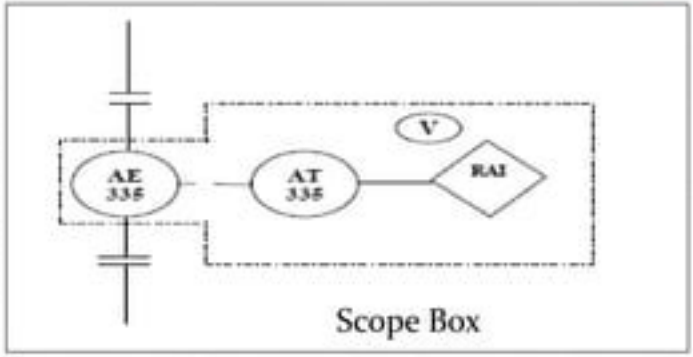
V) Item Status

- (N) - New
- (E) - Existing
- (R) - To be Relocated
- (V) - Vendor Supplied Packages
- (F) - Future
- (M) - To be Modified

VI) Clouding & Scope Box



Clouding



Scope Box

Piping Symbology

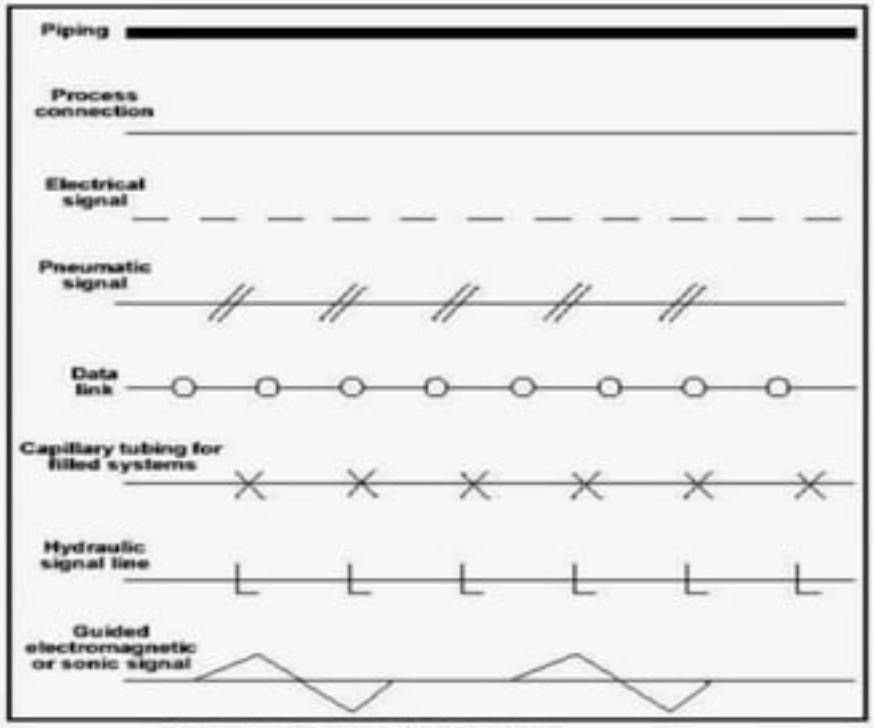
- Piping is shown schematically, in a logical sequence, not as it is actually piped in the field
- Piping specification differentiate between various piping systems
  e.g. pigging line system, cooling jacket pipeline etc.
- The various piping parts are shown according to following category:
  - Drains
  - Vents
  - Flush connections
  - Steam and Air traps
  - Reducers
  - Relief devices

- Each pipeline will have a label that gives a unique identifier, size and piping specification code
- Piping corrections to equipment, and line terminations are shown as flanged or threaded
- Piping length and elevation, isometrics, and stress considerations are not shown

Interconnecting Line types

Types of Connections:

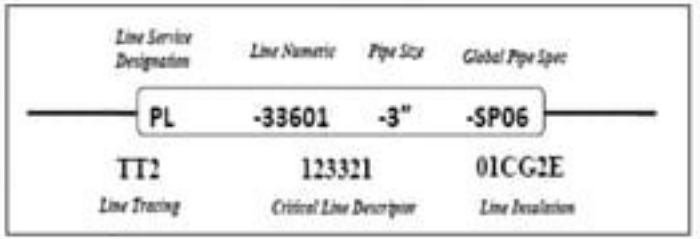
- Main Line(Pipeline)
- Process Connections
- Pneumatic Signals
- Data Links
- Capillary Tubing
- Hydraulic Signals
- Electromagnetic /Sonic Signal

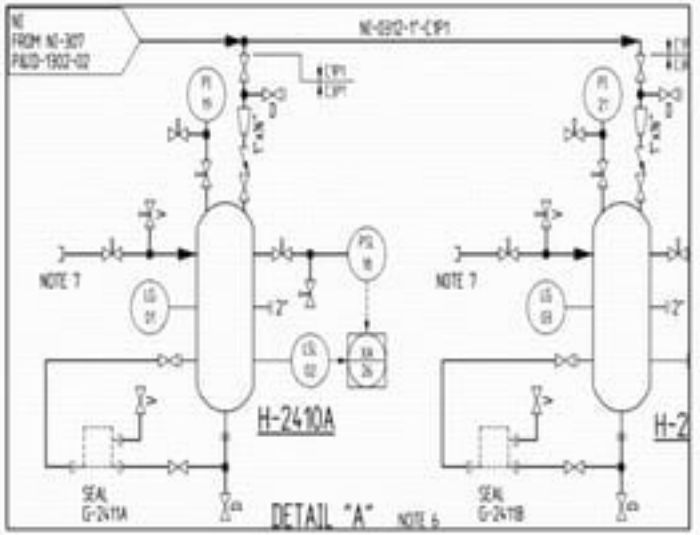


Piping and Connection Symbols

Line Identification

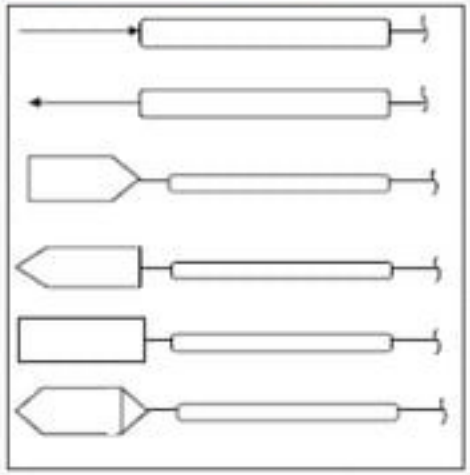
- Line Identification consists of the following information:
  - **Service Designation** – Type of fluid flowing through it
  - **Numeric Number** – Pipe line no. from the drawing
  - **Pipe size** – Outer diameter of the pipe
  - **Global Pipe Specification Code** – MOC of pipe
  - **Tracing Codes** – Type of tracing (if available)
  - **Insulation and Jacketing** –Type of Insulation /Jackets
  - **CLD** – Critical line descriptor





Line Continuation

- In almost all processes in chemical plant, various materials are transferred to different parts of the plant.
- In such cases, one P&ID sheet is not sufficient to show all piping systems of that material spread in various parts of plant.
- We have to continue the pipeline flow in the next sheets also
  → **Line continuation symbols**
- Line continuation symbols show piping connections between different P&IDs.
- It helps to correlate the connections of some materials in different processes within the plant.



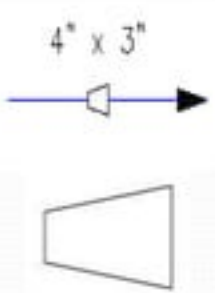
Piping Components

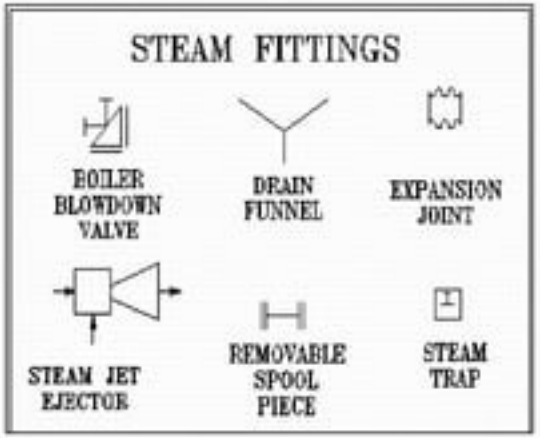
Utility Piping:

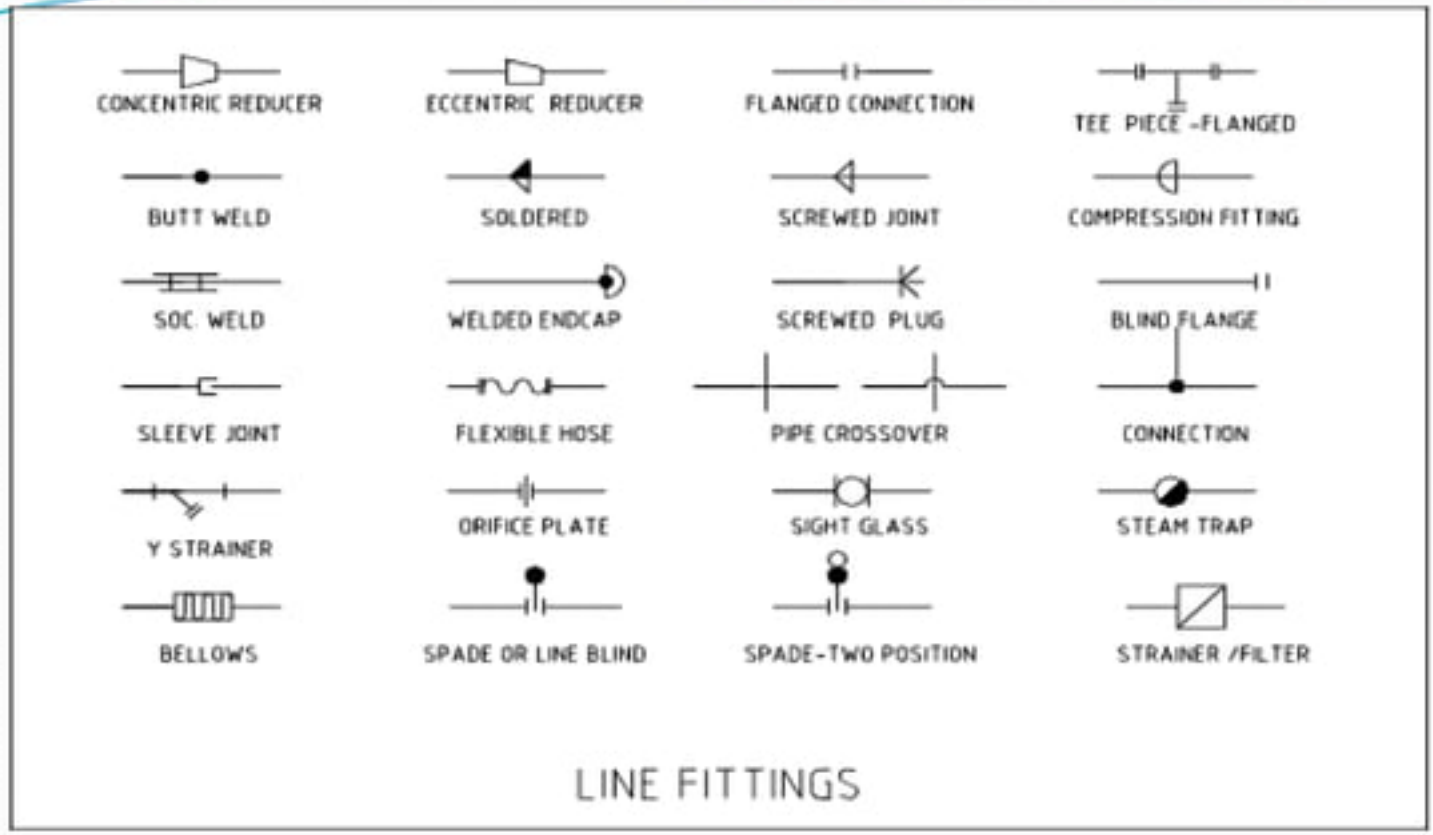
- Shown similar to the process piping in all respects
- Except continued to the margins of the process P&IDs
- Begins or terminates at a non-directional box shown on P&ID
- BOX- Name of the utility and Drawing no. of utility diagram

Miscellaneous Piping Items:

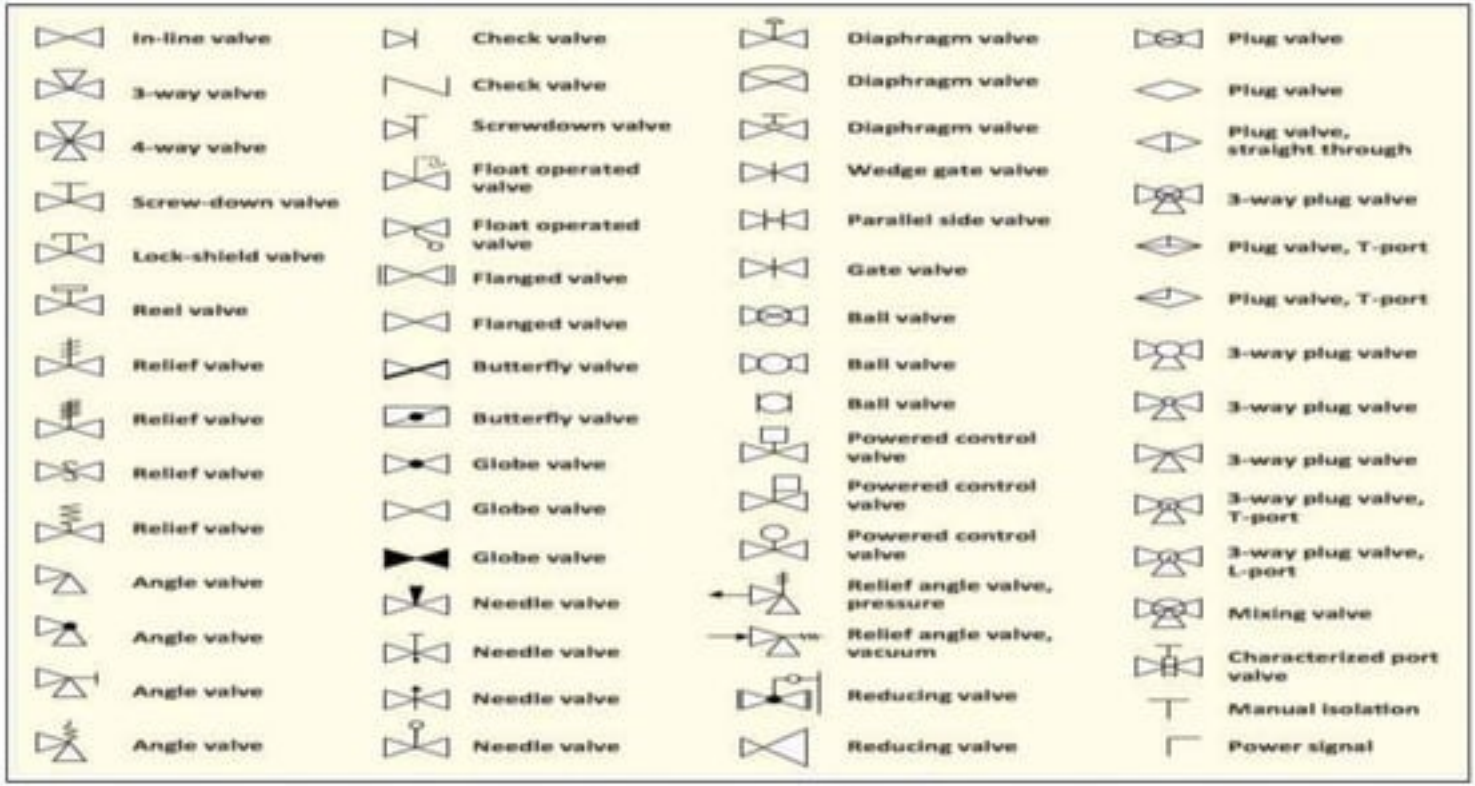
- All manual valves
- Self-contained regulating valve
- Rupture/Safety devices
- Drains
- Vents
- Flush connections
- Steam and Air traps
- Reducers /Expanders






CONCENTRIC REDUCER
ECCENTRIC REDUCER
FLANGED CONNECTION
TEE PIECE -FLANGED
BUTT WELD
SOLDERED
SCREWED JOINT
COMPRESSION FITTING
SOC WELD
WELDED ENDCAP
SCREWED PLUG
BLIND FLANGE
SLEEVE JOINT
FLEXIBLE HOSE
PIPE CROSSOVER
CONNECTION
Y STRAINER
ORIFICE PLATE
SIGHT GLASS
STEAM TRAP
BELLOWS
SPADE OR LINE BLIND
SPADE-TWO POSITION
STRAINER /FILTER
LINE FITTINGS

Valves on Piping



Instrument Symbology

- An instrument is a device that measures a physical quantity such as flow, temperature, level, distance, pressure.

- Instrumentation is the use of measuring instruments to monitor and control process.

- As a chemical plant has different processes occurring and we use instruments for the following reasons:
  - Reduce Variability
  - Increase Efficiency
  - Ensure Safety

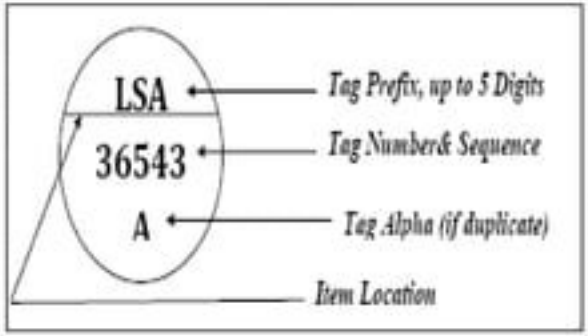
- P&IDs shows all instruments present over the plant in various processes.

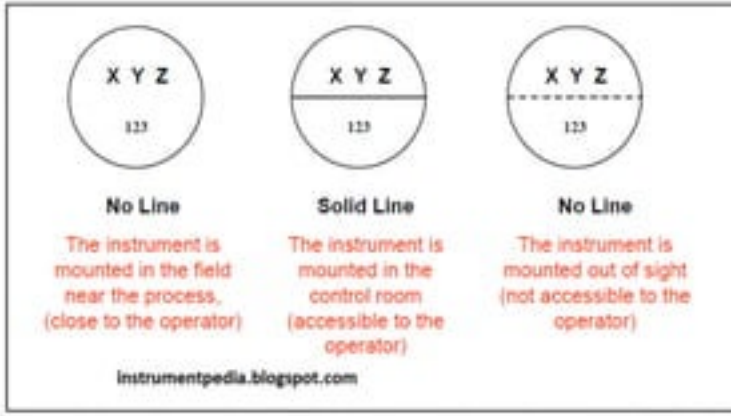
- Every instrument is identified and shown both schematically and symbolically on the P&IDs.

- Instrument specifications give the particular type, service, range, and manufacturer.

Instrument Identification

1. **Tag Prefixes**: 1st Letter, 2nd Letter & 3rd Letter
2. **Tag Number**: P&ID number and Sequence
3. **Tag Alphabetic**: In case of Duplicate
4. **Item Location**:
   - No Line → On Field
   - Solid Line → In control Room Panel
   - Dash Line → In control Room Behind panel
   - Double Solid Line → On Remote Panel
   - Double Dash Line → Behind Remote Panel

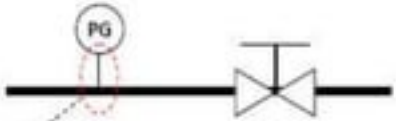




Process piping and sub-piping

A thick straight line represent main process piping

A thin straight line represent process sub-piping either to instruments or by-pass process line.



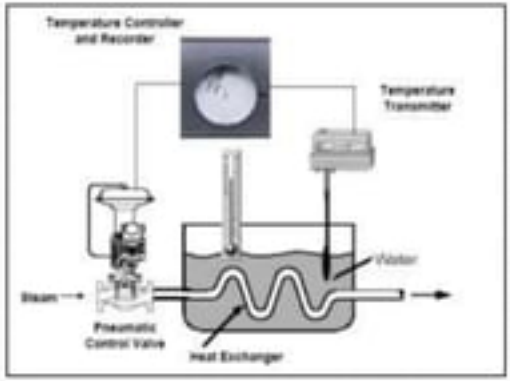
A circle representing locally mounted instrument

A circle with horizontal line representing control room panel mounted instrument.

A circle with horizontal line inside a square representing its function in DCS.

Industry to P&ID

1



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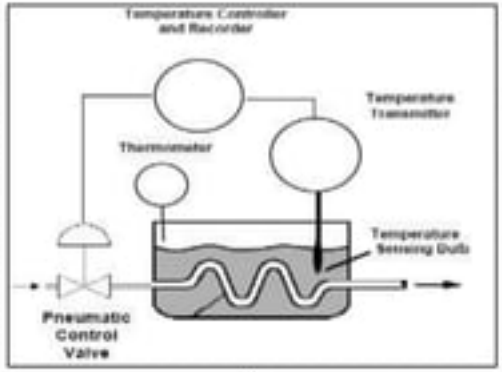

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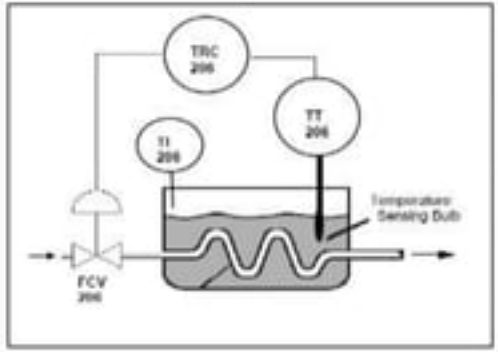

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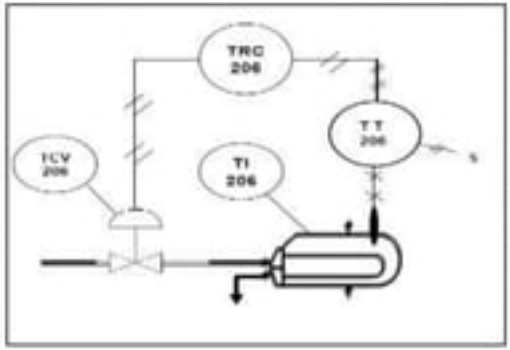
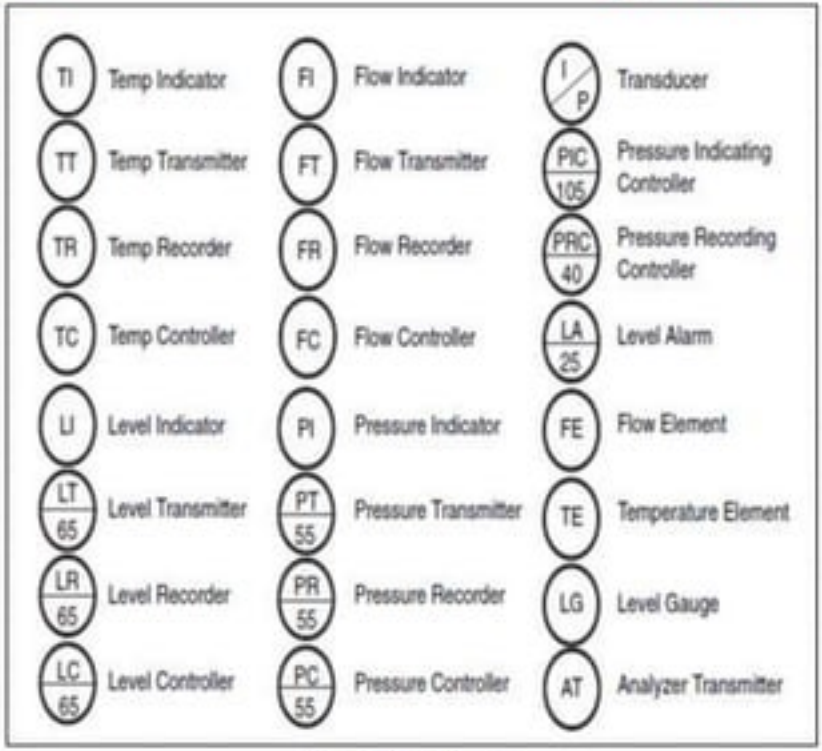
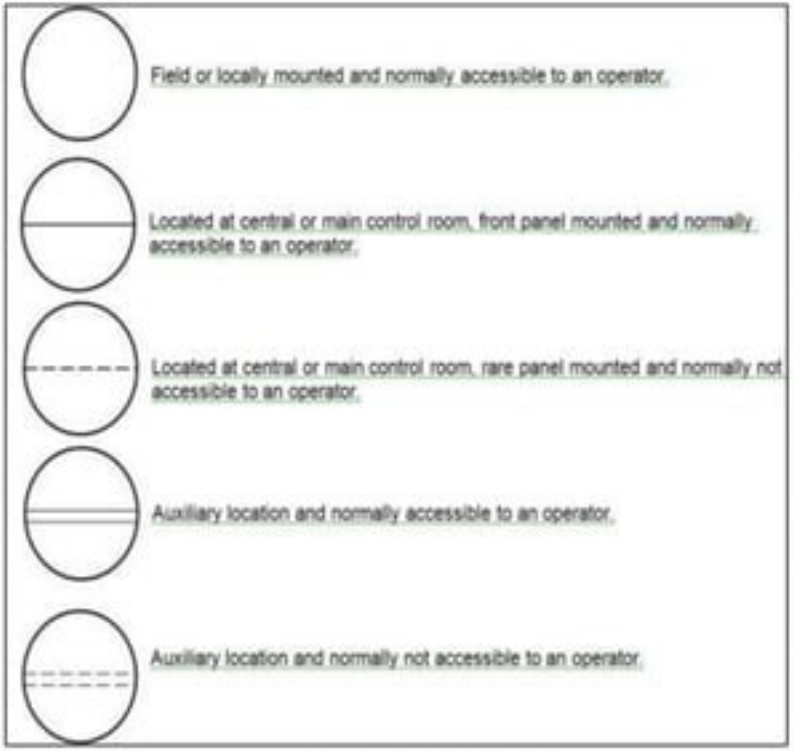


Tag Symbols



Tag Prefixes

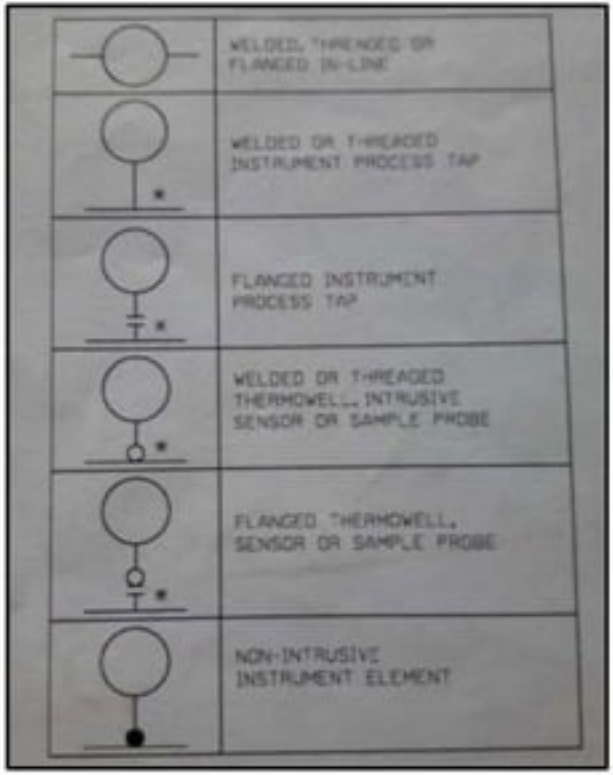


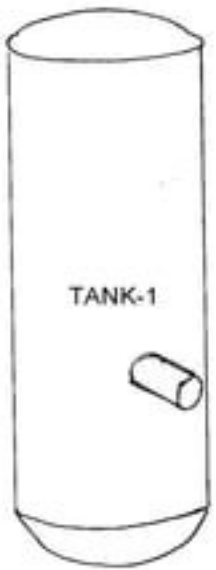
Item Location

Instrument Connections

- Welded, threaded or flanged in-line
- Welded or threaded instrument process tap
- Flanged instrument process tap
- Welded or threaded thermo well sensor or sample probe
- Flanged thermo well sensor or sample probe
- Non-intrusive instrument element

e.g. Temperature, Pressure, Level Instruments





S. Kundu
31st Aug 2002

In any plant various fluids flow through pipes from one end to other.

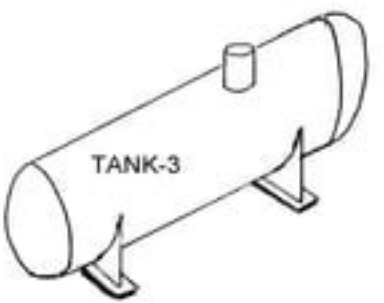
Now let us start with a plant where we see three tanks.

Tank-1, Tank-2 and Tank-3

We have to transfer the content of Tank no. 1 to the other two tanks.

We will need to connect pipes to transfer the fluids from Tank-1 to Tank-2 and Tank-3

LET US BRING THE PIPES.

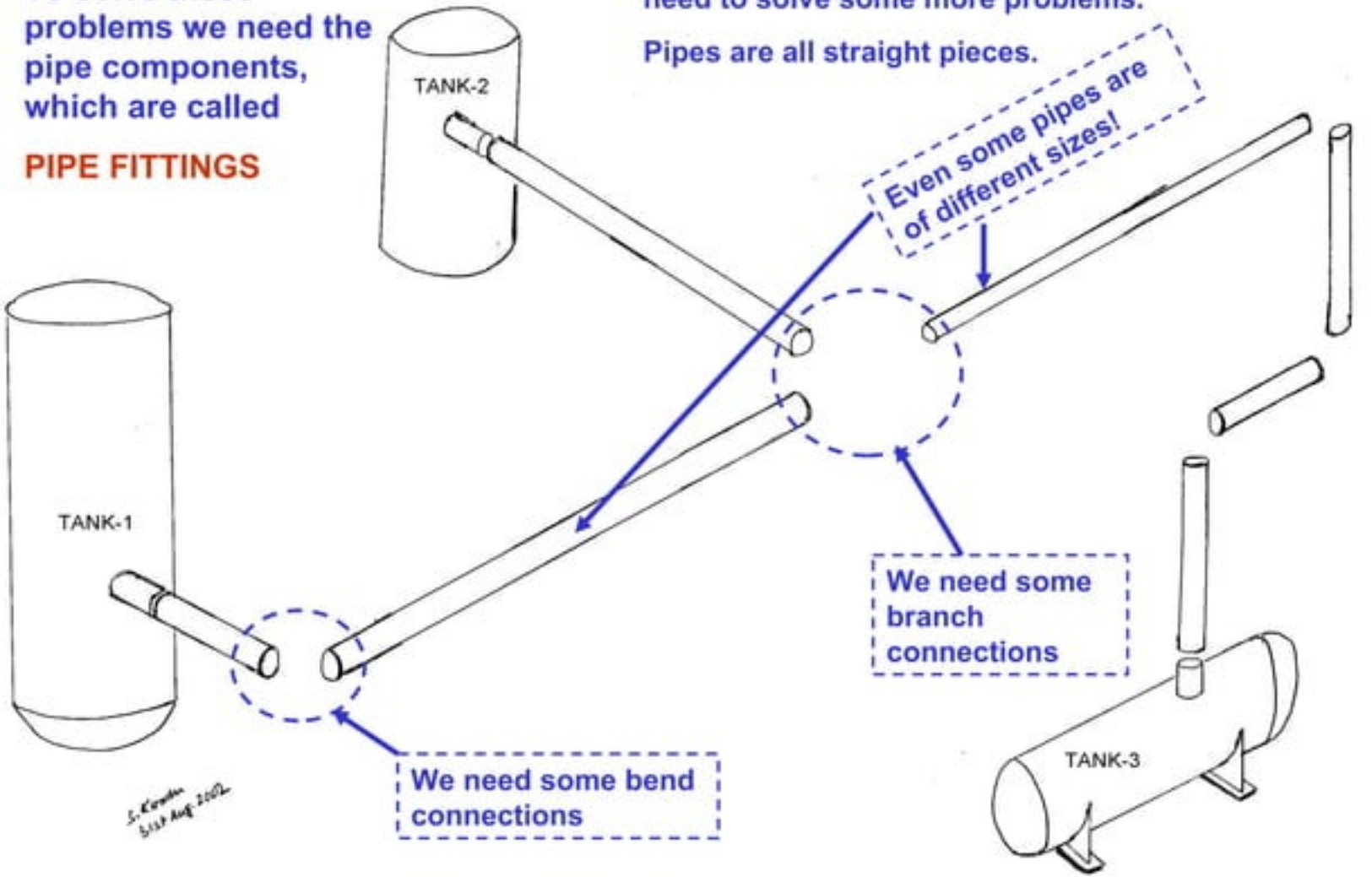


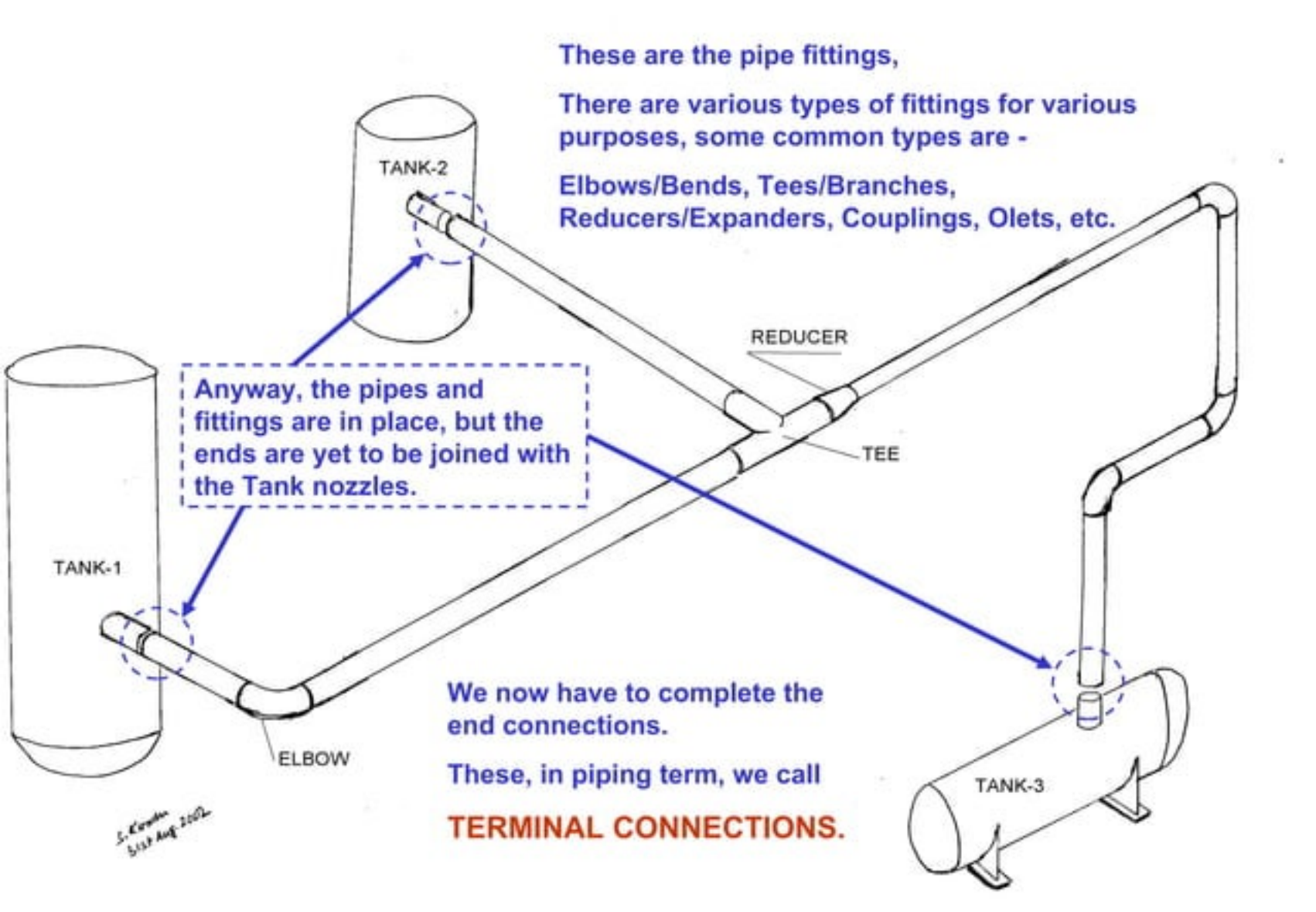
To solve these problems we need the pipe components, which are called

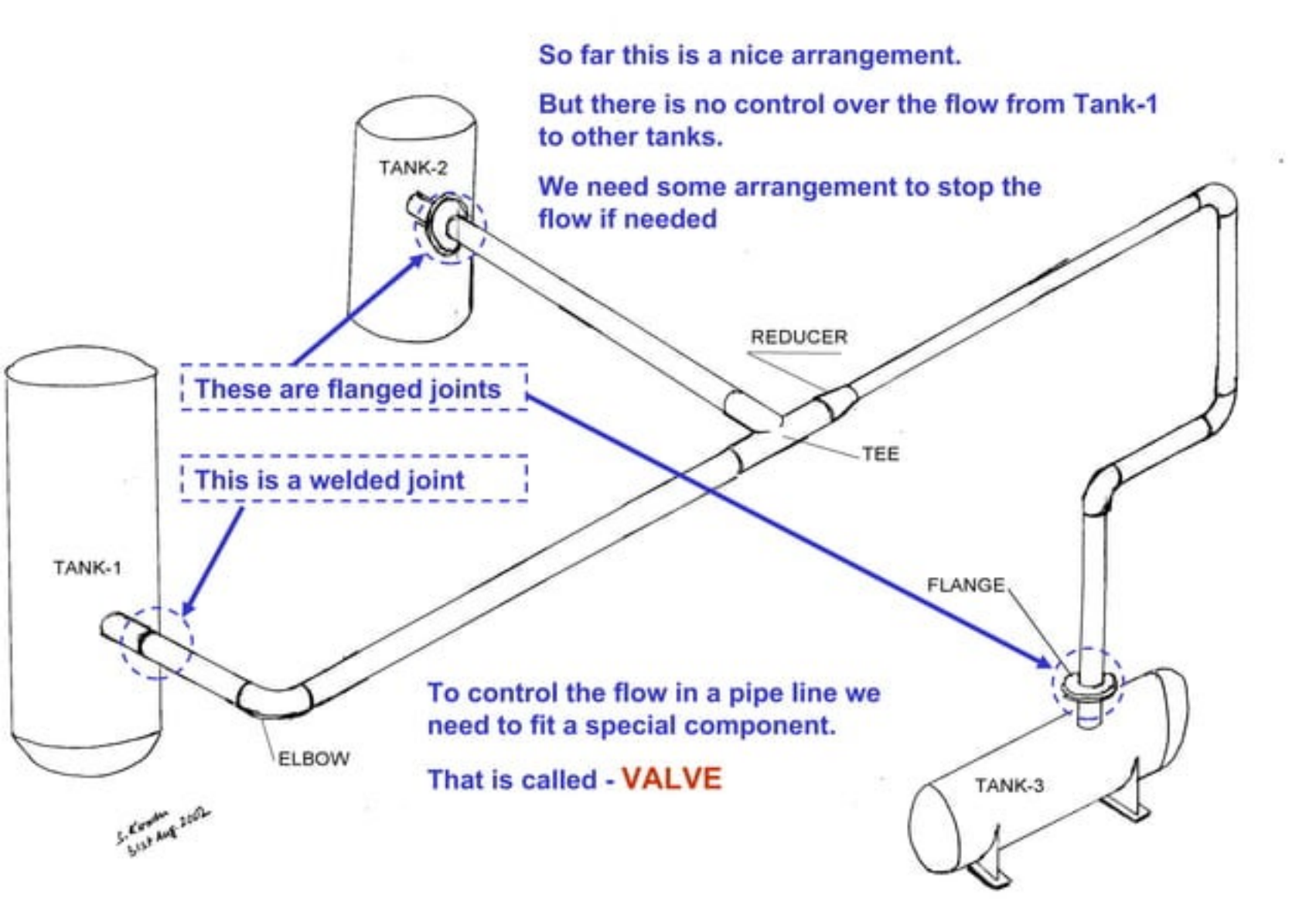
PIPE FITTINGS

We have just brought the pipes, now we need to solve some more problems.

Pipes are all straight pieces.

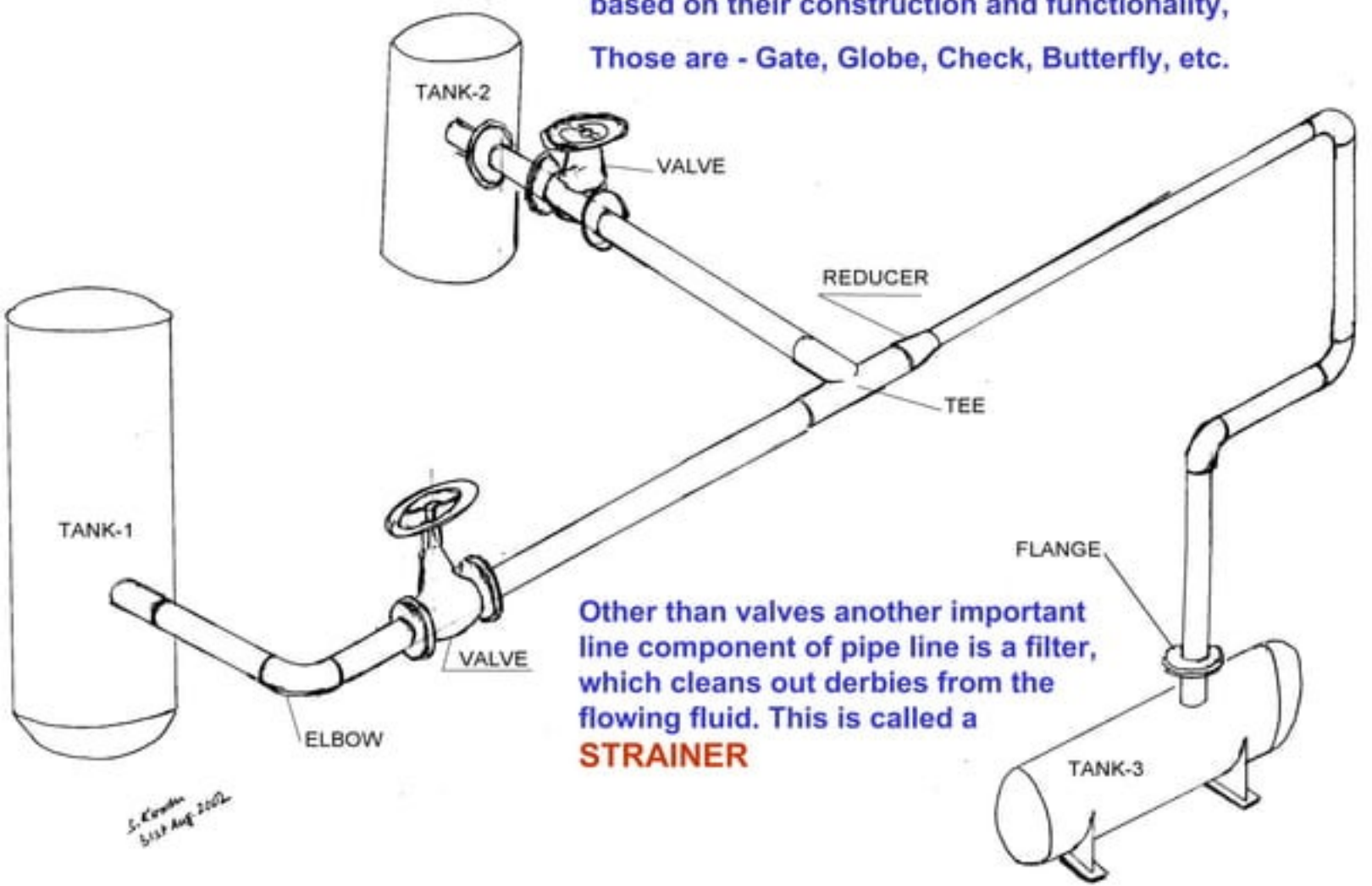



These are the pipe fittings,
There are various types of fittings for various purposes, some common types are -
Elbows/Bends, Tees/Branches, Reducers/Expanders, Couplings, Olets, etc.
TANK-2
REDUCER
TEE
Anyway, the pipes and fittings are in place, but the ends are yet to be joined with the Tank nozzles.
TANK-1
ELBOW
We now have to complete the end connections.
These, in piping term, we call
TERMINAL CONNECTIONS.
TANK-3

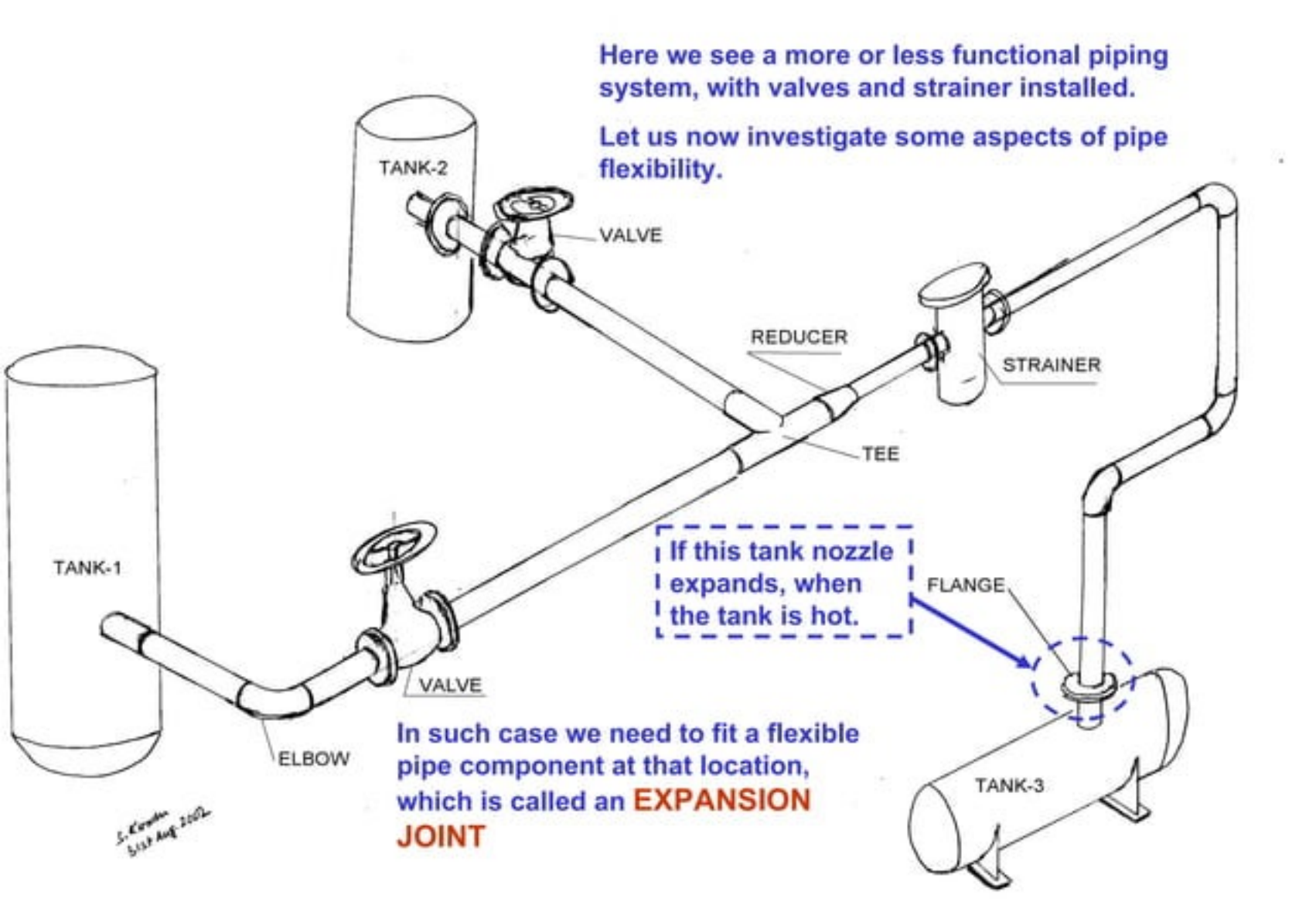

So far this is a nice arrangement.
But there is no control over the flow from Tank-1 to other tanks.
We need some arrangement to stop the flow if needed
TANK-2
REDUCER
These are flanged joints
TEE
This is a welded joint
TANK-1
FLANGE
ELBOW
To control the flow in a pipe line we need to fit a special component.
That is called - VALVE
TANK-3

There are many types of valves, categorized based on their construction and functionality,

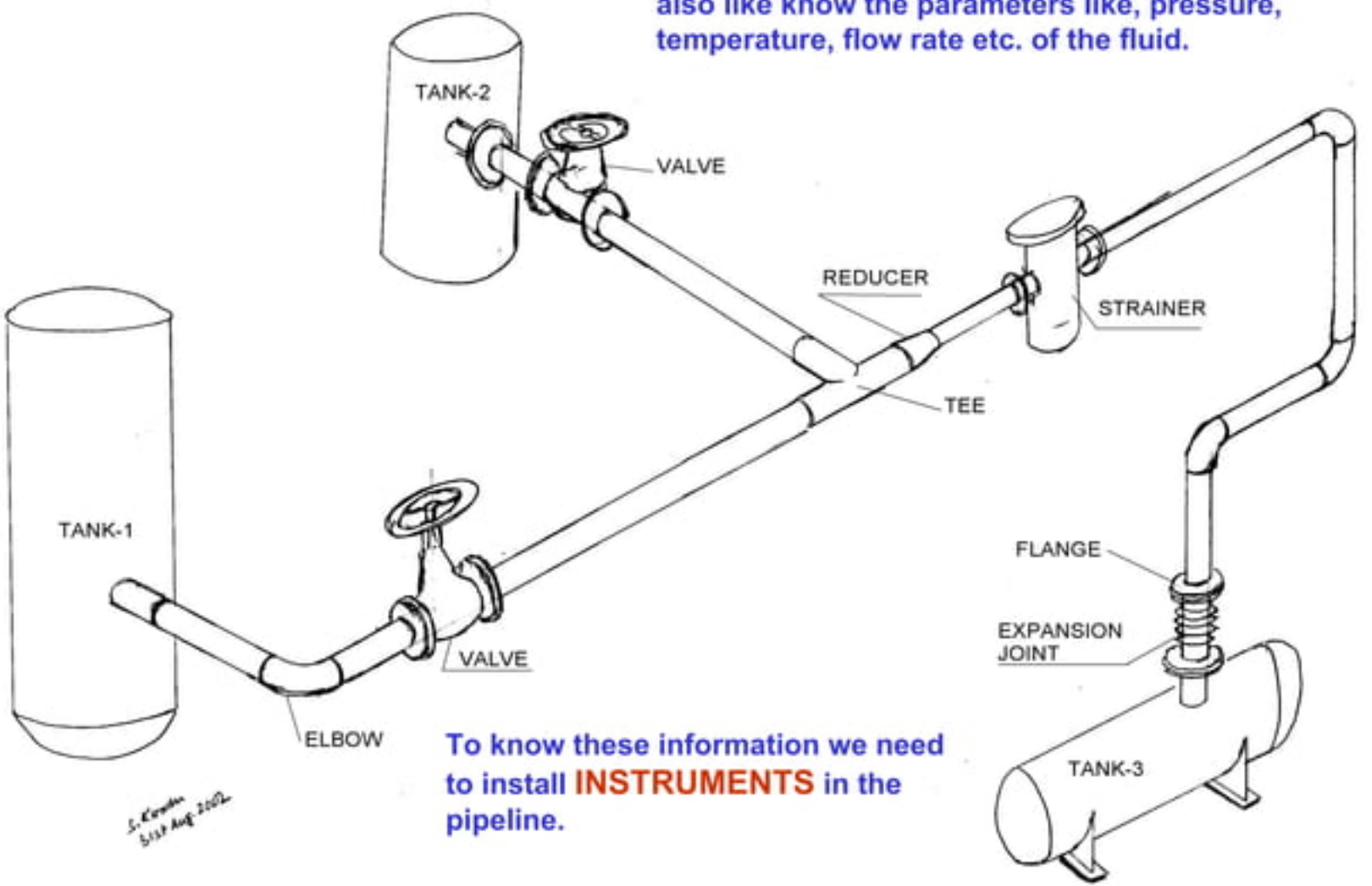
Those are - Gate, Globe, Check, Butterfly, etc.



Other than valves another important line component of pipe line is a filter, which cleans out derbies from the flowing fluid. This is called a **STRAINER**


Here we see a more or less functional piping system, with valves and strainer installed.
Let us now investigate some aspects of pipe flexibility.
TANK-2
VALVE
REDUCER
STRAINER
TEE
TANK-1
If this tank nozzle expands, when the tank is hot.
FLANGE
VALVE
ELBOW
TANK-3
In such case we need to fit a flexible pipe component at that location, which is called an EXPANSION JOINT

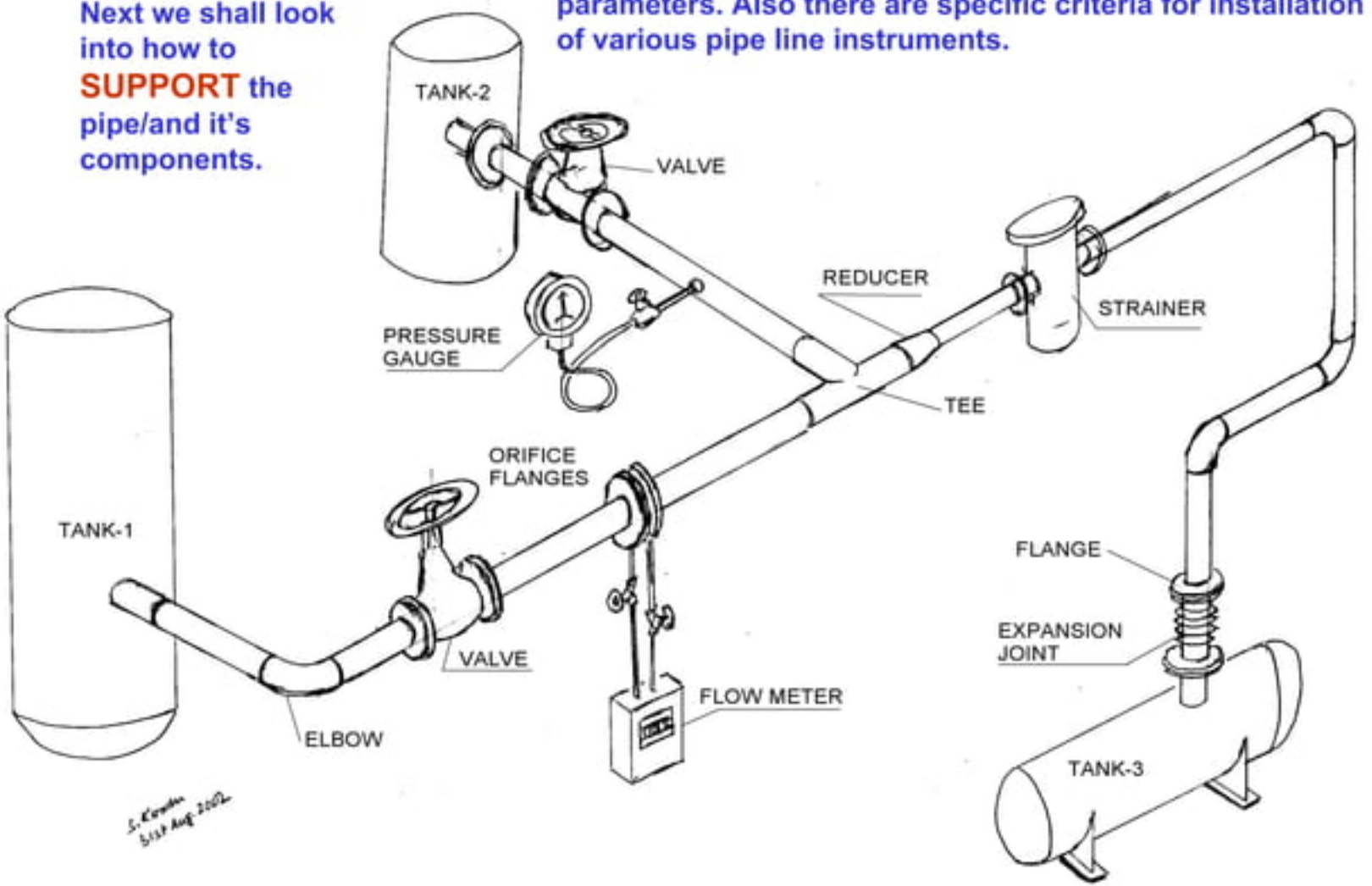
When some fluid is flowing in a pipe we may also like know the parameters like, pressure, temperature, flow rate etc. of the fluid.

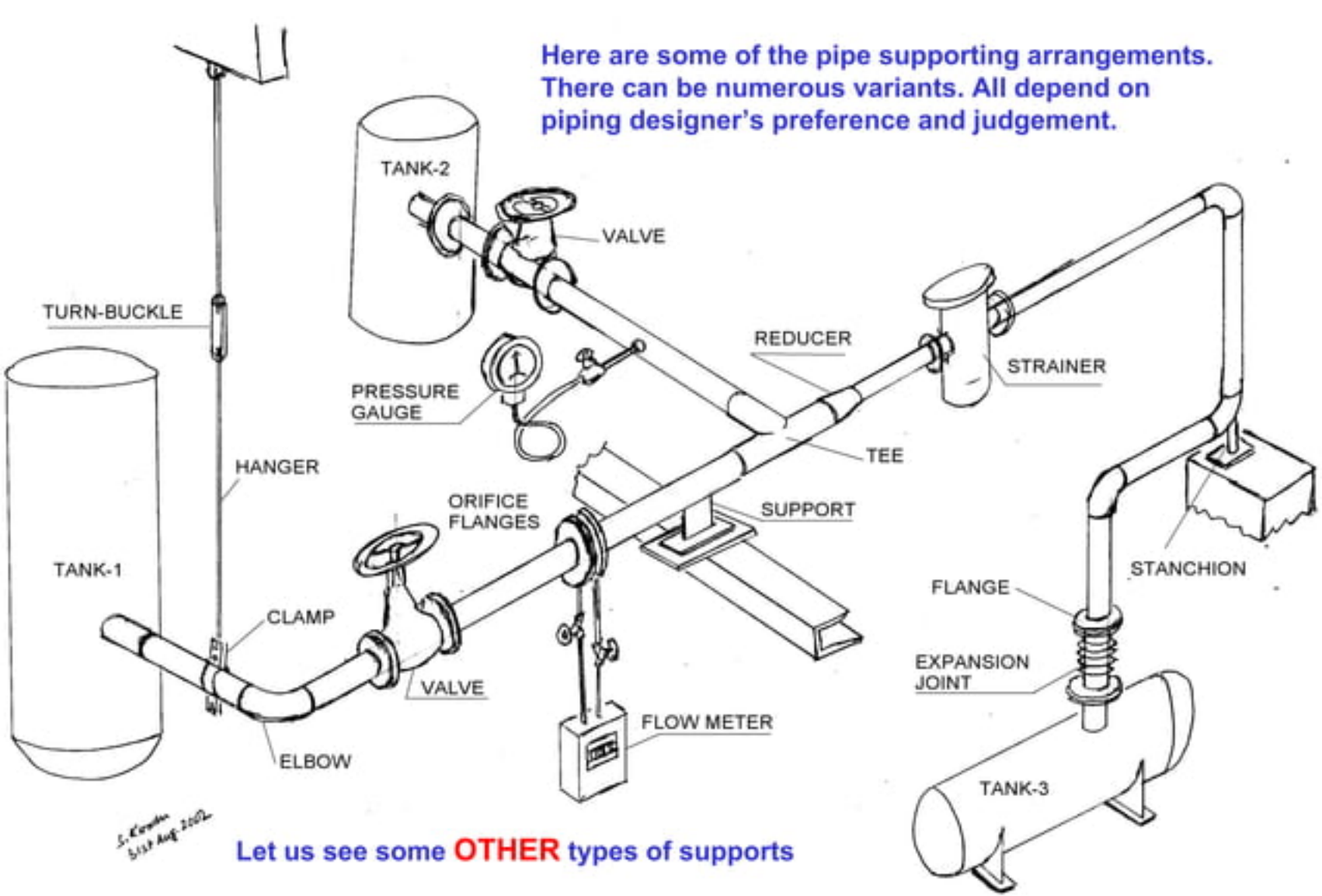


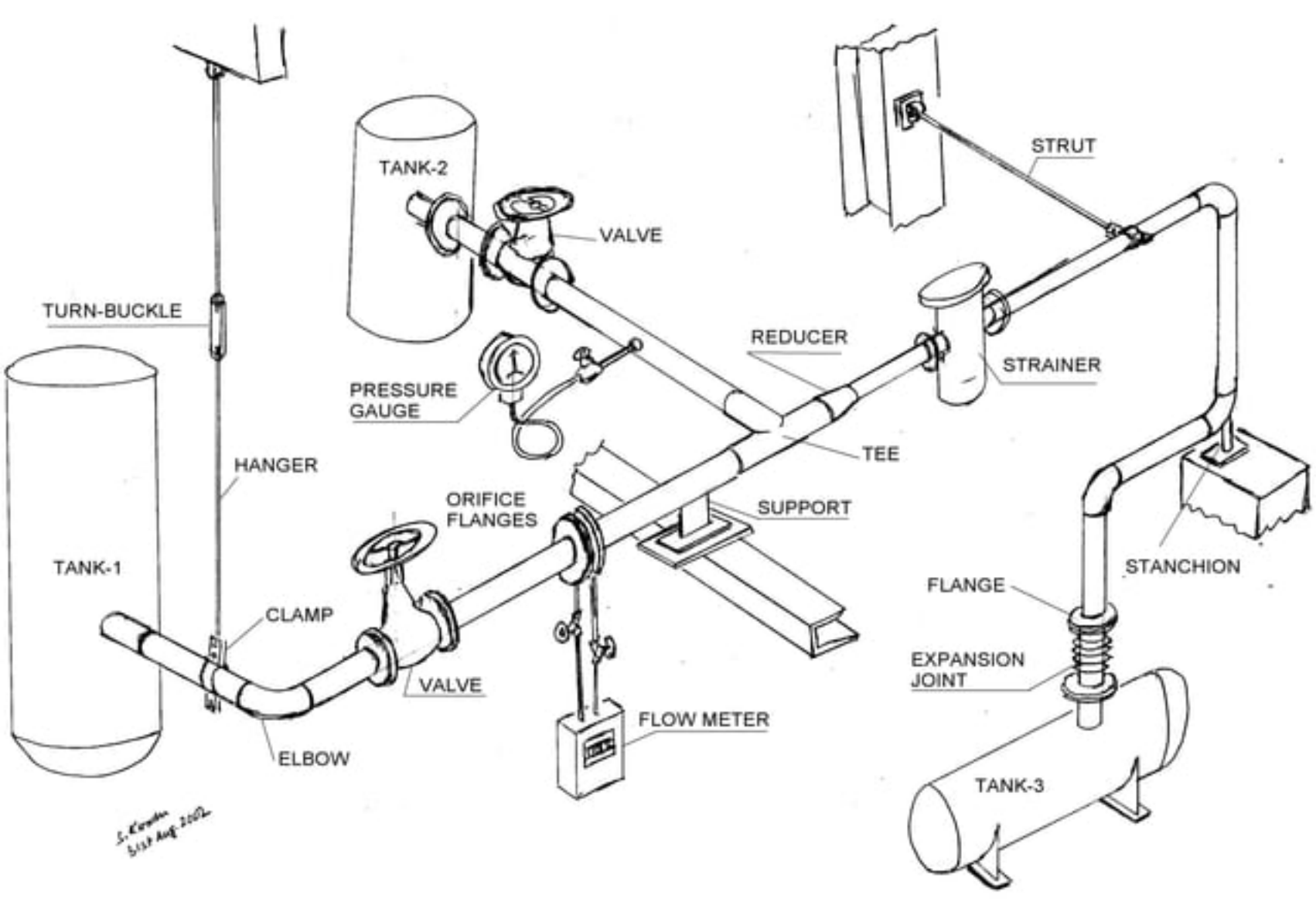
To know these information we need to install **INSTRUMENTS** in the pipeline.

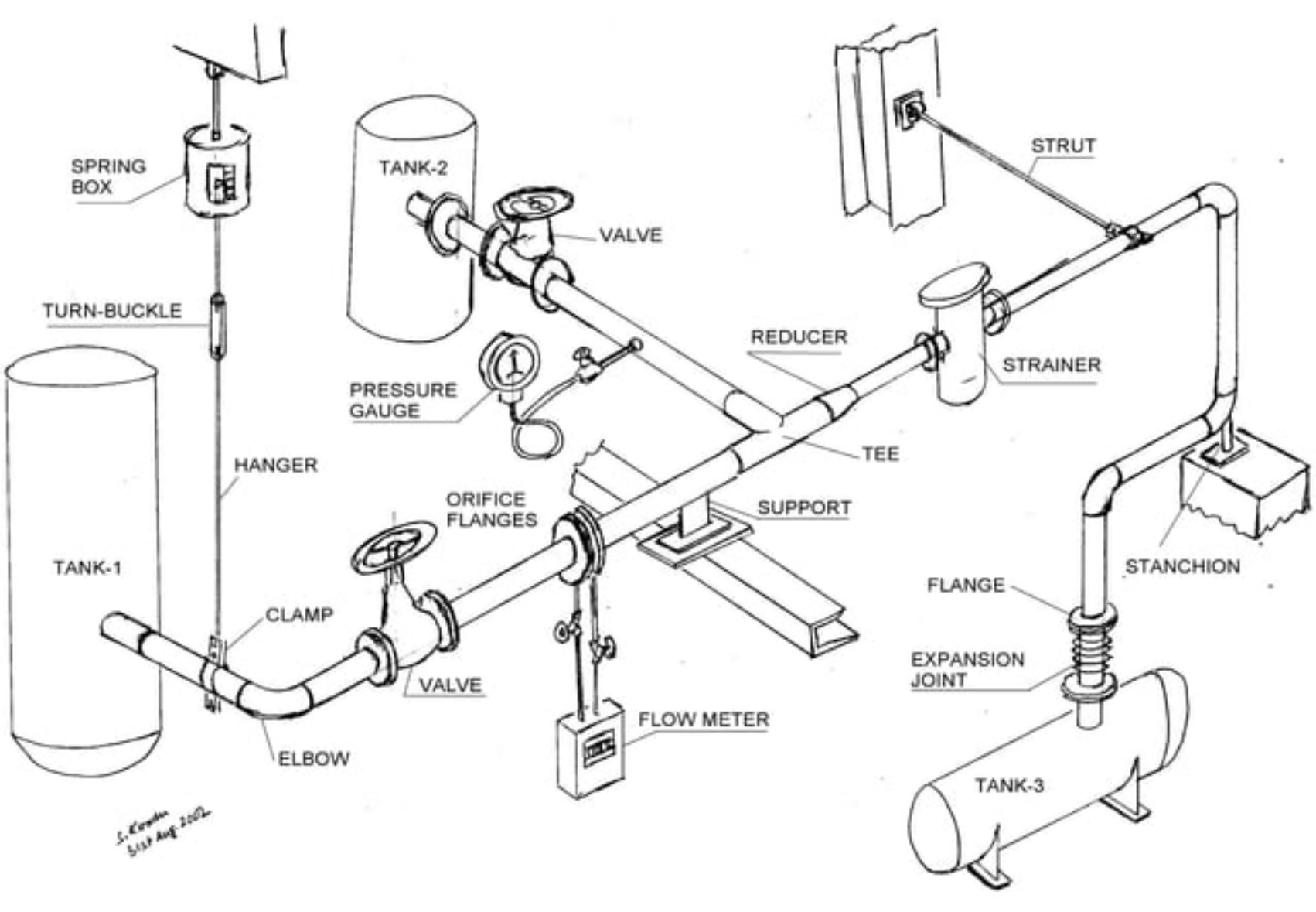
There are various types instruments to measure various parameters. Also there are specific criteria for installation of various pipe line instruments.

Next we shall look into how to **SUPPORT** the pipe/and it's components.




Here are some of the pipe supporting arrangements.
There can be numerous variants. All depend on
piping designer's preference and judgement.
TANK-2
VALVE
TURN-BUCKLE
REDUCER
STRAINER
PRESSURE
GAUGE
TEE
HANGER
ORIFICE
FLANGES
SUPPORT
TANK-1
STANCHION
FLANGE
CLAMP
EXPANSION
JOINT
VALVE
FLOW METER
ELBOW
TANK-3
Let us see some OTHER types of supports


TANK-2
VALVE
STRUT
TURN-BUCKLE
REDUCER
STRAINER
PRESSURE GAUGE
TEE
HANGER
ORIFICE FLANGES
SUPPORT
TANK-1
STANCHION
FLANGE
CLAMP
EXPANSION JOINT
VALVE
FLOW METER
ELBOW
TANK-3


SPRING BOX
TURN-BUCKLE
HANGER
TANK-1
CLAMP
ELBOW
TANK-2
VALVE
PRESSURE GAUGE
ORIFICE FLANGES
VALVE
FLOW METER
REDUCER
TEE
SUPPORT
STRUT
STRAINER
STANCHION
FLANGE
EXPANSION JOINT
TANK-3

We have just completed a pipe line design.

We shall rewind and check how it is really done in practice.

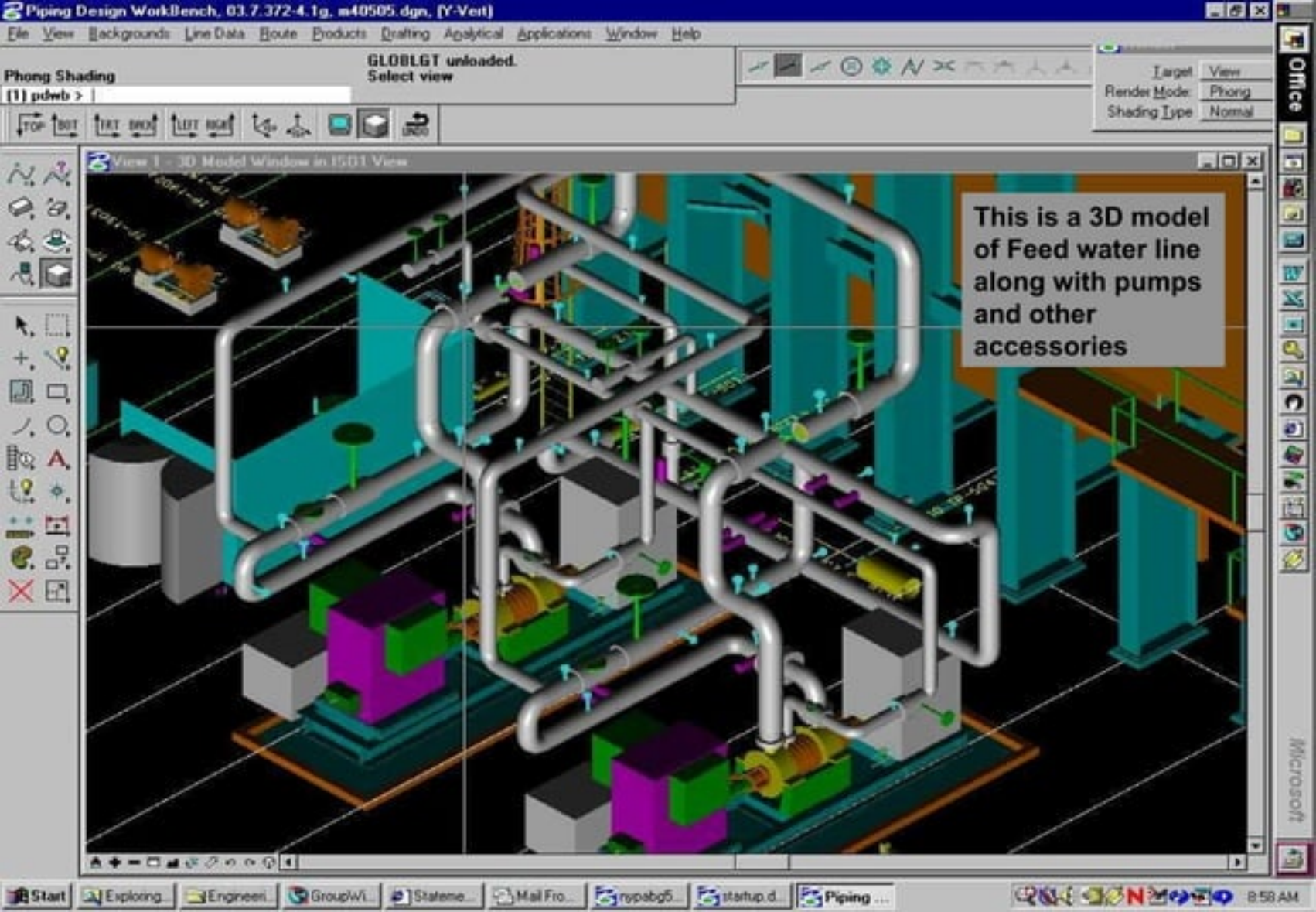
- First the flow scheme is planned,
  1) What, 2) From what point, 3) To which point
- Pipe sizes are selected, pipe material and pipe wall thickness are selected.
- Types of Valves are planned
- Also the types of instruments required are planned

We represent the whole thing in a drawing which is called Piping and Instrumentation Drawing, in short P&ID. For P&ID generation we use SPP&ID software.

By this time you have already come to know that while we prepare P&IDs in SPP&ID, we enter all the pipe lines system information in the drawing.

So the SPP&ID drawing is an Intelligent drawing which under it's surface carries all the information about a pipe like, Pipe size, Flowing Fluid, etc.

Let us see a P&ID prepared in SPP&ID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File View Backgrounds Line Data Route Products Drafting Analytical Applications Window Help
Phong Shading
GLOBLGT unloaded.
Select view
(1) pdwb >
Target View
Render Mode Phong
Shading Type Normal
This is a 3D model of Feed water line along with pumps and other accessories
Start
Exploring
Engineeri
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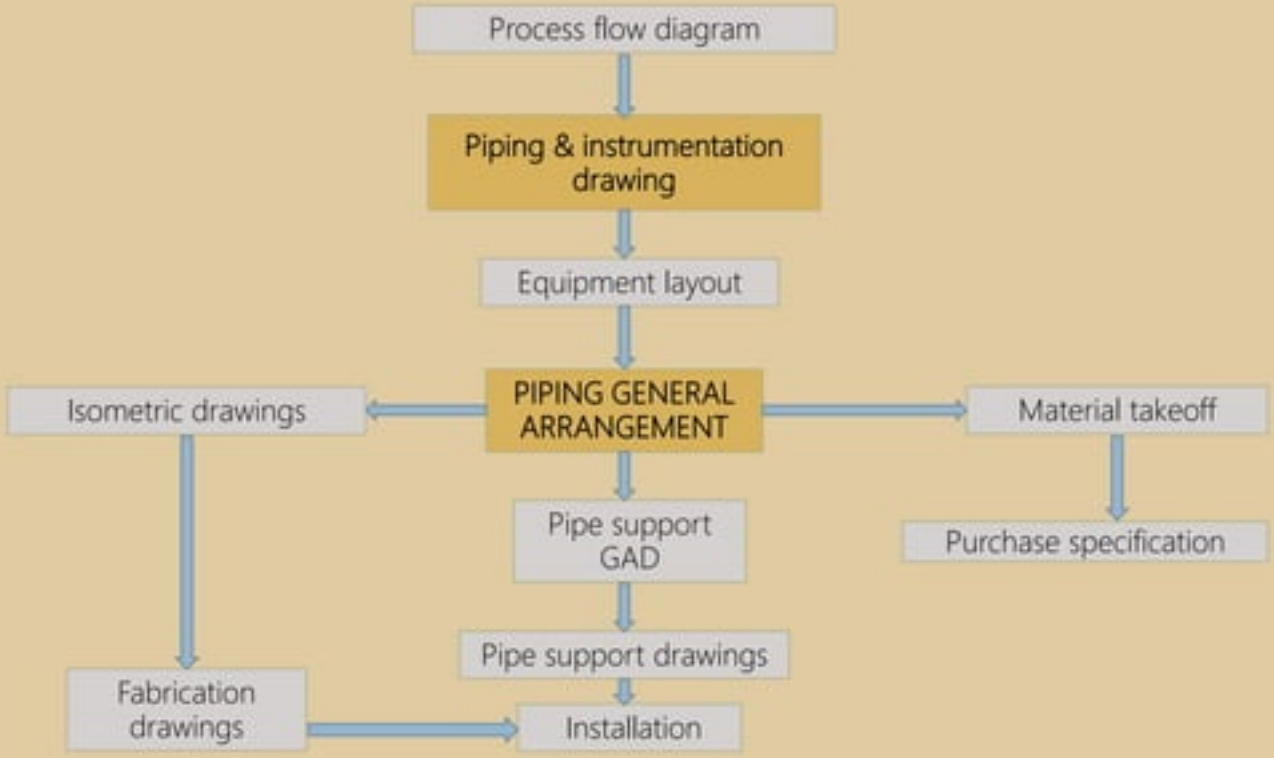
mypabg5
startup.d
Piping ...
8:58 AM

Pipe Scheduling

Week (5-6)

BLOCK DIAGRAM OF PIPING ENGINEERING



PIPING SYSTEM

- It convey the fluids, between the various equipment and end users.
- It consists of various components such as pipes, valves, fittings, online measuring instruments, etc.

DIFFERENCE BETWEEN PIPE AND TUBE

PIPE

- It is a tubular product of circular cross section that has specific sizes and thickness governed by particular dimensional standards.

TUBE

- It is a hollow product having circular, elliptical or square cross section or cross section of any closed perimeter. Tubes are also used for heat transfer purpose.

PIPE PRODUCTS

SEAMLESS PIPE

- A wrought tubular product made without a welded seam by drawing or extrusion process

WELDED PIPES

- Welded pipes are manufactured by ERW (Electric Resistance Welded).
- Pipes in small quantities are manufactured by EFW (electric fusion - welding) process .
- The longitudinal seam is welded by manual or automatic electric arc process.

CLASSIFICATION BASED ON END USE

LINE PIPE

- It is mainly used for conveying fluids over long distances and are subjected to fluid pressure. It is usually not subjected to high temperature.

PRESSURE PIPE

- These are subjected to fluid pressure and /or temperature. Fluid pressure in generally internal pressure or may be external pressure (e.g. Jacketed piping)and are mainly used as plant piping.

STRUCTURAL PIPE

- These are not used for conveying fluids and not subjected to fluid pressures or temperature. They are used as structural components (e.g. handrails, columns, sleeves etc.) and are subjected to static loads only.

NOMINAL PIPE SIZE (NPS)

- Pipes are designated by nominal size, starting from 1/8" nominal size, and increasing in steps.
- For the nominal size up to including 12" there is one unique OD (different from nominal size) and ID would vary depending on schedule number.
- For nominal sizes 14" and above O.D is same as nominal size.

WHY PIPE SIZE IS MORE IMPORTANT

- According to American Survey 30 % of the total cost of a chemical process plant goes for piping elements and valves. Take optimum pipe size while designing the pipe size.

AVAILABILTY OF PIPE SIZES

1. Sizes in steps of 1/8" from 1/8"to ½"
2. Sizes in steps of ¼"from ½" to 1 ½"
3. Sizes in steps of ½" from 1 ½" to 4"
4. Sizes in steps of 1" from 4" to 6"
5. Sizes in steps of 2" from 6" to 36"

WALL THICKNESS TOLERANCE

MILL TOLERANCE

- During manufacturing of seamless pipe while positioning the mandrel, this can deviate from its center by maximum of ±12.5% Hence minimum thickness of seamless pipe is considered ±12.5% less from average wall thickness.

MILL LENGTH

- Also known as random length .The usual run off mill pipe is 16 to 20 Ft. in length. Line pipe and pipe for power plant used are sometimes made in double length of 30-35 ft.

SCHEDULE NUMBER

Pipes are designated by schedule number .

Schedule number is represented by the pressure carrying capacity of the pipe.

Schedule = 1000 P/S where
P = service pressure (psi) - (Internal pressure)
S = allowable stress (psi) - (Allowable tensile strength of material)

Irrespective of pipe dia., equal schedules have equal pressure carrying capacity. For stainless steels schedule number are designated by suffix S i.e. 5S, 10S, 40S, 80S etc.

For pipes of all dimensions the outside diameter (O.D) remains relatively constant. The variation in wall thickness affects only the inside diameters (I.D.). The higher the schedule number is, the thicker the pipe is.

PIPING SCHEDULE

PIPE SCHEDULES & WEIGHTS					
		SCHEDULE 40		SCHEDULE 80	
NOMINAL PIPE SIZE	OUTSIDE DIAMETER	Wall Thick.	Wt. Per Ft.	Wall Thick.	Weight Per Ft.
1/8	0.405	0.068	0.245	0.095	0.315
1/4	0.540	0.088	0.425	0.119	0.535
3/8	0.675	0.091	0.568	0.126	0.739
1/2	0.840	0.109	0.851	0.147	1.088
3/4	1.050	0.113	1.131	0.154	1.474
1	1.315	0.133	1.679	0.179	2.172
1-1/4	1.660	0.140	2.273	0.191	2.997
1-1/2	1.900	0.145	2.718	0.200	3.631
2	2.375	0.154	3.653	0.218	5.022
2-1/2	2.875	0.203	5.793	0.275	7.661
3	3.500	0.216	7.576	0.300	10.250
3-1/2	4.000	0.226	9.109	0.318	12.510
4	4.500	0.237	10.790	0.337	14.980
5	5.563	0.258	14.620	0.375	20.780
6	6.625	0.280	18.970	0.432	28.570
8	8.625	0.322	28.550	0.500	43.390
10	10.750	0.365	40.480	0.500	54.740
12	12.750	0.375	49.560	0.500	65.420

PIPING SCHEDULE

Nominal Pipe Size		Outside Diameter	Wall Thickness (mm)															
			Stainless Steel				Carbon Steel											
DN	NPS	(mm)	Sch 5S	Sch 10S	Sch 40S	Sch 80S	Sch 10	Sch 20	Sch 30	Sch 40	STD	Sch 60	Sch 80	XS	Sch 100	Sch 120	Sch 140	Sch 160	XXS
6	⅛	10.3		1.24	1.73	2.41	1.24		1.45	1.73	1.73		2.41	2.41					
8	¼	13.7		1.65	2.24	3.02	1.65		1.85	2.24	2.24		3.02	3.02					
10	⅜	17.1		1.65	2.31	3.20	1.65		1.85	2.31	2.31		3.20	3.20					
15	½	21.3	1.65	2.11	2.77	3.73	2.11		2.41	2.77	2.77		3.73	3.73				4.78	7.47
20	¾	26.7	1.65	2.11	2.87	3.91	2.11		2.41	2.87	2.87		3.91	3.91				5.56	7.82
25	1	33.4	1.65	2.77	3.38	4.55	2.77		2.90	3.38	3.38		4.55	4.55				6.35	9.09
32	1¼	42.2	1.65	2.77	3.56	4.85	2.77		2.97	3.56	3.56		4.85	4.85				6.35	9.70
40	1½	48.3	1.65	2.77	3.68	5.08	2.77		3.18	3.68	3.68		5.08	5.08				7.14	10.15
50	2	60.3	1.65	2.77	3.91	5.54	2.77		3.18	3.91	3.91		5.54	5.54				8.74	11.07
65	2½	73.0	2.11	3.05	5.16	7.01	3.05		4.78	5.16	5.16		7.01	7.01				9.53	14.02
80	3	88.9	2.11	3.05	5.49	7.62	3.05		4.78	5.49	5.49		7.62	7.62				11.13	15.24
90	3½	101.6	2.11	3.05	5.74	8.08	3.05		4.78	5.74	5.74		8.08	8.08					
100	4	114.3	2.11	3.05	6.02	8.56	3.05		4.78	6.02	6.02		8.56	8.56		11.13		13.49	17.12
125	5	141.3	2.77	3.40	6.55	9.53	3.40			6.55	6.55		9.53	9.53		12.70		15.88	19.05
150	6	168.3	2.77	3.40	7.11	10.97	3.40			7.11	7.11		10.97	10.97		14.27		18.26	21.95
200	8	219.1	2.77	3.76	8.18	12.70	3.76	6.35	7.04	8.18	8.18	10.31	12.70	12.70	15.09	18.26	20.62	23.01	22.23
250	10	273.1	3.40	4.19	9.27	12.70	4.19	6.35	7.80	9.27	9.27	12.70	15.09	12.70	18.26	21.44	25.40	28.58	25.40
300	12	323.9	3.96	4.57	9.53	12.70	4.57	6.35	8.38	10.31	9.53	14.27	17.48	12.70	21.44	25.40	28.58	33.32	25.40
350	14	355.6	3.96	4.78	9.53	12.70	6.35	7.92	9.53	11.13	9.53	15.09	19.05	12.70	23.83	27.79	31.75	35.71	
400	16	406.4	4.19	4.78	9.53	12.70	6.35	7.92	9.53	12.70	9.53	16.66	21.44	12.70	26.19	30.96	36.53	40.49	
450	18	457	4.19	4.78	9.53	12.70	6.35	7.92	11.13	14.27	9.53	19.05	23.83	12.70	29.36	34.93	39.67	45.24	
500	20	508	4.78	5.54	9.53	12.70	6.35	9.53	12.70	15.09	9.53	20.62	26.19	12.70	32.54	38.10	44.45	50.01	
550	22	559	4.78	5.54			6.35	9.53	12.70		9.53	22.23	28.58	12.70	34.93	41.28	47.63	53.98	
600	24	610	5.54	6.35	9.53	12.70	6.35	9.53	14.27	17.48	9.53	24.61	30.96	12.70	38.89	46.02	52.37	59.54	
650	26	660					7.92	12.70			9.53			12.70					
700	28	711					7.92	12.70	15.88		9.53			12.70					
750	30	762	6.35	7.92			7.92	12.70	15.88		9.53			12.70					

These dimensions are nominal – substantial tolerances apply to both OD and WT – refer to the standards for details.
Stainless steel pipe nominal dimensions based on ASTM A312M and ASME B36.19M-2004.
Carbon steel pipe nominal dimensions based on ASTM A106M and ASME B36.10M-2004. For other wall thicknesses and for sizes of carbon steel pipe above DN 750 consult ASME B36.10M.

COMPONENTS OF PIPING SYSTEM

1. Pipe
2. Fittings (Elbows, Tees, Reducers, Couplings, Unions, Olets)
3. Flanges
4. Gaskets
5. Fasteners
6. Valves
7. Special fittings
8. Specialty items (strainers, traps, bellows etc.)

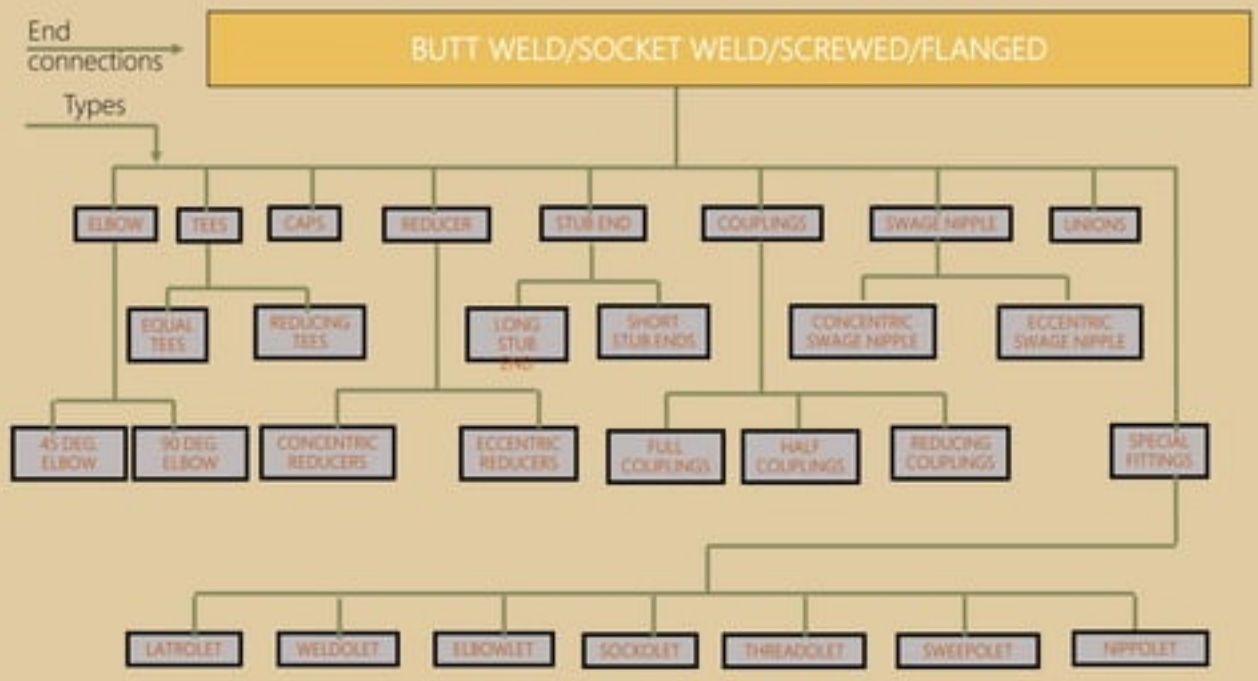
Pipe Fitting

Week (7-8)

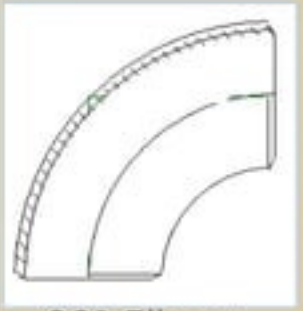
FITTINGS

- Pipe fittings are the components which tie together pipelines, valves, and other parts of a piping system.
- Fittings may come in butt Welded, Socket welded, Screwed and flanged connections.
- They are used to change the size of the line or its direction.

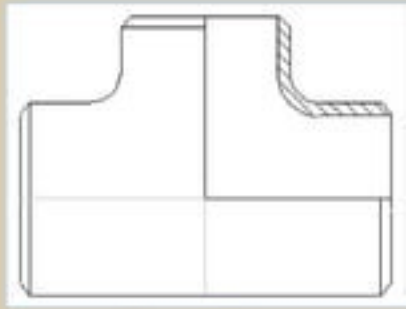
STANDARD PIPE FITTING



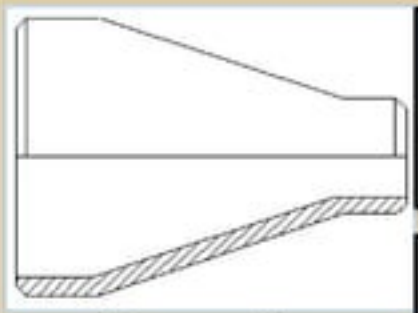
COMMON PIPE FITTINGS



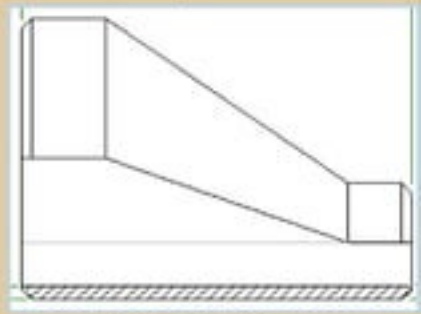
90° Elbow



Equal Tee

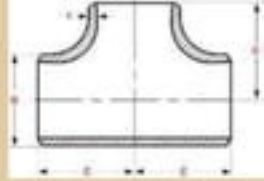


Concentric Reducer



Eccentric Reducer

TEES



STRAIGHT TEE / EQUAL TEE

It is used when the branch and header are the same.

REDUCING TEE

It is used when the branch size is smaller than the header size.

POINT TO REMEMBER

It is expensive and requires three butt welds. Alternatively for low pressure services , branching off is done by direct welding of pipe to pipe instead of standard Tee.

ELBOWS

They are used to change direction of pipe.

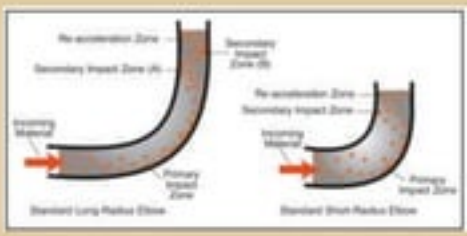
1. LONG RADIUS (LR) AND
2. SHORT RADIUS (SR)ELBOWS.

90 degree elbow comes in LR and SR.

45 degree elbow comes in LR only.

The LR elbows radius is 1.5 times the nominal size. The SR elbows radius is 1 times the nominal size.

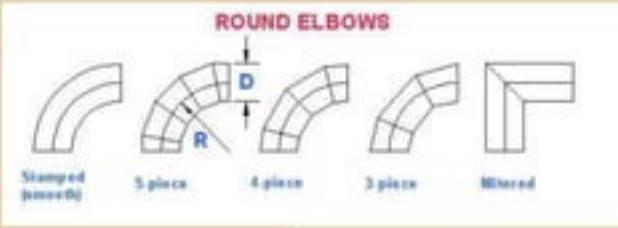
Normally elbows are butt-welded, socket welded or sometimes bolted connections are also available. Reducing elbows are available on 90 degree only and the radius is 1.5 times of the larger end



MITRE BENDS

These are fabricated bends for larger diameter piping, low pressure (50 psi are less) pressure applications.

It is made out of two, three, four segments of pipe pieces. These are normally used for non critical services. (water, drainage, and wend piping)

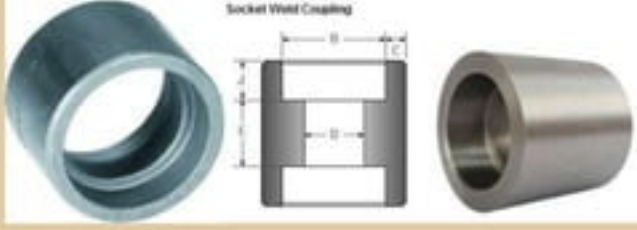


COUPLINGS & UNIONS

COUPLINGS

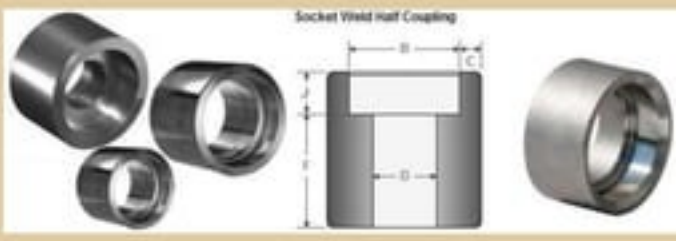
FULL COUPLING

It is used to connect small bore pipes as projection of welding inside the pipe bore reduce the flow area



HALF COUPLING

It is used for branch connection

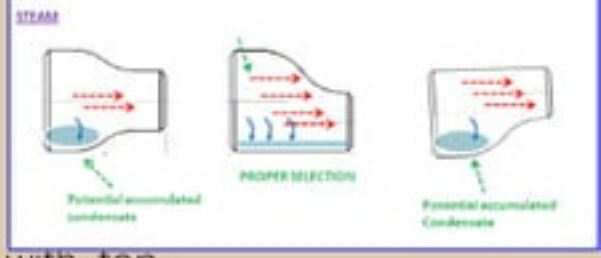


UNIONS

It is used where dismantling of the pipe is required more often. It can be with threaded end or socket weld ends.

REDUCERS

It makes reduction in line size

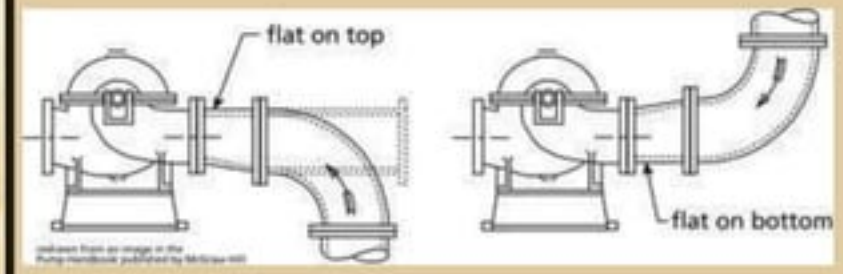


ECCENTRIC REDUCER

It is used to pump suction to avoid cavitation with top surface being flat.

To maintain elevation bottom of pipe (BOP) in rack.

Offset dimension is ½ the difference of the two inside diameters. Eccentric reducer are costlier than concentric reducer. <u>Designer to optimize the requirement</u>



REDUCERS

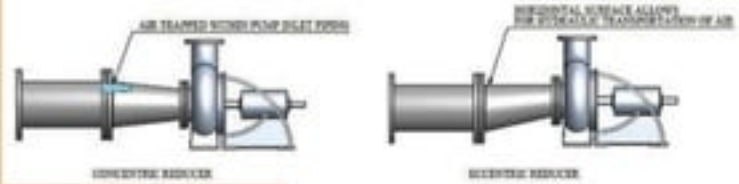
CONCENTRIC REDUCER

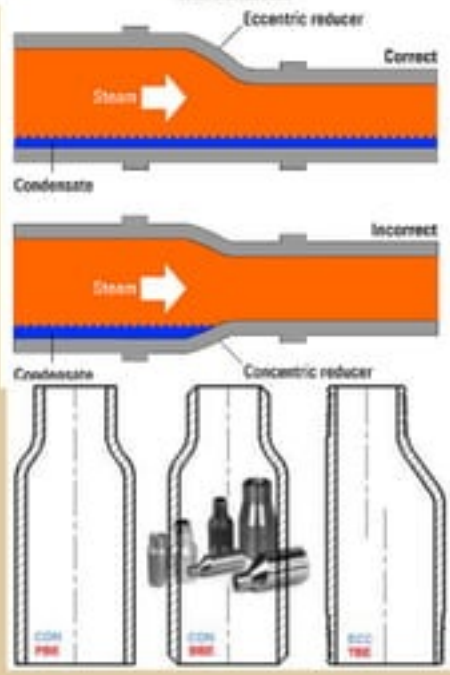
It is used on pump discharge, vertical pipe line etc.

SWAGE NIPPLE

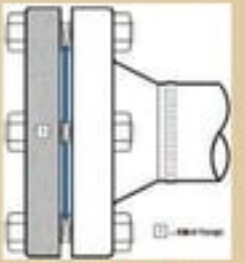
It is also like a reducer, it connect butt welded pipe to smaller screwed or welded pipe .

concentric and eccentric swage nipples are also available.



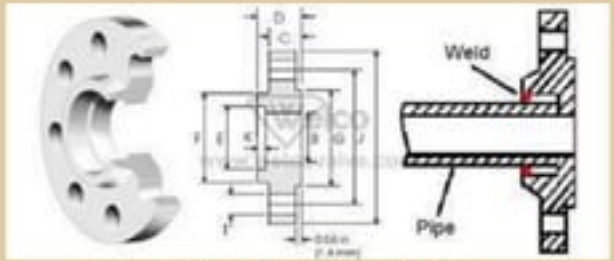


FLANGES

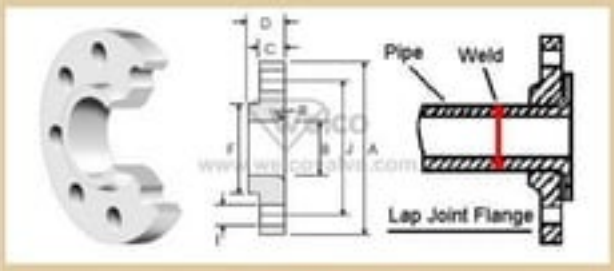


BLIND FLANGES

SLIP ON FLANGES



SOCKET WELDING FLANGE



LAP-JOINT FLANGE

THREADED FLANGES

WELDING NECK FLANGES

FLANGES

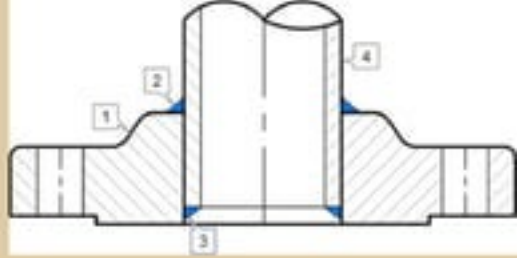
Flanges can be classified based on the attachment to the piping

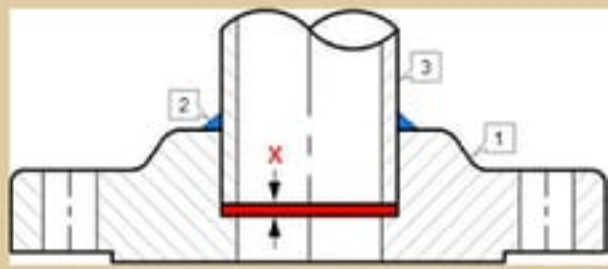
SLIP ON

These flanges are attached by fillet welding inside as well as outside. Used where quick assembly, saving in cost and where extreme load condition are not present .

SOCKET WELD

These flanges are welded only one side. Is is used for small bore only.

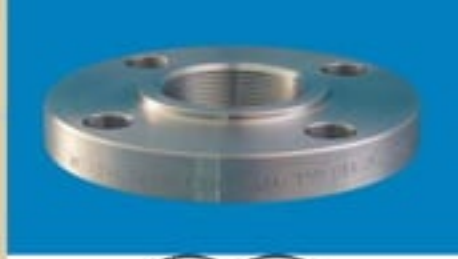


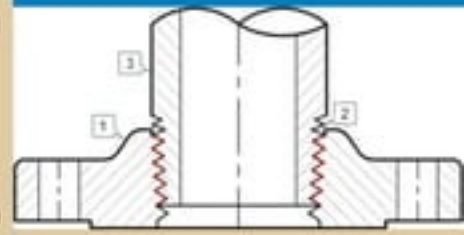


FLANGES

SCREWED

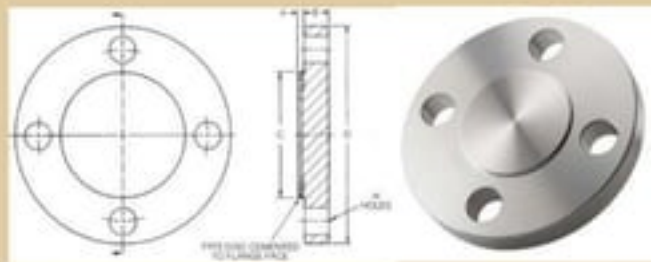
These flanges are used on pipe lines where low pressure and temperature are envisaged. Generally used in galvanized lines.





BLIND FLANGE

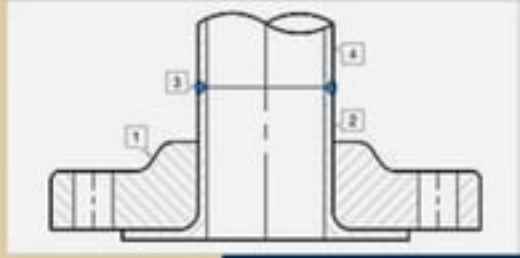
These flanges are used to close the ends which need to be reopened later, also used for blanking the dead end during hydro test.



FLANGES

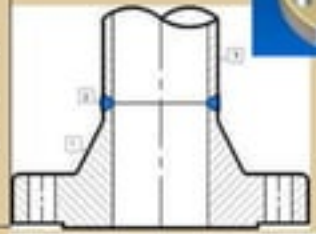
LAP JOINT

These flanges are used with stub ends when piping is of a exotic material. Stub ends will be butt welded to the piping and the flanges are keep loose over the same.



WELDING NECK

These flanges are generally butt welded to the pipes where excessive direct bending stress on the flanged joint or supporting heavy equipment are envisaged.



BUTT WELDED FITTINGS (ASME B16.9)

ADVANTAGES

Higher pressure and temperature conditions. Leak proof joints and almost maintenance free.

DISADVANTAGE

Weld projection will affect flow. Edge preparation is necessary.

RATING OF FLANGE

Flange are also classified by pressure – temperature ratings as per ANSI B 16.5.It is available in seven ratings 150#, 300#, 400#, 600#, 900#, 1500# and 2500#.These flange rating are called nominal rating. pressure – temperature combines determines the flange rating.

FLANGE RATING

All Dimension in Inches

LINE SIZE	150#			300#			600#			900#			1500#			2500#		
	O.D.	I.D.	THKS	O.D.	I.D.	THKS	O.D.	I.D.	THKS	O.D.	I.D.	THKS	O.D.	I.D.	THKS	O.D.	I.D.	THKS
1/2	1 3/8	5/8	5/16	2	5/8	5/16	2	5/8	5/16	2 3/8	5/8	5/16	2 3/8	5/8	5/16	2 3/8	5/8	3/8
3/4	1 7/8	7/8	5/16	2 1/2	7/8	5/16	2 1/2	7/8	5/16	2 5/8	7/8	5/16	2 5/8	7/8	3/8	2 7/8	7/8	3/8
1	2 1/2	1 1/16	5/16	2 3/4	1 1/16	5/16	2 3/4	1	5/16	3	1	5/16	3	1	3/8	3 1/4	1	3/8
1 1/4	2 7/8	1 3/8	5/16	3 1/8	1 3/8	5/16	3 1/8	1 3/8	3/8	3 3/8	1 3/8	3/8	3 3/8	1 3/8	1/2	4	1 3/8	1/2
1 1/2	3 1/4	1 7/8	5/16	3 5/8	1 7/8	5/16	3 5/8	1 3/8	3/8	3 3/4	1 3/8	3/8	3 3/4	1 3/8	1/2	4 1/2	1 3/8	5/8
2	4	2 3/8	5/16	4 1/4	2 3/8	3/8	4 1/4	2 1/8	3/8	5 1/2	2 1/8	1/2	5 1/2	2	1/2	5 1/2	2	5/8
2 1/2	4 3/4	2 7/8	5/16	5	2 7/8	3/8	5	2 3/8	1/2	6 3/8	2 3/8	1/2	6 3/8	2 1/2	5/8	6 1/2	2 3/8	3/4
3	5 1/2	3 1/2	5/16	6 3/4	3 1/2	3/8	5 3/4	3 1/4	1/2	6 1/2	3 1/4	5/8	6 3/4	3	3/4	7 1/2	3	7/8
3 1/2	6 1/4	4	5/8	6 3/8	4	3/8	6 1/4	3 3/4	5/8									
4	6 3/4	4 1/2	5/8	7	4 1/2	1/2	7 1/2	4 1/4	5/8	8	4 1/4	3/4	8 1/2	4	7/8	8 1/2	4	1 1/8
5	7 3/8	5 1/2	5/8	8 3/8	5 1/2	5/8	8 3/8	5 3/8	3/4	8 3/8	5 1/4	7/8	9 1/4	5	1 1/8	10 1/2	5	1 3/8
6	8 3/8	6 5/8	1/2	9 3/4	6 5/8	5/8	10 3/8	6 3/8	7/8	11	6 3/8	1	11	6	1 3/8	12 3/8	6	1 5/8
8	10 7/8	8 5/8	1/2	12	8 5/8	7/8	12 1/2	8 3/8	1 1/8	14	8 3/8	1 3/8	13 3/4	8	1 5/8	15 1/8	7 7/8	2 1/8
10	13 1/8	10 3/4	5/8	14 1/8	10 3/4	1	15 3/8	10 3/8	1 1/4	17	10 3/8	1 5/8	17	10	2	18 5/8	9 3/4	2 5/8
12	16	12 3/4	3/4	16 1/2	12 3/4	1 1/8	17 3/8	12 3/4	1 3/8	19 1/2	12 3/4	1 7/8	20 3/4	12	2 3/8	21 1/2	11 3/4	3 1/8
14	17 3/8	14	3/4	18	14	1 1/4	18 1/4	13 3/8	1 3/4	20 3/8	13 3/8	2 1/8	23 3/8	13 1/4	2 3/8			
16	20 1/8	16	7/8	21 1/8	16	1 1/2	22 1/8	15 3/8	2	22 1/2	15 3/8	2 3/8	25 1/8	15	3			
18	21 1/2	18	1	23 3/8	18	1 5/8	24	17 3/8	2 1/8	25	17 3/8	2 5/8	27 3/4	16 7/8	3 3/8			
20	23 3/4	20	1 1/8	25 3/8	20	1 3/4	26 3/4	19 1/2	2 1/2	27 3/8	19 1/2	2 7/8	29 3/4	18 7/8	3 3/4			
22	25 7/8	22	1 1/4	27 5/8	22	1 7/8	28 3/4	21 1/2	2 3/4									
24	28 1/8	24	1 3/8	30 3/8	24	2	31	23 1/2	2 7/8	32 7/8	23 1/2	3 1/2	32 3/8	22 3/8	4 3/8			
26	30 3/8	26	1 1/2	32 3/4	26	2	34	25 1/2	3 1/8	34 5/8	25 1/2	3 3/4						
28	32 5/8	28	1 5/8	33 1/4	28	2 1/8	36 1/8	27 1/2	3 3/8	37 1/8	27 1/2	4 1/8						
30	34 5/8	30	1 3/4	37 3/8	30	2 3/8	38 1/8	29 1/2	3 5/8	39 3/8	29 1/2	4 3/8						
32	36 7/8	32	1 3/4	39 1/2	32	2 1/2	40 1/8	31 1/2	3 3/4	42 1/8	31 1/2	4 3/4						
34	38 7/8	34	1 7/8	41 1/2	34	2 5/8	42 1/8	33 1/2	4 1/8	44 3/8	33 1/2	5						
36	41 1/8	36	2	43 7/8	36	2 3/4	44 3/8	35 1/2	4 1/4	47 1/8	35 1/2	5 1/4						
38	43 3/8	38	2 1/8	45 3/8	38	3	46 3/8	37 1/2	4 1/2	47 1/8	37 1/2	5 1/2						
40	45 3/8	40	2 1/4	43 3/4	40	2 1/8	48 3/8	39 1/2	4 3/4	48 1/8	39 1/2	5 7/8						
42	47 7/8	42	2 3/8	45 3/4	42	2 1/4	47 7/8	41 1/2	5	51 1/8	41 1/2	6 1/8						
44	50 1/8	44	2 1/2	47 7/8	44	2 3/8	48 7/8	43 1/2	5 1/4	53 3/4	43 1/2	6 3/8						
46	52 1/4	46	2 1/2	50	46	2 5/8	51 7/8	45 1/2	5 1/2	56 3/8	45 1/2	6 3/4						
48	54 3/8	48	2 5/8	52	48	2 3/4	54 3/8	47 1/2	5 3/4	58 3/8	47 1/2	7						

CLASSIFICATION OF FLANGES (BASED ON FACING)

FLAT FACE

Normally C I flanges having 125 # has a flat face. Since no raised face it requires full faced gasket.

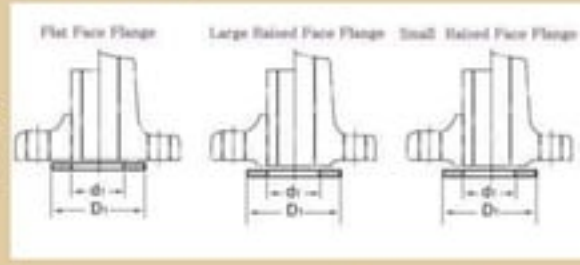
RAISE FACE

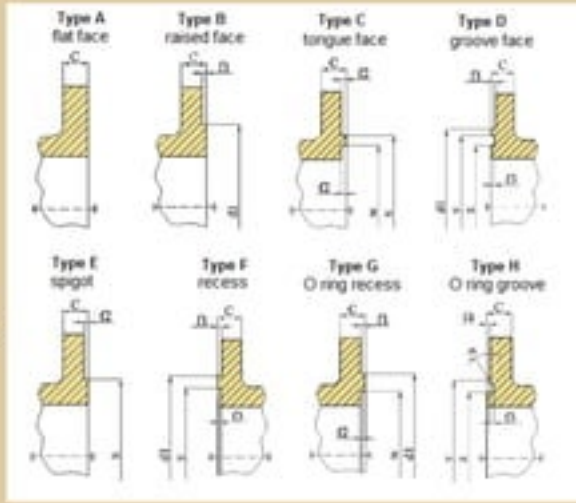
Raised face 1/16" for 150 # and 300 #

Raised face ¼" for other series

RING TYPE JOINT

Metallic rings are used in this ring type joint (RTJ) flanges

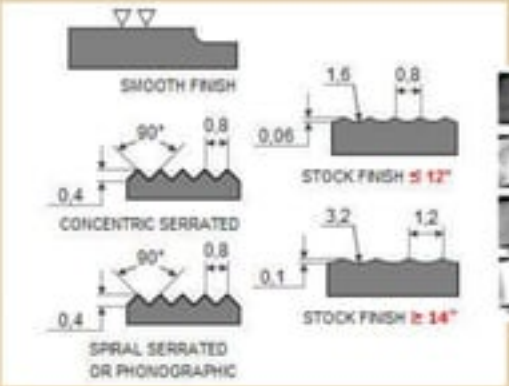


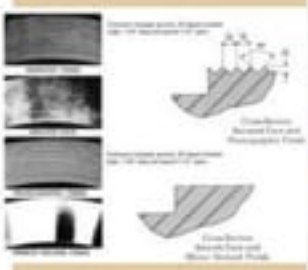


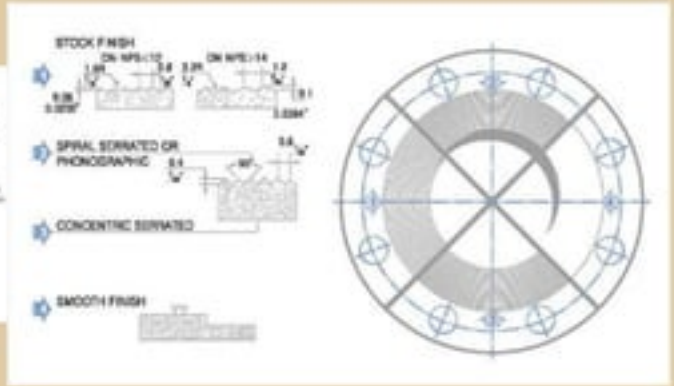
SURFACE FINISH ON THE FLANGE

Normally smooth finish is recommended for metallic gaskets.

Serrated finish are used when non metallic gaskets are used.



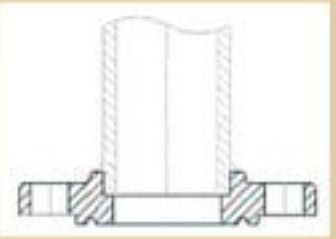




SOCKET WELDED FITTINGS (ASME B16.11)

ADVANTAGES

Fast production, No need to bevel the edges. Can be used in lieu of thread fittings. Weldment can not extend in to the pipe line.



DISADVANTAGE

The 1/16" recess pocket liquid. Use not permitted by code if severe erosion or crevice corrosion anticipated.

Types of Fasteners

- Carbon Steel –ASTM A193-B7
- Stainless Steel –ASTM A-B8
- LTCS –ASTM A320-L7
- Alloy-ASTM A193-B16
- Hex. Bolt Structure Steel - ASTM 325
- Machine Bolt (RTRP) – ASTM A307 Grade A/B, ASTM 593 2H
- Stud Bolt
- U-Bolts
- Anchor bolts
- Hilty Bolts

STUD BOLT

HEXAGONAL BOLT

HILTY ANCHOR

ANCHOR FASTENER

U-Bolt

Types of Valves

- Plug Valve
- Gate Valve
- Globe Valve
- Ball Valve
- Check Valve
- Butterfly Valve
- Needle Valve
- Control Valve
- Pressure Safety Valve
- Breather Valve

BALL VALVE

GATE VALVE

GLOBE VALVE

CHECK VALVE

BUTTERFLY VALVE

NEEDLE VALVE

CONTROL VALVE

PLUG VALVE

PRESSURE SAFETY VALVE

BREATHER VALVE

Pipe Schedules

- 5s
- 10s
- 20
- STD
- 30
- 40
- 40s
- 60
- 80
- XS
- 80S
- 100
- 120
- 140
- 160
- XXS

Ratings

- Class 125
- Class 150
- Class 300
- Class 600
- Class 900
- Class 1500
- Class 2500

Types of Fittings

- 90 Degree Elbow
- 45 Degree Elbow
- Concentric Reducer
- Eccentric Reducer
- Concentric Swage
- Eccentric Swage
- 5D bend
- Cap
- Stub End
- Equal Tee
- Reducing Tee
- Coupling
- Lateral
- Thredolet
- Weldolet
- Sockolet
- Nippolet
- Elbolet
- Union
- Plug
- Strainer
- Pipe Nipple
- Expansion Bellow

90 DEG ELBOW

45 DEG ELBOW

CONCENTRIC REDUCER

ECCENTRIC REDUCER

CONCENTRIC SWAGE

ECCENTRIC SWAGE

5D BEND

BUTT WELD CAP

STUB END

EQUAL TEE

REDUCING TEE

FULL COUPLING

LATERAL

THREADOLET

WELDOLET

SOCKOLET

NIPPOLET

ROUND PLUG

Y- STAINER

PIPE NIPPLE PLAIN BOTH END

PIPE NIPPLE THREADED ONE END

PIPE NIPPLE THREADED BOTH END

EXPANSION BELLOW

Types of Flanges

- Weld neck
- Slip-on
- Lap-Joint
- Orifice
- Blind
- Socket Weld
- Spectacle Blind / Fig.8

WELD NECK FLANGE

LAP JOINT

SOCKET WELD FLANGE

ORIFICE FLANGE

BLIND FLANGE

SPECTACLE BLIND / Fig. 8

Types of Gaskets

- Spiral wound
- O-Ring
- Rubber
- Neoprene
- Graphite
- Teflon

SPIRAL WOUND GASKET

O-RING

NEOPRENE GASKET

TEFLON GASKET

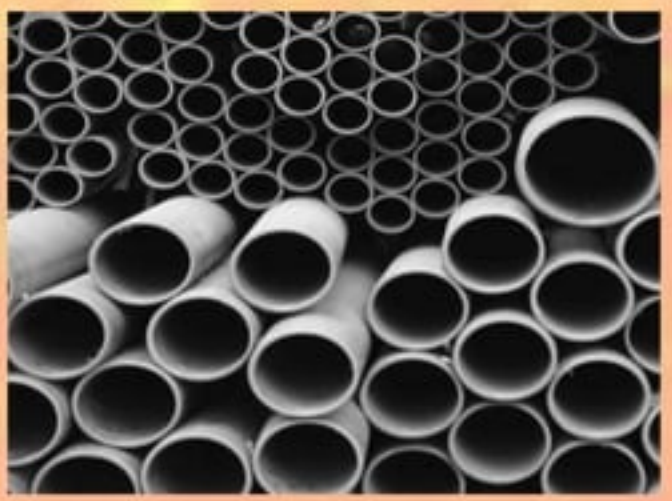
SAMPLE SPOOL

Pipe Cutting, Welding, Bolting

Week (9-11)

DEFINITION OF PIPE WELDING

- Involves joining two or more pipes together without the use of fittings.
- Pipe welds that are poorly executed can result in the ultimate failure of the pipe at the welding point.
- Pipe welding is a more complicated process than structural welding, and only a minority of certified welders does pipe welding.

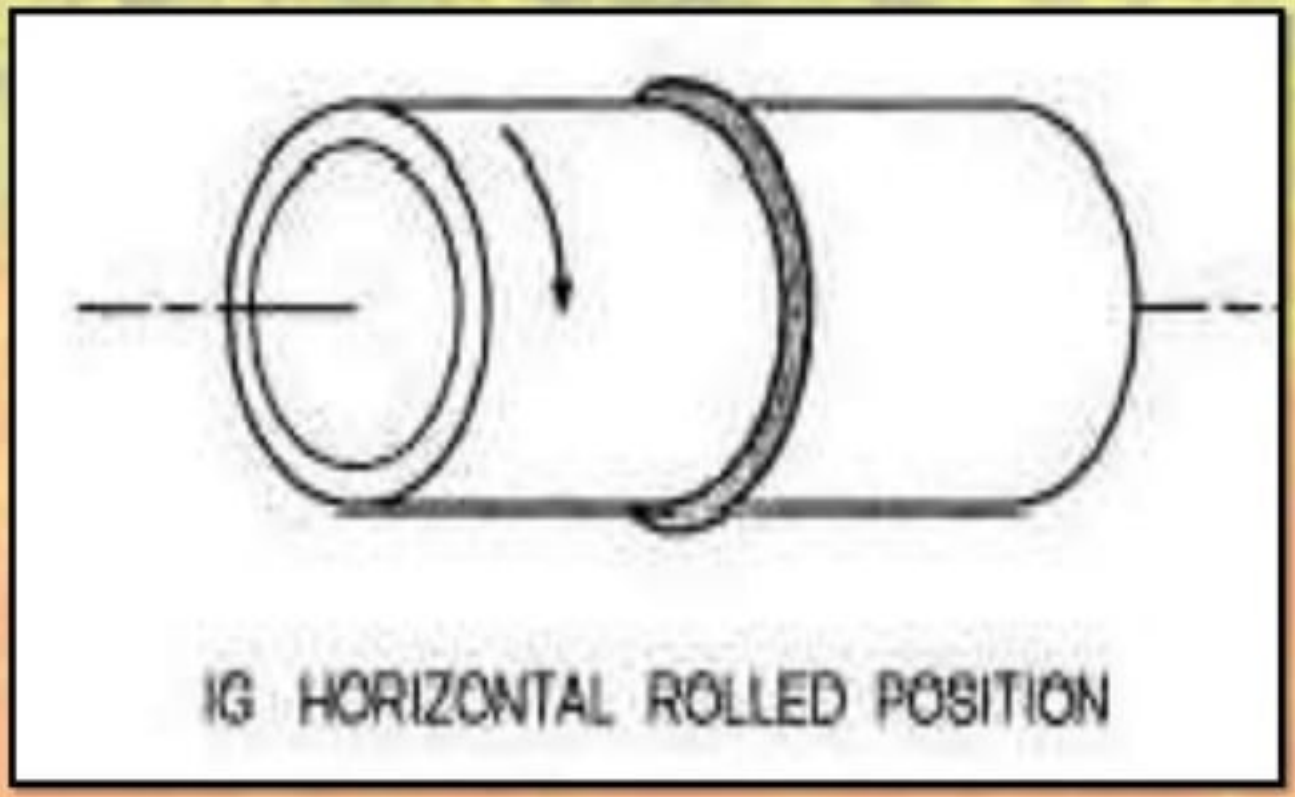


Types of Pipe Welding according to **PIPE POSITIONS**

The four principal positions of pipe welding are classified according to **the position of the pipe, not of the weld:**

- **1G - pipe in the horizontal position that is rolled;**

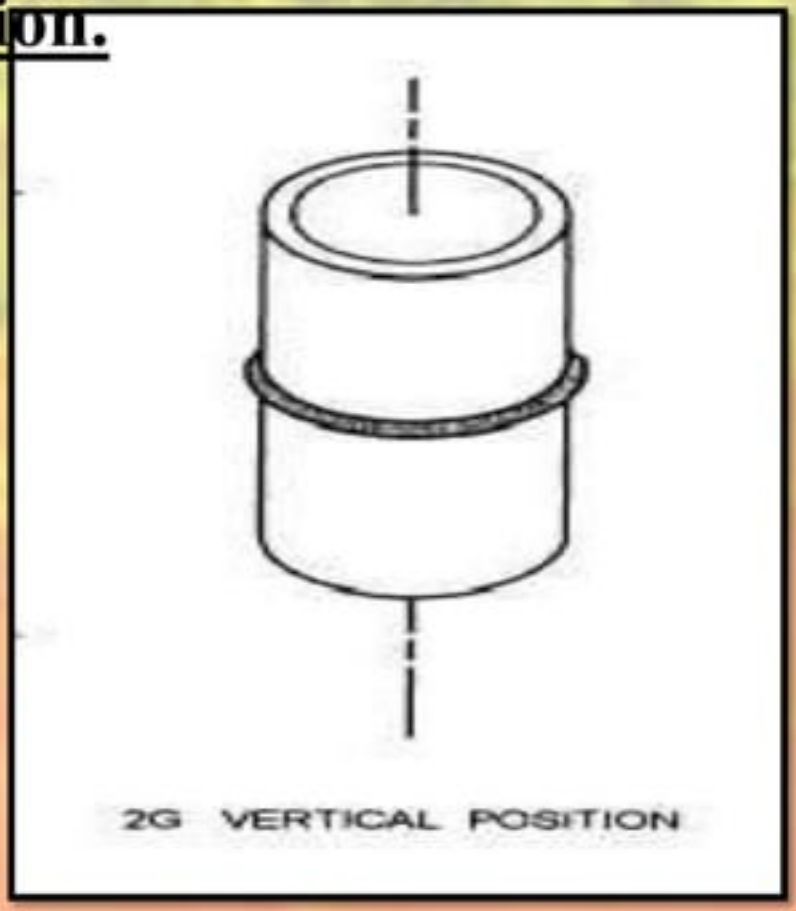
1G- HORIZONTAL ROLLED POSITION



1G HORIZONTAL ROLLED POSITION

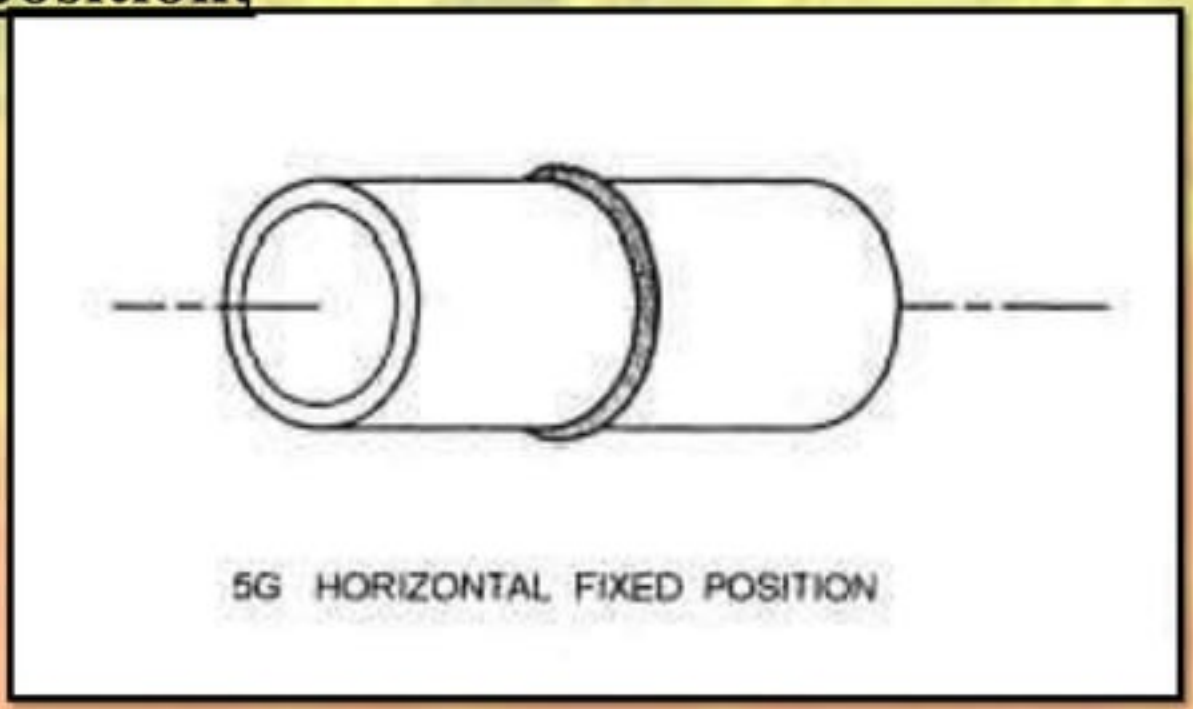
2G – VERTICAL POSITION

- **2G- pipe in the fixed vertical position.**



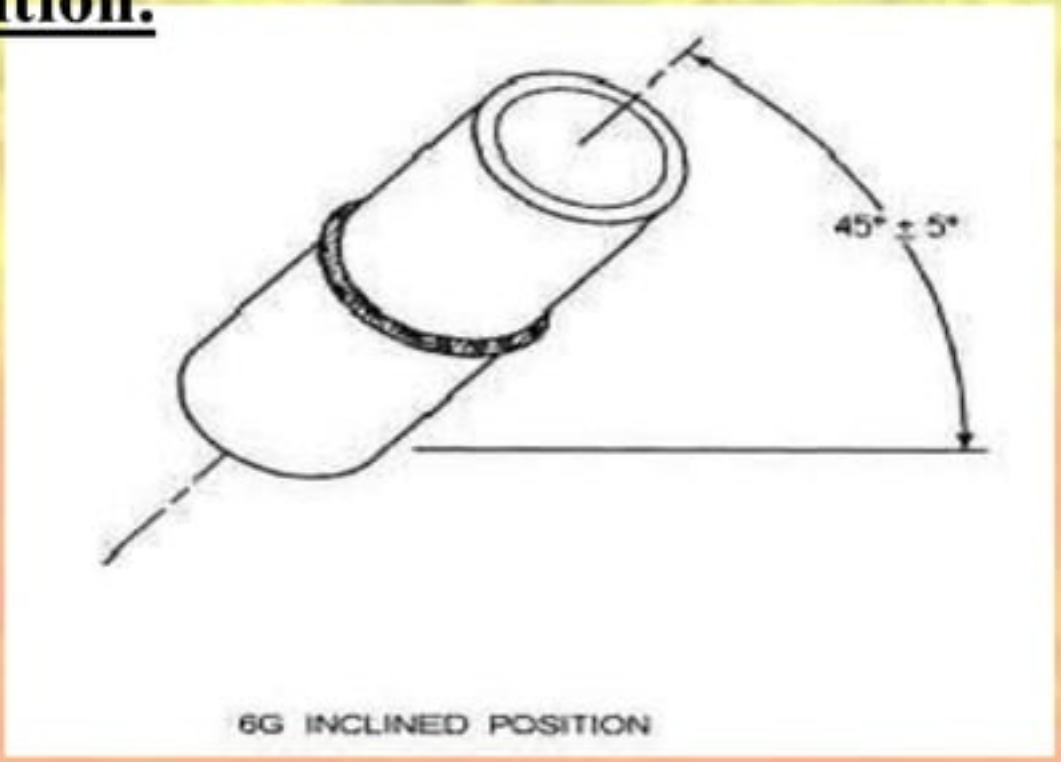
5G HORIZONTAL FIXED POSITION

- **5G- pipe in the fixed horizontal position;**



6G INCLINED POSITION

- **6G-pipe in a fixed 45-degree position.**

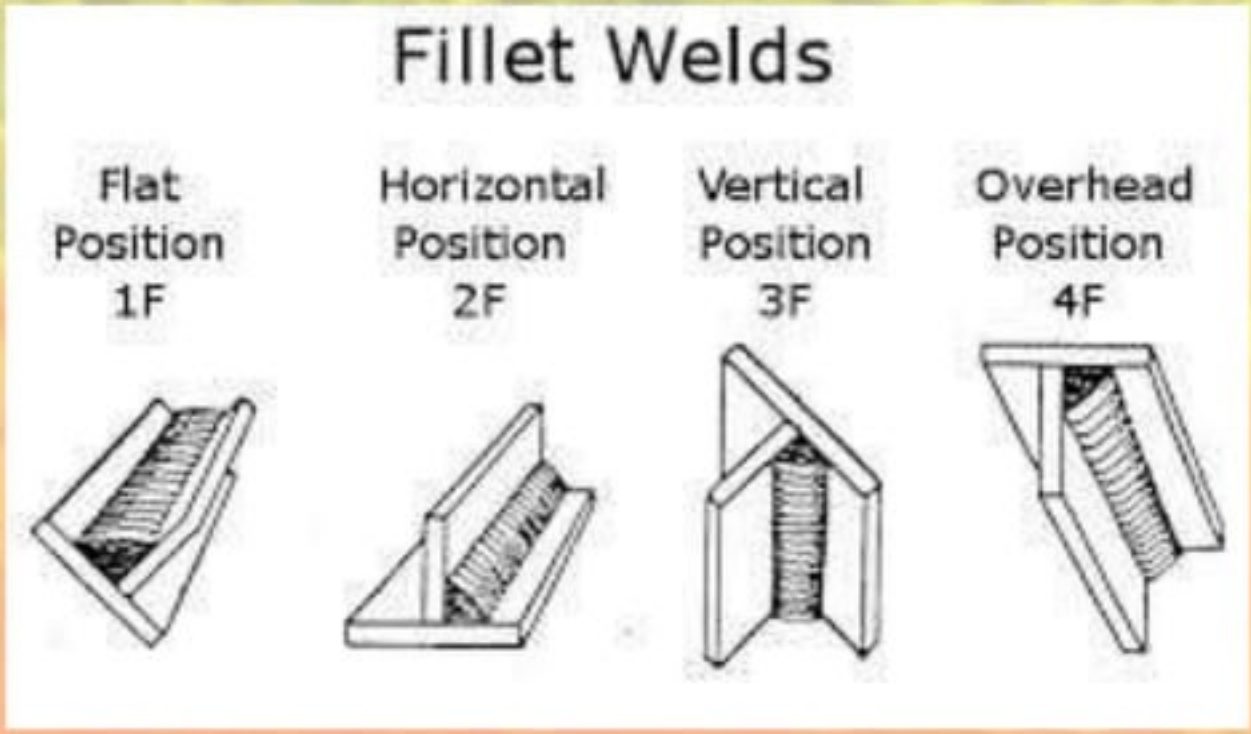


6G INCLINED POSITION

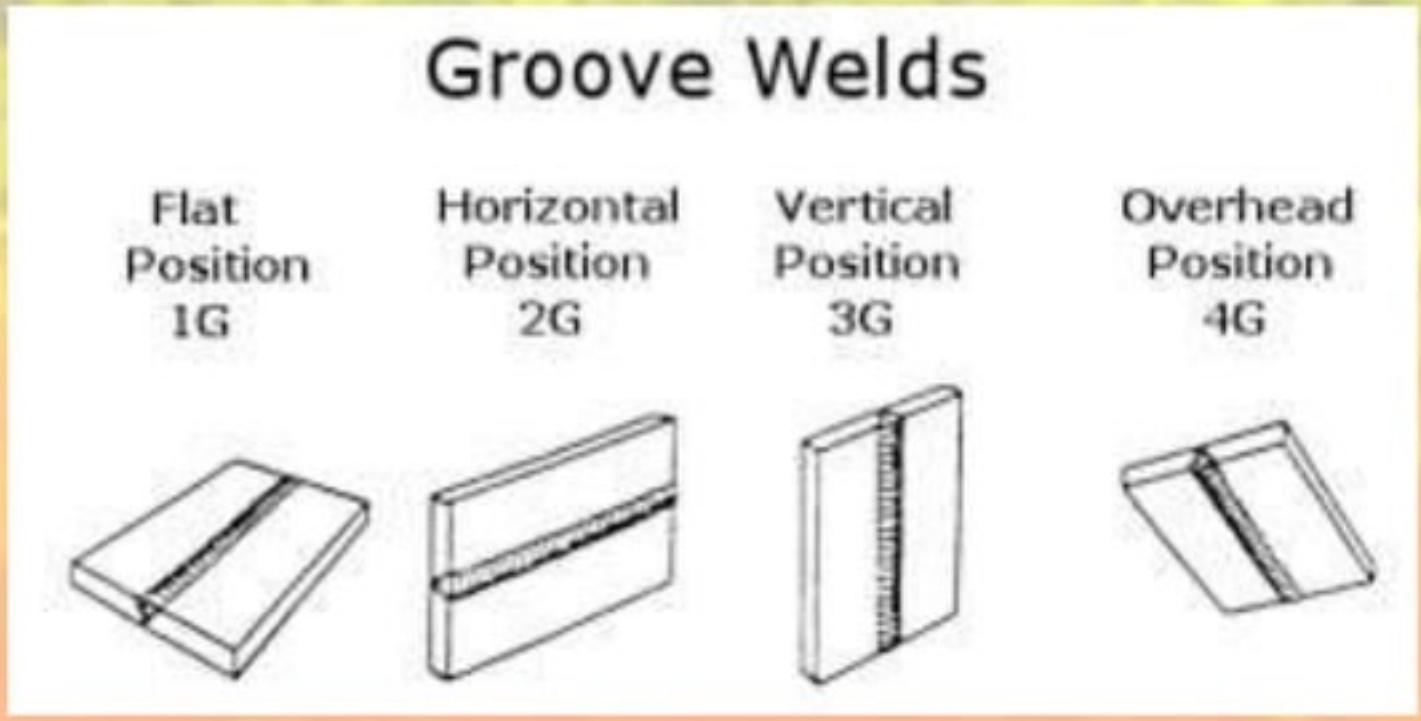
In addition to these four positions are special case positions or welds:

- R - pipe in a restricted position;
- F - a fillet weld; and
- G - A groove weld.

FILLET WELDS



GROOVE WELDS



CUTTING

FABRICATION

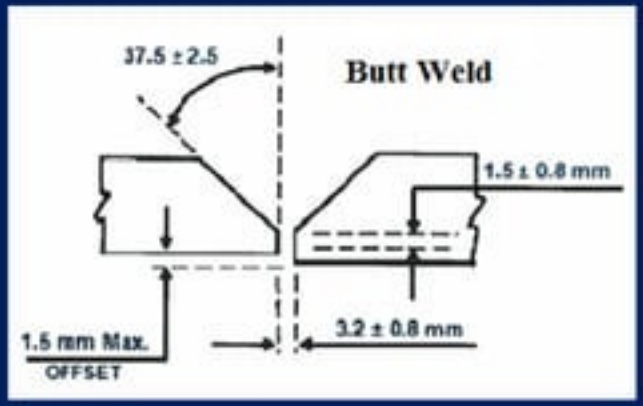
❖CUTTING :

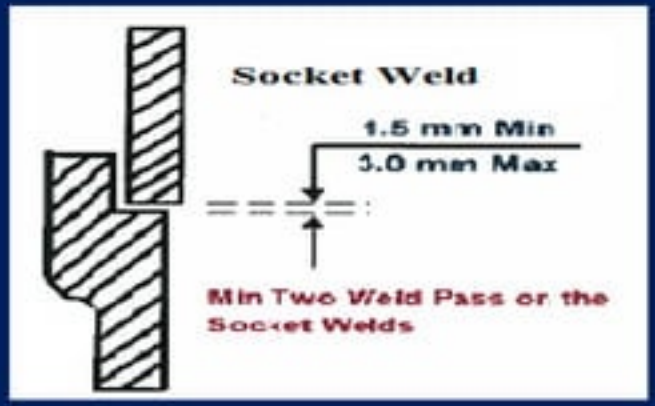
- ✓ Before cutting any pipes, heat number / ident. Codes shall be transferred to cut piece for identification.
- ✓ Cutting of non-galvanized carbon steel pipe shall be done by means of mechanical tools.
- ✓ Cutting of austenitic stainless steel materials shall be done by mechanical tools, sawing, abrasive discs or plasma arc cutting. No flame cutting shall be used for this purpose. If SS is used for oxygen service plasma cutting is not allowed.
- ✓ Cutting shall be performed perpendicularly to the piping component centerline unless otherwise indicated in the drawings.
- ✓ All tools used for Stainless Steel shall be marked and care will be taken to prevent that tools used for CS shall not be used for Stainless Steel.

FIT-UP:

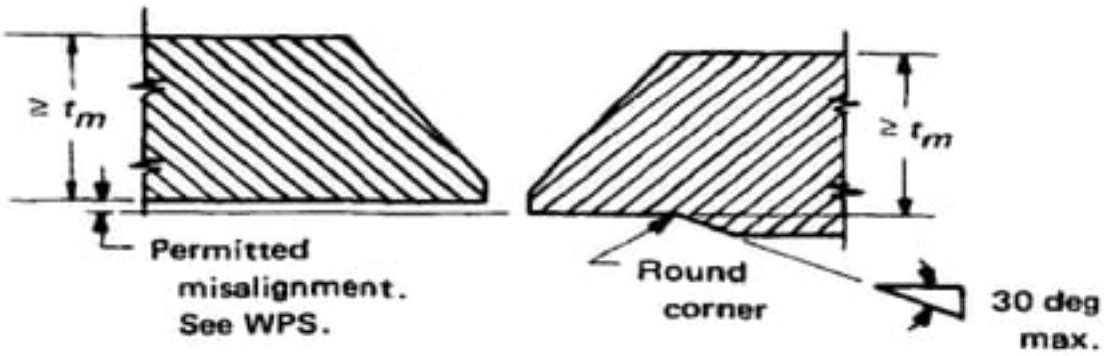
❖FIT-UP :

- ✓ Check drawings are Approved (IFC) before Fit-Up and they are of correct revision.
- ✓ Check Welding procedure specification and welder approval.
- ✓ Bevelled end shall be grinded to bright metal with a minimum metal removal of 2mm to ensure complete removal of surface contamination.
- ✓ Oil, moisture, rust, scale, sand, paint metallic coatings (e.g., zinc), or other foreign matter shall be removed from the weld surface and at **least 25 mm (1 in)** of adjacent base metal prior to welding, including any such coatings on temporary attachments or supports.
- ✓ All tack welds shall be made by qualified welders.
- ✓ All tacks or temporary welds shall be performed with the same care, materials, electrodes, minimum preheat, and procedures that are used for permanent welds.

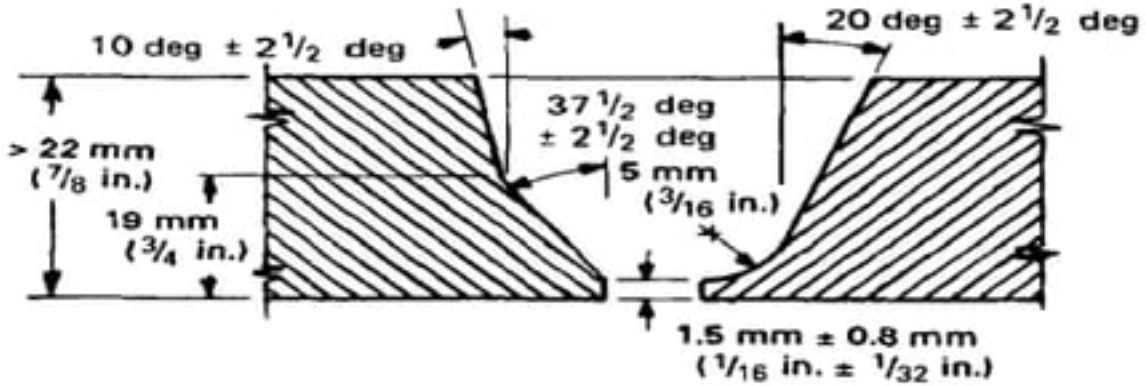




(a) Thicker Pipe Taper-Bored to Align



(a) Wall Thickness 6 mm to 22 mm, Inclusive ($^3/_{16}$ in. to $^7/_8$ in.)



- ✓ Tack welds shall be of sufficient size to maintain joint alignment. The recommended tack thickness is 3.2-4.8mm and length is 12.5–25.4mm. the minimum number of tack welds are:
  - a) Pipe diameter of 101.6mm or less: three equally spaced tacks.
  - b) Pipe diameter above 101.6mm: minimum of four equally spaced tacks. The designated inspector should determine if more tacks are needed.
- ✓ Tack welds that are to be incorporated into the final weld shall be thoroughly cleaned, prepared at each end, and inspected for cracks. any cracked tacks shall be removed before welding the joint.
- ✓ Bridge tacks (located above the root area) are acceptable but such tacks must be made completely within the weld groove and shall be completely removed prior to completion of the weld.
- ✓ Any temporary welded attachments or temporary tack welds shall be ground off. Attachments may be cut off no closer than 3 mm to the base metal surface, prior to the required grinding.

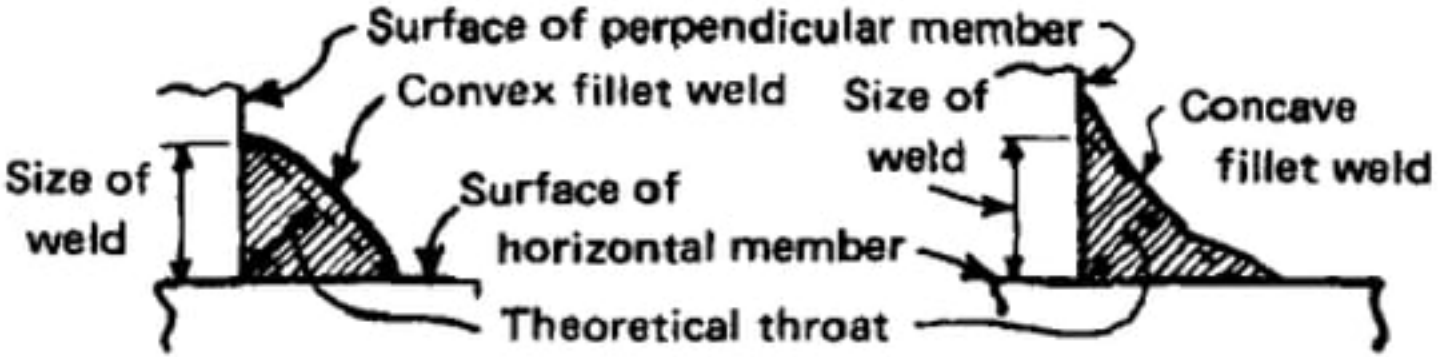
FABRICATION

❖ SPOOL FABRICATION:

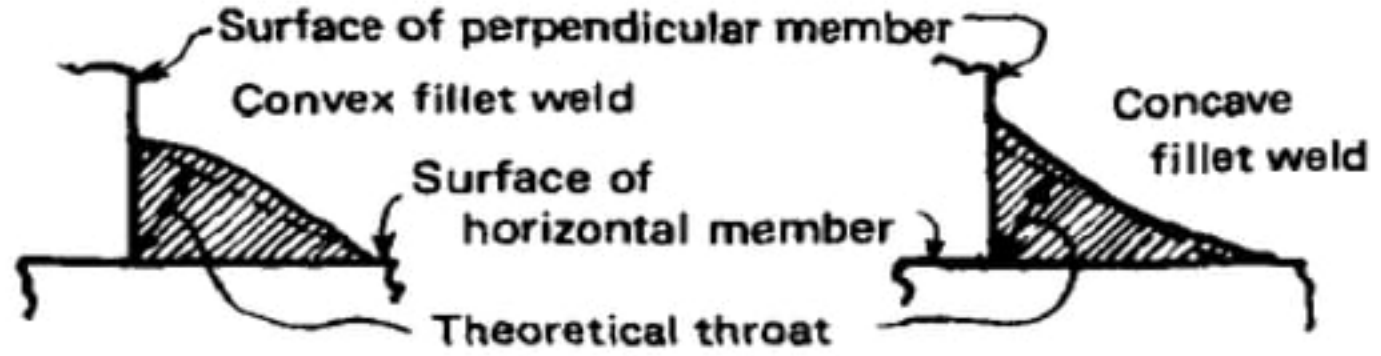
- ✓ Marking shall be done according to drawing requirement and the same shall be checked by concerned supervisor prior to cutting.
- ✓ The cutting shall be generally done as follows:

Carbon Steel pipes	-	By gas cutting & grinding.
Alloy Steel pipes	-	By grinding or flammable cutting.
Stainless Steel Pipes	-	By grinding or plasma cutting (Except Oxygen Service).

- ✓ Before cutting the pipe Heat Number shall be transferred to the cut pieces by low stress dye stamping, Paint marking or Tagging.
- ✓ End preparation and fit-up shall be done at shop as per the approved YERP Specification (SAES and approved WPS.
- ✓ Care shall be taken to make sure that longitudinal seams on the joining pipes will not come in one line in a butt joint. Seams will be staggered at least 100mm apart and also will clear the branch connections. Care shall be taken to make sure that longitudinal seams are not resting on the steel structure and pipe support.
- ✓ Pipes and Fittings for fit-up will be placed on temporary pipe bed and will make sure that supports are secured properly.
- ✓ Welding of the joint will be done after getting NSH QC fit-up Inspection clearance and the same shall be offered for TRG inspection randomly as per approved ITP. All flange connected to equipment shall be tack welded only.



Equal Leg Fillet Weld



Unequal Leg Fillet Weld

FABRICATION

- ✓ Line No, Component Heat No., Joint No., Fit-up inspection signature, Welder No., Visual inspection signature and date of welding will be marked near to the joint with metal paint marker.
- ✓ Spool No. will be marked with paint marker and aluminum tag will be tied to the spool. Fabrication completed spools will be shifted from shop to lay down area.
- ✓ NDT shall be performed as required by YERP specification. After NDT clearance, spools shall be released for erection / painting with release notice.
- ✓ NDT rejected spools will be identified and kept in separate location with yellow & black tag and the repair will be done immediately and NDT will be executed on repaired weld areas as required. After painting, field inspection shall be offered for TRG QC and the same shall be QC recorded in the prescribed format of approved procedure.
- ✓ After painting inspection, the spool shall be released for erection.
- ✓ Stainless Steel fabrication will be done in the shop with an isolated area from carbon steel and alloy steel.
- ✓ No tools, tackles, equipment will be used for SS which has been used for CS. All tools and equipment dedicated to SS work shall be clearly marked "For Stainless Steel" only.
- ✓ For Stainless steel materials, stainless steels tools will be used for grinding, brushing and clamping etc.
- ✓ Pre heating and PWHT will be done at shop and field as per specification requirements and approved WPS.
- ✓ All flanged raised faces of completed spools will be fitted with plywood blinds for protection and spool ends shall be fitted with proper caps.

FABRICATION

❖PIPE SUPPORT FABRICATION:

- ✓ All supports, anchors, guides and other support attachments shall be fabricated in accordance with details indicated in the pipe support drawings, isometric drawings and manufacturer requirements, etc.
- ✓ Fit-up & welding shall be done at shop as per the approved SAUDI ARAMCO Specification and approved WPS.
- ✓ Separate storage facility shall be made to store fabricated supports in area wise and material wise,
- ✓ Fabricated CS, AS and SS supports shall be placed separately with proper identification like type of support, sequence No etc. with legible marking.
- ✓ After painting inspection, the support shall be released for erection.


ERECTION & INSTALLATION
3 4:49 PM

ERECTION

- ✓ Prior to erection, the interior of all piping components shall be thoroughly cleaned of loose scale, sand blasting grits or sand and all other foreign matter by air blowing.
- ✓ The piping ends shall be covered after inspection to prevent unauthorized removal of the end cover prior to making the joint to the succeeding section of piping.
- ✓ Orifice plates, strainer, rupture discs, Insulation, thermo wells, pressure gauges, in line instruments, check valves, etc. shall not be installed until the pressure test is completed.
- ✓ Piping shall be installed in such a manner that the resultant force on the equipment shall be kept to a minimum. Proper care shall be taken at connection joint to pump, compressor and other mechanical equipment. Flange alignment check shall be performed and witnessed.
- ✓ Piping spools placed in location must be well supported with wooden planks.
- ✓ Special care shall be taken to avoid corrosion and damages of machined flange face to enable proper alignment of connections.
- ✓ Field weld joint shall be inspected by Welding Inspector. If the result of inspection is unacceptable, the joint shall be repaired and re-inspected in accordance with welding procedure specification. All NDE activities shall be recorded in the Line History Sheet.
- ✓ Piping will be disconnected / insulated from rotating equipment until all welding is complete.
- ✓ Special care shall be taken while handling Safety relief valves, control valves, etc.

❖ Piping Works on the Pipe Rack

- ✓ Straight run pipe shall not be pulled through the pipe racks unless a roller is used or the steel/precast face is covered with carpet to avoid paint damage.
- ✓ Position of lines shall be marked on the sleeper / pipe rack beams according to coordinates on Isometrics.
- ✓ Spool shall be lifted on the rack / sleepers on their designated position by using chain pulley block or crane.
- ✓ After lifting it shall be inserted into the pipe rack & placed in a required location, where the welding is going to be carried out.
- ✓ Piping being welded shall be grounded on pipe and not to steel structure and shall not go through valves or bolted flanges.
- ✓ After placing the pipes, joint fit-up shall be made from scaffolding platform which is made below the joint location between two grids.

- ✓ If tie-in alignment with outside pipe rack piping is required, coordination of pipe installing between working teams shall be done for ensuring proper alignment.
- ✓ For installation of slop lines, check levels of tie-in points (both high and low) shall be checked. The line slope shall be given between these two points. Slope is obtained by different shoe height and shim plates.
- ✓ For installation of branch, header shall be installed and aligned before commencement of branch installation.
- ✓ During lifting and fit-up by chain block, care shall be taken to avoid any damage on components of structure. By distributing load to strong components of structure, bending or twist of structure shall be avoided. Structure shall be protected to avoid damage to the galvanized surface.

ERECTION

❖ **Other piping Erection Requirements**

The following activities shall be carried out as per approved Quality Procedure for AG Piping fabrication.

- ✓ Cutting and Marking;
- ✓ Buttering or Weld Build up on joints;
- ✓ Weld Cleaning; Welding
- ✓ Tack welds;
- ✓ Back purging;
- ✓ Seal Welding;
- ✓ Weld encroachment and minimum distance between welds;
- ✓ Orifice Flange Internal Requirements;
- ✓ Welding of Special Corrosion resistance materials (High Temperature Applications and Corrosive Services)

ERECTION

❖ INSTALLATION OF BRANCH CONNECTION

- ✓ For new construction of metallic piping branch connection selection shall be made in according with chart 1 in SAES-L-110
- ✓ Branch connection such as those for drain and vent connection on tees, elbows and reducers are not permitted. When not avoidable piping design shall be approved by company.
- ✓ Branch connections with reinforcement pad size pad shall be as per applicable code.
- ✓ Branch connections with reinforcement shall not cover girth welds.
- ✓ Reinforcement pad material shall be of the same pipe material unless otherwise approved by Company.

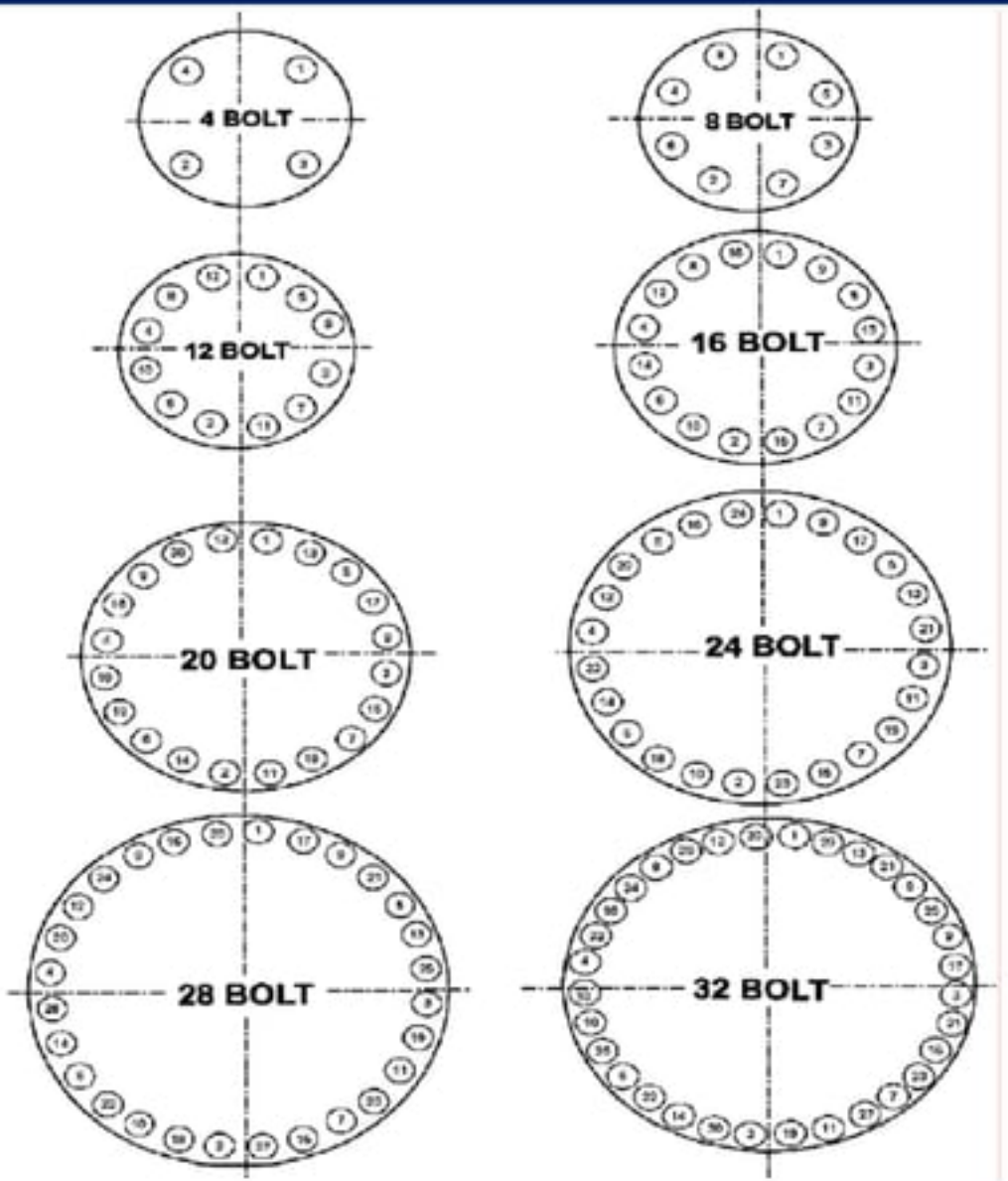
ERECTION

- **PIPING AROUND ROTATING EQUIPMENT (PUMP, COMPRESSOR)**
- ✓ Pump and compressor piping shall be installed up to a break point between the nearest pipe support and the equipment.
- ✓ No welding will be performed on piping while connected to rotating equipment.
- ✓ Temporary / Permanent support shall be given to the piping all the time to avoid load on equipment nozzles.
- ✓ All bolting will remain loose at rotating equipment until final pipe stress.
- ✓ Final tie-in weld for alignment with equipment nozzle shall be done after initial alignment of equipment.
- ✓ Align equipment nozzle flange and spool flange within acceptable tolerance by checking gap by dial gauge or filler gauge in minimum 4 points in circle of raised faces. Tie-in weld shall be done during welding.
- ✓ Flange gap shall be checked with filler gauge after welding.
- ✓ Final bolt up to rotating equipment will be performed under the supervision.

INSTALLATION

❖ INSTALLATION OF FLANGE AND STUD BOLT TIGHTENING

- ✓ Prior to flange connection, following points shall be verified to get the good condition of flange joint.
- ✓ Flange faces shall be aligned horizontally and verified.
- ✓ Flange faces shall be protected from damage like scratch, dent, rust etc.
- ✓ All bolts, nuts and gaskets shall be checked and be free from damage, corrosion and correct size.
- ✓ Flange faces shall be cleaned to ensure a good seal. Flange face shall be protected during all stages of construction, including during installation. End protector for flanges shall be provided.
- ✓ Gasket identification for permanent and temporary application shall be as per approved procedure.
- ✓ An insulating kit such as PIKOTEC gaskets with isolating bolt sleeves and washers shall be used for isolating dissimilar metal flanged joints. Insulating gasket not required for the following services.
  - ❖ -Hydrocarbon gas services.
  - ❖ -Dry gas services temperature is above the limitation of non-metallic gasket application.
  - ❖ -When internal liquid media is not an electrolyte.
  - ❖ -When the mass ration of SS compared to CS is very low where galvanic corrosion in CS is insignificant.
- ✓ Apply lubricants to stud threads over length and nut engagement and to face of nut which contacts flange. Ensure that the nuts run freely down the thread of the stud. (Refer table SAES-351-01)
- ✓ Install all studs and nuts hand tight; ensure that studs pass freely through the flange holes. Position the nut on one end of the stud such that only the crown of the stud projects beyond the face of the nut. The excess stud length should project beyond the nut on the other side.
- ✓ Number each stud according to its position in the flange as shown in figure.


4 BOLT
8 BOLT
12 BOLT
16 BOLT
20 BOLT
24 BOLT
28 BOLT
32 BOLT

INSTALLATION

- ✓ For inserting gaskets enough gap ($^1/_2$" of gap is recommended) should be available between flange faces to avoid any damage to seals during inserting the gaskets, if due to any reasons, seals are damaged, change the seal before installing gaskets.
- ✓ Matting flange faces and the gaskets should be dry free from grease, oil or water.
- ✓ Tighten studs per the Stud Bolt Tightening Sequence, for 4 to 32 bolts use Figure SAES-351-01 and for 36 to 68 bolts see Figure SAES-351-02 for bolts numbering and then follow the tightening sequence of Table SAES-351-04. An appropriate tool should be used such as a Torque wrench or equivalent.
- ✓ Tighten the stud bolts in stages to obtain the final required torque from the appropriate torque Table-SAES-351-02. The first stage should not be more the 30% of the final torque. The final torque shall be within ±5% of the required torque value.
- ✓ The sequence of bolt tightening shall be as follows using the cross technique and shall be as per approved procedure.
- ✓ Align flanges and gasket. Forced tightening is not allowed to overcome non acceptable alignment tolerances. Clamp securely in place.
- ✓ Apply the torque evenly to each stud following the stud bolt tightening sequence.

INSTALLATION

❖ FLANGE FIT-UP AND TOLERANCES

- ✓ The maximum tolerance for axial dimensions, face-to-face, center-to-face and location of attachments shall be ± 3mm.
- ✓ Lateral transition of branches and connections from the centreline of the run shall not exceed ± 1.5 mm.
- ✓ Flange bolt holes shall be oriented as follows, unless otherwise indicated on the construction drawings:
    - Flange face vertical – bolt holes to straddle vertical centrelines.
    - Flange face horizontal – bolt holes to straddle horizontal centrelines.
    - Rotation of flanges, measured as the offset between elevations of bolt holes on opposite sides of a flange centreline, shall not exceed ± 2.4 mm.
    - The tilt of a flange measured at the periphery across any diameter shall not exceed 1.6 mm from the square position.
- ✓ For piping over 3-inch NPS and connected to machinery/equipment, flange alignment shall be within the following limits unless piping analysis per SAES-L-120 shows that loads and moments are within the manufacture's limits for the machinery/equipment nozzle:
    - Vertical bolt hole offset: ± 2.4 mm
    - Horizontal bolt hole offset: ± 2.4 mm

INSTALLATION

- Rotational offset: ± 2.4 mm
- Flange face tilt across diameter : 0.025mm per 25mm (0.001 inch per inch) of flange outside diameter up to a maximum of 0.672 mm (0.030 inch), and 0.254mm (0.010 inch) for all flanges with an outside diameter less than 10 inches.
- Flange face separation, gasket thickness : ± 1.6 mm
- Combination of vertical, horizontal and rotational offset: ± 3.2 mm

✓ In the case where a spectacle plate is installed between two flanges, these tolerances can be increased by 30% except for tolerances for flanges face tilt across diameter and flange face separation.

✓ When a piping flange a aligned to a machinery flange, the machinery alignment should be within the equipment vender specified tolerances, after the stud bolts of the connecting flanges are removed following the completion of piping assembly.

INSTALLATION

❖ INSTALLATION OF VALVES

- ✓ Value shall be installed as shown on the Isometric drawing. The value shall be installed in accordance with value manual.
- ✓ Prior to installation of values, tag number and flow direction will be verify with Isometric drawing / P&ID and installed accordingly.
- ✓ Values will be correctly handled to prevent damage of value body, handle and flange surface.
- ✓ Value will be installed in the position as indicated on the isometric drawing.
- ✓ Welding between pipe and value will be performed with value open as per manufacture's instruction.
- ✓ All the internals of Bud Weld / Socket Weld values will be checked before welding and removed if welding will damage internals (Follow value manufacture's recommendations for welding & PWHT)
- ✓ Values shall be checked for correct operation before installed and spindle threads will be preserved to assure good value operation. (No greasing of spindles used in oxygen service).
- ✓ Check value in vertical position shall be avoided. In case not avoidable the type of check value shall be of a kind that it shall not stuck in open position subject to prior approval of company.
- ✓ New values designated for isolation purpose(On-Off) shall be field tested as per approved procedure.
- ✓ The testing includes a high pressure hydrostatic shell test and a high pressure hydrostatic closure test. Values shall be separated in to inspection lots based on the criteria mentioned SAES-L-150.

INSTALLATION

- **INSTALLATION OF PIPING SPECIALITIES AND INSTRUMENTS**

- ✓ All supports, anchors, guides and other support attachments shall be installed in accordance with details indicated in the pipe support drawing, isometric drawings and manufacturer requirements, etc.
- ✓ Separate storage facility shall be made to store fabricated supports in area wise and material wise.
- ✓ Fabricated CS, AS, and SS supports shall be placed separately with proper identification like type of support, sequence No etc. With legible marking.
- ✓ Attachments, such as supports Bracing, lugs and T-bars shall be installed in the field.
- ✓ Installation of supports shall be performed in accordance with construction specification for piping construction works.
- ✓ If pipe thickness is very less (below 5 mm), welding activities to be controlled specially for distortion. The use of U Clamp between pipe & support to be maximized as allowed by Engineering and project specification.
- ✓ A 6mm weep hole shall b drilled for all dummy supports. The weep hole shall be located near the base plate for all vertical dummy supports and near the run pipe at 6 o'clock for all horizontal supports.
- ✓ The spring support shall be in full engagement with pipe. All springs shall be in compression.
- ✓ Rod hangers shall be avoided wherever possible. Rod hangers shall not be used for lines 12" NPS and larger in liquid or multi phase flow. All hangers shall be provided with means for vertical adjustments.

Pipe Testing

Week (12)

TESTING OF PIPING SYSTEM

(AS PER ANSI B 31.3)

Piping system can be tested for leak tightness and pressure integrity by hydro test / pneumatic test methods.

HYDROSTATIC TEST

TEST PRESSURE =(1.5 X Design Pressure X stress value at test temp) / stress value at design temperature

TEST DURATION

A leak test shall be maintained for at least 10 minutes, and all joints may be examined for leaks.

TEST MEDIUM

Water at ambient temperature is the test medium. Incase of possibility of freezing exists, other fluids may be used.

PNEUMATIC TEST

TEST PRESSURE

(1.1 x Design Pressure x stress value at test Temperature) / stress value at design temperature

TEST DURATION

A leak test shall be maintained for at least 10 minutes, and all joints may be examined for leaks.

TEST MEDIUM

Air at ambient temperature is the test medium.

CHECK LIST FOR HYDRO TEST

1. COMPLETION OF WELDING ON PRESSURE PARTS.
2. ALL LONG SEAMS & CIRC. SEAMS ARE MADE VISIBLE FOR INSPECTION.
3. COMPLETION OF ALL NDT.
4. GASKETS & GASKET SEATINGS ARE CHECKED FOR ANY DAMAGE.
5. EQUIPMENT WHICH IS NOT TO BE TESTED SHALL BE EITHER DISCONNECTED OR ISOLATED.
5. RAISE THE PRESSURE TILL 50% OF TEST PRESSURE.
6. INCREASE THE PRESSURE IN INCREMENTS OF 10% OF TEST PRESSURE.

CHECK LIST FOR HYDRO TEST

7. STOP PUMPING FOR 5 MINUTES AFTER EACH INCREMENT OF 10% OF RISE IN PRESSURE.
8. IF ANY LEAKAGE IS OBSERVED THROUGH GASKET CONNECTION, REPEAT THE TEST AFTER DEPRESSURISING THE SYSTEM.

Pipe Flushing

Week (13-14)

Why are Chemicals needed in the process?

Chemicals are used to clean, remove and then control the debris, fouling, and organic matter of a closed-loop system helping maintain its cleanliness from installation to handover and then for the life of the system.

- General flow rate issues around the system due to accumulation of debris.
- Blockages at strainers.
- Issues with control valves.
- Coils are being blocked.
- Coils not operating at required design loadings.
- Increased maintenance and shortened life expectancy due to corrosion of terminal units, major equipment, ancillaries, and pipework that the water comes into contact with.
- Increased usage and costs of chemical treatment.

The deposits can create aeration and a concentration of cells which will usually result in localized corrosion that we have all seen, resulting in pitting and/or perforations of the pipework.

Common Types of Deposits

The most common deposits are from the following:

- Iron Oxide is the resultant reaction with the pipework material used and can be present in organic residues.
- Scaling from water hardness – Calcium [Ca] and Magnesium [Mg]
- Treatment chemicals and corrosion products, if not controlled and used properly can also cause deposits and scaling.

This is why need to make sure the Dynamic Flushing is completed properly, to remove the bulk of the above issues.

Selecting the Chemicals to be used

The Chemical Engineer will be responsible for specifying the chemicals, their types, and that they are selected in line with the type of system being cleaned and materials used.

The Chemical Engineer will consider the following regarding the selection of products and sequence they are to be used:

- The chemical should be able to disintegrate or dissolve deposits for removal by the flow of water around the system.
- Inhibition is needed in the chemical so as not to affect the base metals in the system.
- Should not be toxic or explosive, which would mean expensive removal and disposal.

Here are some common ones that would be considered:

- **Biocide/Biodispersant** – To reduce bacterial levels in the system water and help remove biofilms [depending on requirements of the system]. Usually called a biocide wash.
- **Acid Cleaners**– To aid the removal of surface oxides from the internal surface of the pipework.
- **Complexing Agents –** Chelants and Sequestrants, to aid scale removal
- **Polymers/Dispersants –** Used to break down any loose surface deposits to allow easy flushing to drain or catch in the filtration system.
- **Neutralizers, Passivators, and Inhibitors/Biocide dosing** – To manage the rate of corrosion within the system.
- **Formulated cleaning products** – To aid the removal of surface oxides from the internal surface of the pipework.

How do you use an Acid Cleaner?

Systems that are mainly constructed from mild steel [so most closed systems], will need to undergo an 'Acid Clean' to help with the dissolving and removal of scale and debris build-up.

Although there are options to use quite aggressive cleaners, they are generally not ideal for the flushing and cleaning process as the disposal can be complex and expensive.

So, the Chemical Specialist would usually **specify 'Organic Cleaners'** such as Formic, Acetic, or Citric Acid.

Citric Acid is usually the most common and should be paired with the appropriate 'Acid Inhibitor' to stop any problems with corroding the base metals in the system.

As the organic compounds are weaker they are usually used and blended with other chemicals during the process.

Again like with all chemicals the Chemical Engineer is the only person that should be selecting and specifying the chemicals used.

What is Neutralization?

During a cleaning process, if an inhibited acid cleaning chemical is used, there will be a risk, that even after the clean flush has been carried out, the inhibitor is lurking somewhere in the remote corners of the system.

To ensure the acid will not react with the system and metals a neutralizing solution, alkali, is used to 'neutralize' it and circulated around the system.

Why do you Passify the pipework?

Due to the chemicals and cleaning method used to ensure the system and pipework are cleaned, when it is completed the pipework surfaces will be left 'bare and exposed' to further corrosion.

Pacifying the pipework straight after the final flushing and before being put into use, handing it over to the facilities company and building owner will ensure that the system is not exposed to further corrosion.

To do this a 'Passifying Agent' will be used and circulated around the system.

Pre-Requisites to be completed prior to Starting

Use the pre-requisites as detailed in the Dynamic Flushing stage **here**.

Chemical Cleaning Steps

Once all the above has been completed and understood, the following steps should be completed:

Step 1 – Ensure the system is set up in line with the drawing

[add information based upon the drawing – valve positions and how to set it up].

Step 2 – Ensure the cleaning specialist has accepted the results from the dynamic flushing

Step 3 – Check that temporary drain valves & water supplies are closed

Step 4 – Ensure pumps are running and circulating water

Step 5 – Complete a biocide wash if Chemical Engineer advises

Step 6 – Chemical Engineer to introduce the chemicals to the system

Based upon the chemicals that have been selected by the engineer.

Step 7 – Chemicals to be circulated, the Chemical Engineer to monitor system and advise when complete

Monitoring iron levels to ensure they stabilize and plateau.

Continue to circulate the system, and take readings 2 hours apart to ensure are stable.

If the system is not stable, continue to circulate until are.

Step 8 – Conduct a Drain and Fill until the system water is of a similar quality to the water being filled.

Verify the similar water qualities by completing site sampling and testing for pH, Total Iron Increment, and Total Dissolved Solids.

Move to the next step once the chemical engineer has accepted the results.

Step 9 – With the pumps still running, close the temporary drain and water valves

Step 10 – Final Inhibition and Passivation chemicals added by Chemical Engineer

Step 11 – Circulate the water and chemicals for a time in line with the Engineers advice

Take multiple site samples of the system to check the condition of pH, Iron, and Total Dissolved Solids.

This is to check that the system is in line with expectations and specifications.

Step 12 – Circulate the system in line with Chemical Engineers advice

Chemical Engineer to provide status and confirm when complete

Step 13 – Take samples and send them to the laboratory for final analysis/documenting

Depending upon your specification, the analysis can cover the following types of quality metrics:

- Suspended Solids
- Conductivity
- pH
- Total Alkalinity
- Total Hardness
- Nitrates
- Sulfates
- Chlorides
- Total Iron
- Dissolved Iron
- Total Copper
- Molybdate
- Phosphates
- Glycol
- Total Viable Count [TVC]

- Pseudomonas

Step 14 – Ensure all documentation is fully completed, witnessed, and signed

This is important as will ensure that the activities are able to be proved later if any issues.