Abu Dhabi Gas Liquefaction Company Ltd

Job Training

Mechanical Technician Course

Module 4

Pipework

ADGAS Personnel & Training Division

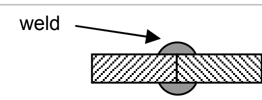
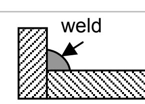
Contents

Contents

Pre-Requisite	Completion of A.T.I. Maintenance Programme, ADGAS Induction Course and Basic Maintenance Technician Course.
Course Objectives	The Job Training Mechanical Technician Course is the second phase of the development programme. It is intended specifically for Mechanical Maintenance Developees. On completion of the Course the developee will have acquired an awareness of some of the equipment, terminology, and procedures related to mechanical maintenance of ADGAS LNG plant. Appropriate safety procedures will continue to be stressed at all times.
Module Objectives	On completion of this module, the developee will be able to: • correctly interpret pipe specifications • be aware of the ADGAS and international codes and standards applicable to pipes and fittings • correctly identify pipe fittings used on the ADGAS plant • correctly identify flanges used on the ADGAS plant • correctly identify pipe supports used on the ADGAS plant • correctly interpret relevant information from piping drawings and diagrams • correctly demonstrate the correct use of pipe benders and thread cutters • correctly tighten flange joints (manually)
Methodology	The above will be achieved through the following: • pre-test • classroom instruction • audio visual support • tasks & exercises • site visit • post-test

Abbreviations and Terminology

ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
BS	British Standard
BSP	British Standard Pipe
BW	Butt weld
FF	Flat face
LPG	Liquid petroleum gas
MCR	Mixed component refrigerant
NPT	National Pipe Thread
PTFE	Polytetraflouroethylene
RF	Raised face
RTJ	Ring-type joint
SCRD	Screwed
SO	Slip on
SW	Socket welding
SWG	Standard wire gauge
WN	Welding neck

Blank (a pipe)	Close the end of a pipe.
Butt weld	Simplest weld between two plates, the ends of which are *butted* together. 
Commodity (P&ID)	Used here to mean the fluid in the pipe.
Condensate	Water formed as steam condenses.
Condensation	The process of turning steam back to water by cooling or increasing pressure.
Corrosion allowance	An additional thickness of material above that needed to perform the required task. As corrosion slowly reduces the material thickness, the item can still perform to specification until design thickness is reached.
Elevation	Height.
Evaporation	The process of turning a liquid into a vapour, e.g. water to steam
Fillet weld	Weld along the internal corner between two perpendicular items. 

Flow rate	Amount of fluid flowing (e.g. through a pipe) in unit time (e.g. 1 second).
Galvanising	Process of coating steel with a thin protective layer of zinc to reduce corrosion.
High-tensile	Able to take large pulling force without damage.
Jack	Device that lifts by pushing up from below.
Non-conductive	A very poor conductor of heat (or electricity).
Olive	A ring of metal, often brass, that is compressed onto a pipe by a compression joint fitting to form a seal.
Orifice plate	Plate with accurately sized hole (orifice) placed in a pipeline to measure flow rate. Flow rate is calculated from the difference in fluid pressure before and after the orifice.
Pipe schedule	A number that indicates pipe wall thickness for a particular pipe size.
Pivot	Hinge point—a point about which something can turn or swing.
Pressure tapping	Connection into a fluid line for a pressure measuring instrument.
Pressure-tight	Able to contain fluid under pressure without leakage.
Ratchet	Device that applies torque to an item in one direction but can turn freely in the other.
Spade (or blind)	Plate inserted between two flanges to stop flow.
Spading	The use of spades to isolate a section of pipework or piece of equipment.
Spigot	A machined protrusion that locates in a matching recess. (Also used in US-Technical English for a tap)
Stirrup	Support that hangs from above and passes below the item being supported. Comes from the name of the device used to support the feet when riding a horse.
Straining element	Item with small holes that do not allow larger solid particles to pass—a kind of filter.
Tack weld	Small temporary weld to hold items in place—often used before making a permanent weld.
Tie rods	Structural items designed to take tensile force.
Tightening sequence	The order of tightening nuts, screws, etc.
Vapour barrier	Layer that keeps out moisture in the form of vapour.

1 Introduction

Pipework is an important part of any processing industry. As a Mechanical Maintenance Technician, a lot of your work will be on pipework or on equipment that has to be connected to or disconnected from pipework.

Pipes carry fluid (liquid or gas) from one place to another. In the ADGAS plant, most fluids are being carried from one item of equipment to another between the stages of a process.

A piping system includes:

- pipes—to carry the fluid
- fittings—to join sections of pipe and direct the flow of the fluid
- flanges—to temporarily join sections of pipe and connect pipes to valves and equipment
- valves—to control the flow of fluid through pipes
- supports and hangers—to fix piping in position

As a Mechanical Maintenance Technician you may have to fit or replace sections of pipe. You also have to *isolate* and disconnect sections of pipework from items of equipment before maintenance and/or removal.

To ***isolate*** something is to separate it or cut it off from everything else.

In this module you will learn the importance of using the correct pipes and fittings for the job and the importance of codes and standards for piping. You will also learn about the way pipes are joined and how to bend them without damaging them. You looked at some pipe drawings and diagrams in an earlier module: *Drawings and Diagrams*, in the Basic Course. Here you will get more practice at reading and *interpreting* piping layout drawings and piping and instrumentation diagrams.

To ***interpret*** something is to explain its meaning.

2 Pipes

There are many different pipes in the ADGAS plant that carry different fluids. ADGAS uses a colour code system to identify what a pipe is carrying. This is based on the British Standard BS 1710 colour codes shown in **Figure 2.1**.

Yellow ochre	Gases (other than air) including liquefied gases	Note: ochre is pronounced 'oker'
Light blue	Air	
Green	Water	
Red	Fire extinguishing materials	
Silver grey	Steam	
Violet	Acids and alkalis	
Black	Trapped solids	
Yellow	Used for chemicals in ADGAS	

Figure 2.1: ADGAS Piping Colour Codes—BS 1710

These colours are usually painted in bands around the pipe. Fire water pipes that are not on the ADGAS plant are often all red.

Most pipes on the ADGAS plant are light grey. Three colour bands identify what fluid the pipe is carrying as shown in **Figure 2.2**:

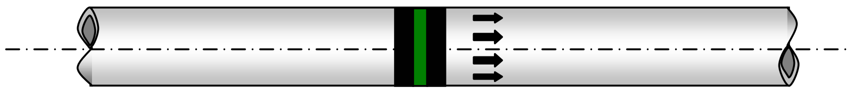


Figure 2.2: ADGAS Pipe Colour Code for Lube Oil

- the two outer bands indicate the general type of fluid in the pipe: gas, air, water, etc., as shown in **Figure 2.1**
- the middle band identifies the name of the fluid, propane, instrument air, sea water, etc.

Arrows on the pipe show the direction of flow.

Appendix A shows the colour codes used on pipes on the ADGAS plant. You do not need to learn these but can refer to them if you want to know what a pipe is carrying.

The materials and sizes of pipes for any application are described in the ADGAS Piping Specifications. An example of the ADGAS Piping Specification for Trains I and II is shown in **Appendix B.**

Now try **Exercise 1**

2.1 Pipe Specifications

Pipes are identified by their:

- material
- dimensions

A pipe specification includes the pipe material and its diameter and wall thickness. Always make sure that the correct specification pipe is used.

- If the wrong material is used the fluid may corrode the pipe.
- If the diameter is too small, the flow of fluid through the pipe will be restricted.
- If the wall is too thin, the pipe may not be able to take the pressure of the fluid inside without bursting.
- Pipes that are too big or too thick are unnecessarily heavy and expensive.

2.1.1 Pipe Materials

Some typical pipe materials are:

- carbon steel—an alloy of iron and up to 0.25% carbon is used on the plant, it is the most common general purpose pipe material. Some steel pipes are protected with a coating of zinc in a process called *galvanising*.
- alloy steels—contain iron, carbon and other elements to improve the metal's properties. Low temperature carbon steel alloy is used for liquid petroleum gas (LPG) and mixed component refrigerant (MCR).
- stainless steel—a common alloy steel containing elements that resists corrosion. It is used to carry corrosive chemicals.

Most pipes on the ADGAS plant are made of carbon steel. If the fluid being carried corrodes carbon steel, another material is used.

Other non-ferrous alloys used for pipes on the ADGAS plant are:

- nickel alloys
- copper alloys
- aluminium alloys

The ADGAS pipe material specifications give the American Petroleum Institute (API), American Society for Testing and Materials (ASTM) and British Standards (BS) codes for the materials that are used.

Sometimes it is cheaper and better to coat the inside of a steel pipe with a lining material to protect it from corrosion. Sea water contains salt, which is very corrosive. Sea water is used on the plant for fire fighting and cooling water. Pipes that carry sea water are lined with cement to keep the sea water from contacting the steel pipe, as shown in **Figure 2.3**.

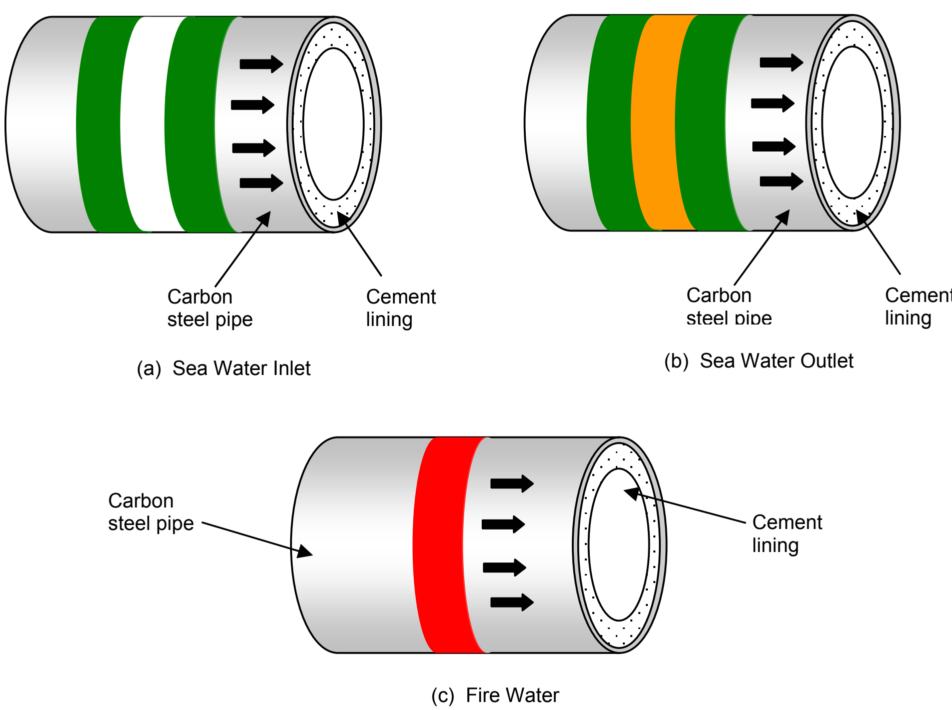


Figure 2.3: Cement-lined Pipes

2.1.2 Pipe Dimensions

Pipe dimensions are specified by:

- nominal size
- a *pipe schedule* number that describes the thickness of the pipe material (the *wall thickness*)

All pipes of one nominal size have the same OD but they come in different schedules. The ID depends on the nominal size and the wall thickness. **Table 2.1** shows examples of typical pipe dimensions.

Nominal Pipe Size in	Schedule No.	Wall Thickness		Inside Diameter (ID)		Outside Diameter (OD)	
		in	mm	in	mm	in	mm
1/2	5	.065	1.65	.710	18.03	.840	21.3
	10	.083	2.11	.674	17.12		
	40	.109	2.77	.622	15.80		
	80	.147	3.73	.546	13.87		
2	10	.109	2.77	2.157	54.79	2.375	60.3
	40	.154	3.91	2.067	52.50		
	80	.218	5.54	1.939	49.25		
	160	0.343	8.71	1.689	42.88		
6	40	.280	7.11	6.065	154.1	6.625	168.3
	80	.432	10.97	5.761	146.3		
	120	.562	14.27	5.501	139.76		
	160	.718	18.24	5.189	131.82		
18	40	.562	14.278	16.876	428.650	18.00	457
	80	.937	23.800	16.126	409.600		
	120	1.375	34.925	15.250	387.350		
	160	1.781	45.24	14.438	366.725		

Table 2.1: Typical Pipe Dimensions

The nominal size for pipes up to 12-inch diameter gives the approximate inside diameters for the different schedules, e.g. 1.689in to 2.157in for the 2-inch pipe. For pipes over 12-inch diameter, the nominal size is equal to the OD.

Wall thickness depends on the schedule number. For half-inch pipe:

- schedule 5 is the thinnest at 0.065in or 1.65mm
- schedule 80 the thickest at 0.147in or 3.73mm

Pipe dimensions are shown in **Figure 2.4**.

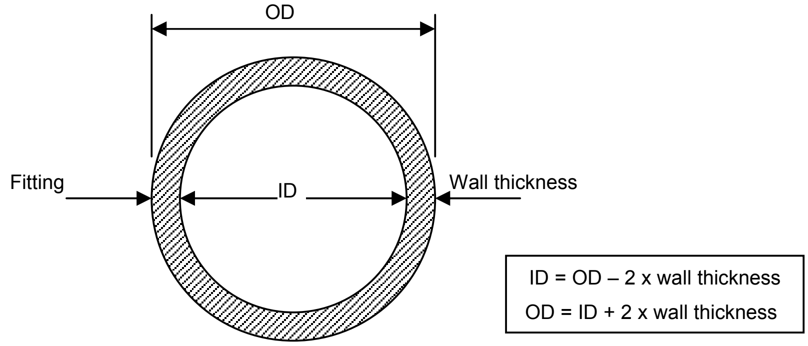


Figure 2.4: Pipe Section Dimensions

Engineers calculate the inside diameter to give the correct *flow rate* of fluid through the pipe. The flow rate tells you how much fluid flows and how quickly. It is measured in units of volume per unit time, e.g. litres/second, or mass per unit time, e.g. tonnes/hour.

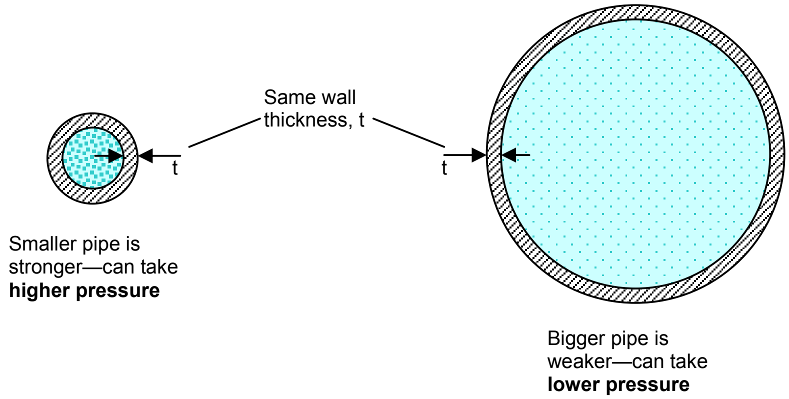
Bigger ID pipes allow higher flow rates.

Also, it is harder to push fluid through a small pipe because there is more fluid friction between the fluid and the pipe walls.

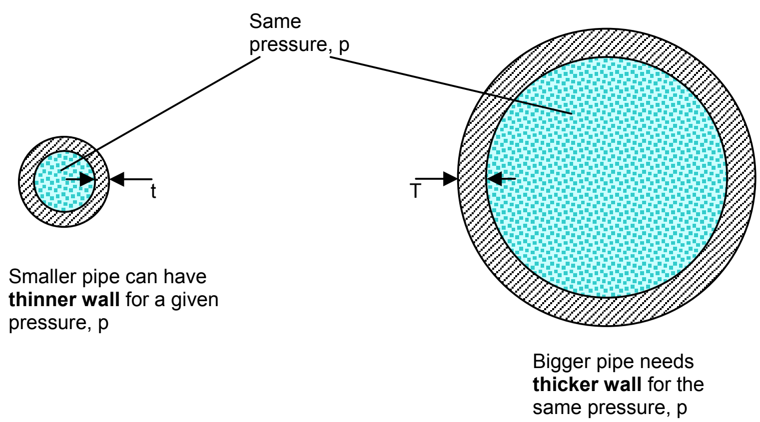
Bigger ID pipes waste less pumping power.

Engineers calculate the pipe wall thickness to make sure that the pipe is strong enough to take the pressure of the fluid inside. Small diameter pipes are stronger than large diameter pipes so they can take higher pressure, as shown in **Figure 2.5(a)**.

To take the same pressure as a small pipe, a big pipe must have a thicker wall, as shown in **Figure 2.5(b)**.



(a) Equal Wall Thickness



(b) Equal Pressure

Figure 2.5: Pressure, Pipe Size and Wall Thickness

The schedule number does not give the same wall thickness for all pipe sizes. The wall thickness for any schedule of pipe becomes greater as the pipe's nominal size increases.

The schedule number used for any application depends on

- the pressure the pipe must take
- a *corrosion allowance* that depends on how corrosive the fluid being carried is—more corrosive fluids need thicker walled pipes or they will not last long

Compare the wall thicknesses of the pipes in **Table 2.1**.

As the nominal size of the pipe increases, the wall thickness for any schedule increases.

For example:

- a schedule-40 $^{1}/_{2}$-inch pipe has a wall thickness of 0.109in or 2.77mm
- a schedule-40 18-inch pipe has a wall thickness of 0.562in or 14.278mm

The schedule-40 wall thickness is greater for the bigger pipe to allow it to take similar pressure to the smaller pipe.

Appendix C shows a more complete table of pipe dimensions for you to refer to.

ADGAS Piping Specifications give the schedule numbers and Standards (API; ASTM; BS) for the materials used for different pipe sizes for all ADGAS applications.

Now try **Exercise 2**

2.1.3 Tube

You will often see the words *pipe* and *tube* used for the same thing. There are two differences between pipe and tube:

- pipe always has a round section but tube can have any shaped section: square, hexagonal, oval, etc.
- Pipe is specified by its nominal size and schedule number as described in **Section 2.1.2**, but tube is specified by its exact OD and wall thickness in inches, millimetres or sometimes *gauge*. **Appendix D** shows conversions from Standard Wire Gauge (SWG) to inches and millimetres for your reference.

Now try **Exercise 3**

2.1.4 Insulated Pipes

Metals are good conductors of heat. Hot fluids, like steam, can lose a lot of their heat through the walls of a pipe.

Heat is a form of energy. Any loss of energy from a process reduces the efficiency of the process.

Efficiency is a measure of how much energy is wasted. Heat lost from pipes is a waste of energy. Wasted energy costs money.

Insulating materials are very poor conductors of heat. Heat can not pass through them easily so they reduce heat loss, increase efficiency and save money.

Look at the boiler supplying steam to a turbine through a pipe, shown in **Figure 2.6**.

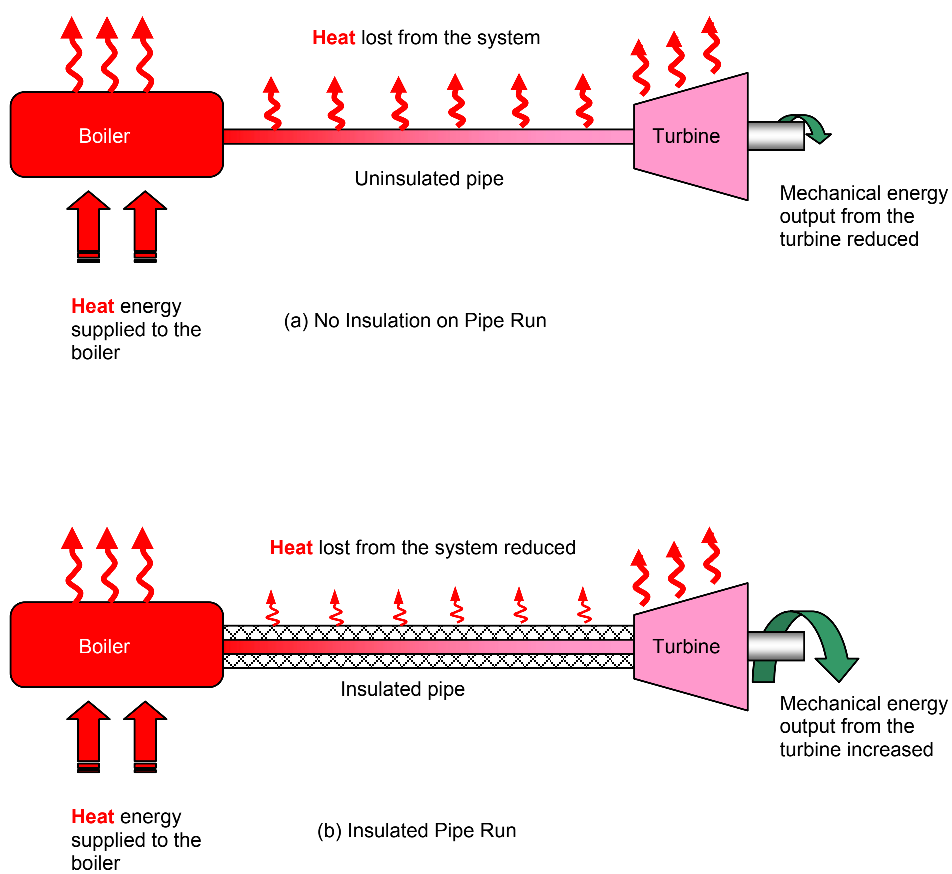


Figure 2.6: Effect of Pipe Insulation on Efficiency

More heat is lost from the uninsulated pipe in **Figure 2.6(a)** than from the insulated pipe in **Figure 2.6(b)**.

You can convert energy from one form to another, e.g., from heat energy to mechanical energy. Heat energy enters the boiler and useful mechanical energy leaves the turbine at the turbine output shaft. Some heat energy is wasted because it is lost from the pipes and equipment.

You can show this type of energy change in the block diagram in **Figure 2.7.**

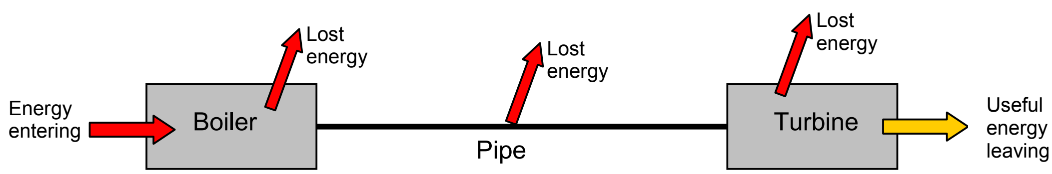


Figure 2.7: Block Diagram of Boiler-Turbine System

The block diagram is just a simplified version of the diagram in **Figure 2.6**.

Efficiency is given by:

$$\boxed{\frac{\text{Useful energy leaving the system}}{\text{Total energy entering the system}}}$$

Also:

$$\boxed{\text{useful energy leaving the system} = \text{total energy entering} - \text{total lost energy}}$$

The less energy that is lost, the more is *available* as useful energy output.

Something is ***available*** when it is free to be used.

Insulating pipes and equipment reduces the lost energy as shown in **Figure 2.6(b)**. This increases the useful energy output and increases the plant efficiency.

It is just as important to stop heat entering pipes that carry cooled fluids as it is to stop it escaping from hot fluids. The gas liquefaction process cools the gas products, LNG, LPG, etc., to very low temperatures. These temperatures, as low as -161°C for LNG, are needed to change the gases into liquids and to keep them in liquid form for transportation. Pipe insulation reduces the heat gained by cold fluids in exactly the same way as it reduces heat lost from hot fluids.

Heat always flows from a higher to a lower temperature. That is why it flows out of a hot fluid into the cooler surrounding air. It is also why it flows into a cold fluid from the warmer surrounding air. This flow is shown in **Figure 2.8**, along with the effect that insulation has on the flow.

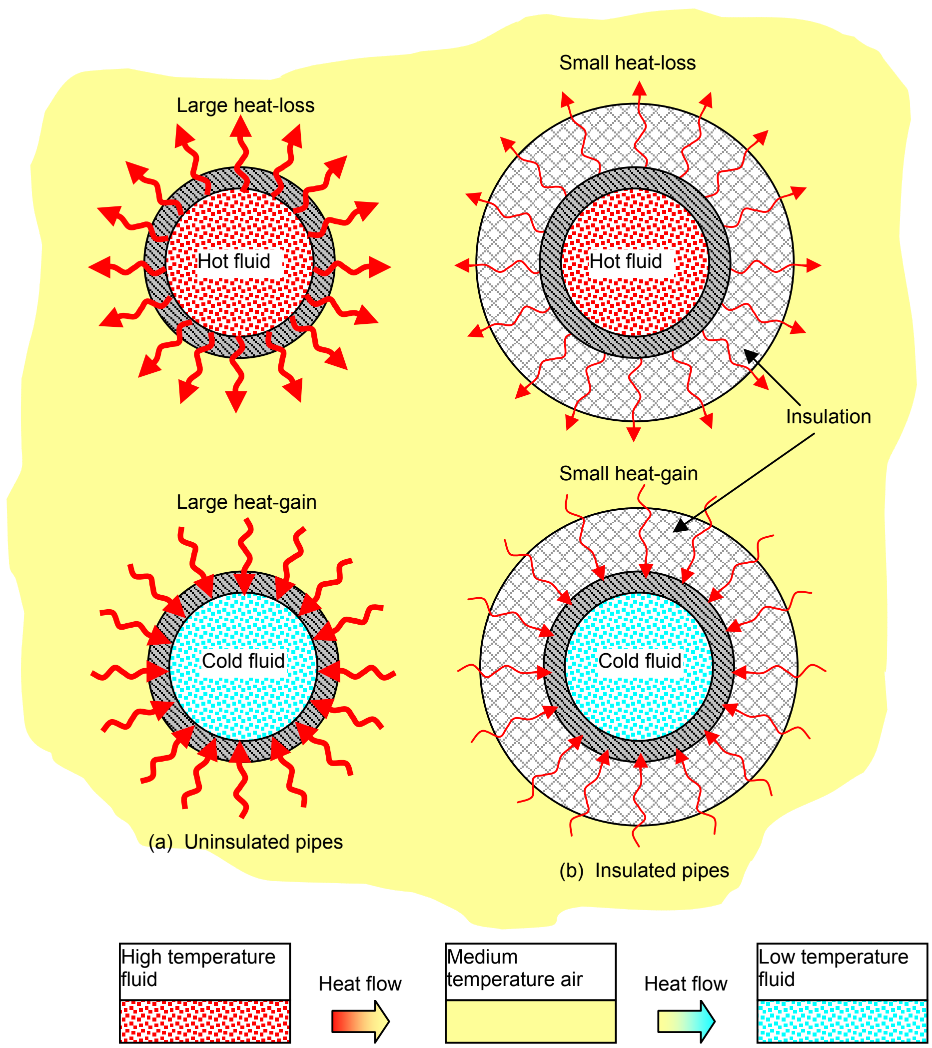


Figure 2.8: Heat Flow from Higher to Lower Temperatures

Heat can travel from one place to another in three ways:

- conduction—through solids
- convection—through gases
- radiation—through a vacuum (nothing)

You learnt about these methods of heat transfer in the *Physics* module of the Basic Maintenance Technician Course.

Insulating materials are poor conductors of heat so heat can not pass through them easily by conduction.

Heat radiates much more easily from a dull, black surface than from a shiny, bright surface.

Dull black surfaces also take in (absorb) radiated heat more easily than bright, shiny surfaces. Men often wear white clothes in hot countries like the U.A.E. This helps to keep them cool. The radiant heat from the sun is reflected and less passes through the clothes.

Pipe insulation often includes a silver or a white layer. This can be under the other insulating material, next to the pipe, or on top. **Figure 2.9** shows examples of insulated pipes with a silver (**Fig. 2.9(a)**) or white (**Fig. 2.9(b)**) outer layer to reduce radiation. This outer layer also acts as a *vapour barrier* on pipes carrying cold fluids.

(a) Silver Outer Surface (b) White Outer Surface

Figure 2.9: Pipe Insulation with Low-radiation Vapour Barrier

In **Figure 2.10(a)** a pipe is insulated by first wrapping a low-radiation layer around the pipe. A low-conduction tape is them wound on top of the silver tape in **Figure 2.10(b)**.

(a) Silver Layer Next to Pipe

(b) White Insulation on Top

Figure 2.10: Pipe Insulation with Inner Low-radiation Layer

2.2 Pipework Supports

Most lengths of pipework, or *pipe runs*, are heavy and need to be supported . Without supports, pipes will sag. Sagging pipes put extra load on fittings and equipment connected to the pipes. If flanges support the weight of the pipe they may start to leak.

Pipes carrying hot or cold fluids will expand and contract as their temperature changes. Supports for these pipes must allow some axial movement of the pipe to allow for expansion and contraction. Expansion is described in **Section 4** of this module.

Pipes may be supported from the floor, from pillars or from overhead *structures*. Pipe hangers are supports that hang from overhead structures, e.g., roofs or ceilings.

Here, a ***structure*** is something built, usually to take load.

The spacing between supports depends on the size and weight of the pipe. A support every 3m is correct for many piping applications.

There are many designs of pipe supports. Some common types used on the ADGAS plant are shown in **Figures 2.11** to **2.19**.

Figure 2.11 shows a simple support for large pipes.

A concrete block supports the pipe. The pipe rests on a steel plate fixed to the concrete block. The pipe's vertical position is fixed. Its horizontal position may also be fixed if it is welded to the steel plate. Welds are *permanent* fixings. Welding a pipe in place makes it difficult to move later.

Permanent means for ever.

Figure 2.11: Simple Concrete Support Block

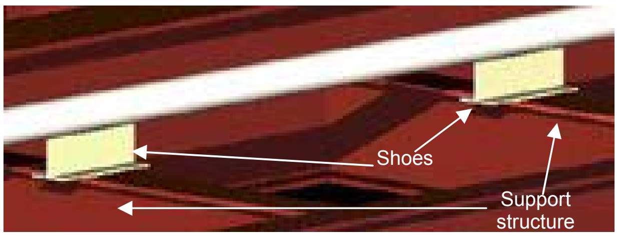
Clamps allow a pipe to be held in position but they can be removed to move the pipe. They are *temporary* fixings.

The clamps may be welded or bolted to a fixed support structure, as shown in **Figure 2.12**. This support allows no vertical or horizontal movement.

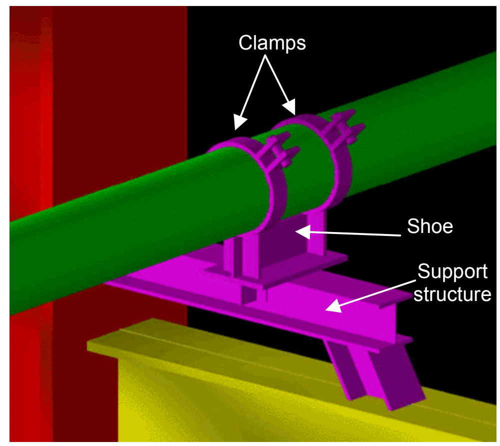
Temporary means not lasting for ever. It is the opposite of permanent.

Figure 2.12: Clamped Support

Shoes, shown in **Figure 2.13**, can support pipes up to about 12-inch diameter. The shoes rest on a support structure and can slide to allow for expansion. They may be welded onto the pipe, as shown in **Figure 2.13(a)** or clamped, as shown in **Figure 2.13(b)**.



(a) Welded Shoes



(b) Clamped Shoe

(c) Shoe Fixed to Insulated Pipe

Figure 2.13: Shoe Supports

Figure 2.13(c) shows a support shoe fixed to an insulated pipe. Some of the insulation has been cut away to show the pipe more clearly.

Shoe supports allow some horizontal movement but no vertical movement of the pipe. Some shoes supports have guides to limit the sideways movement allowed. These are fixed to the support structure, one on each side of the shoe.

U-shaped bolts give a simple way to fix pipes in position. They allow no vertical and no horizontal movement. U-bolt supports are shown in **Figure 2.14**.

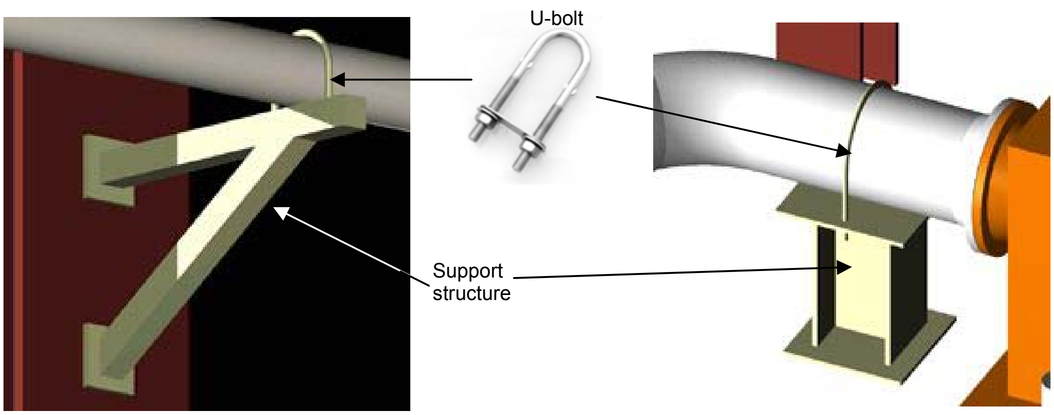


Figure 2.14: U-bolt Supports

U-bolts clamp the pipe securely against a support structure.

Support *jacks* allow adjustment to the height of the support using a screw thread. Two examples are shown in **Figure 2.15**.

(a) Jack Support Allowing Pipe Expansion

(b) Clamped Jack Support

Figure 2.15: Jack Supports

Roller supports are used with uninsulated pipes. They allow the pipe to expand freely. **Figure 2.16** shows two examples of roller supports.

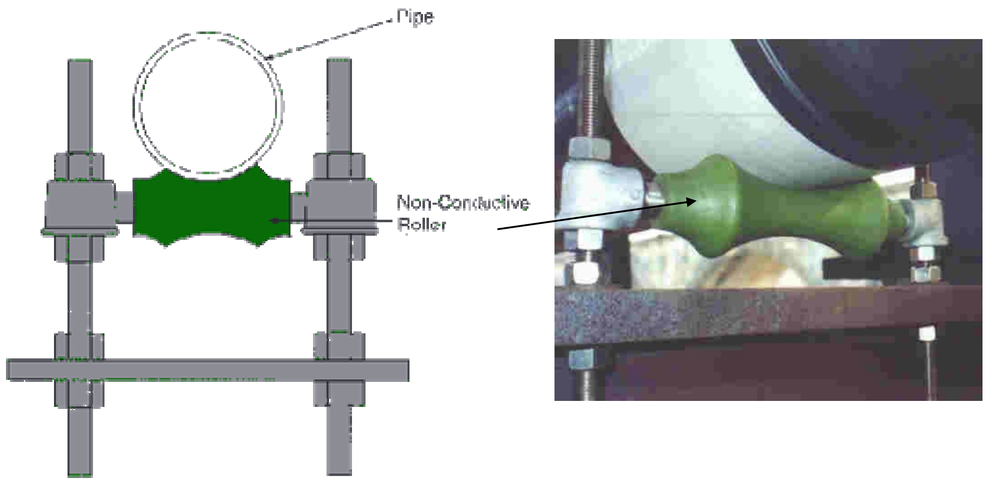
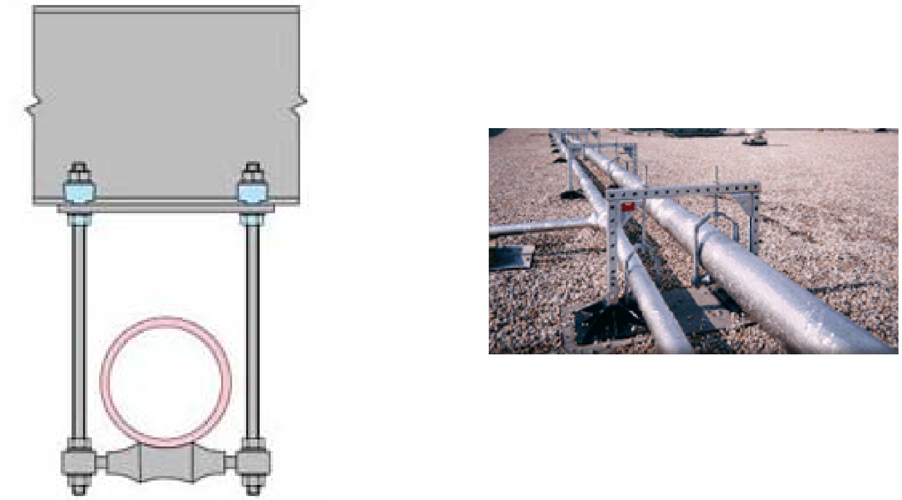


Figure 2.16: Roller Supports

The roller shown is made of a *non-conductive* material. This stops the support from carrying heat into or out of the pipe and its contents. Metal is a good conductor of heat and heat can pass easily to or from a pipe through metal supports. In some cases, where heat loss or gain is not very important, it is not worth the cost of insulating the pipes. It may still be worth fitting non-conductive supports as a cheap way to reduce heat loss or gain through the supports.

The supports described so far are fixed to structures under the pipe. Pipes supports that hang from above the pipe are called pipe hangers.

Figure 2.17 shows two examples of roller supports that are fitted to pipe hangers.



(a) (b)

Figure 2.17: Roller Pipe Hanger

The roller shown in **Figure 2.17(a)** is held by two adjustable studs, or *tie rods*, to the support structure above. The roller shown in **Figure 2.17(b)** is held in a *stirrup* fixed to the support structure by a single adjustable tie rod. The stirrup can turn to align itself with the pipe.

Spring hangers allow freedom for pipes fixed to equipment that vibrates. They also allow for expansion and contraction of pipes. **Figure 2.18** shows a spring hanger in place and a cutaway showing the spring.

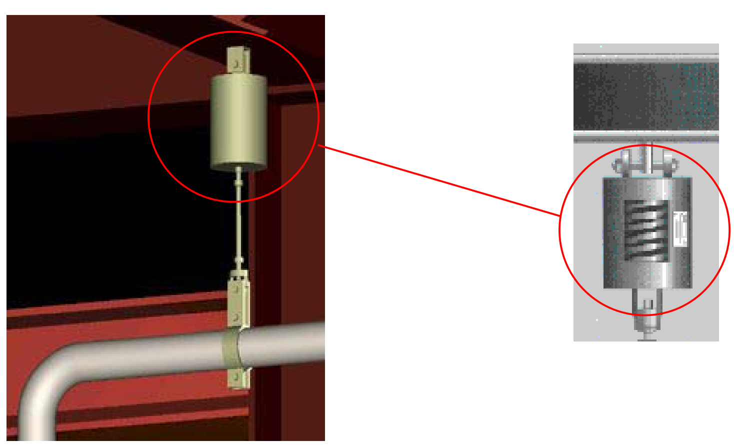


Figure 2.18: Spring Hangers

Where a number of pipes follow the same run, supports can carry more than one pipe, as shown in the examples in **Figure 2.19**.

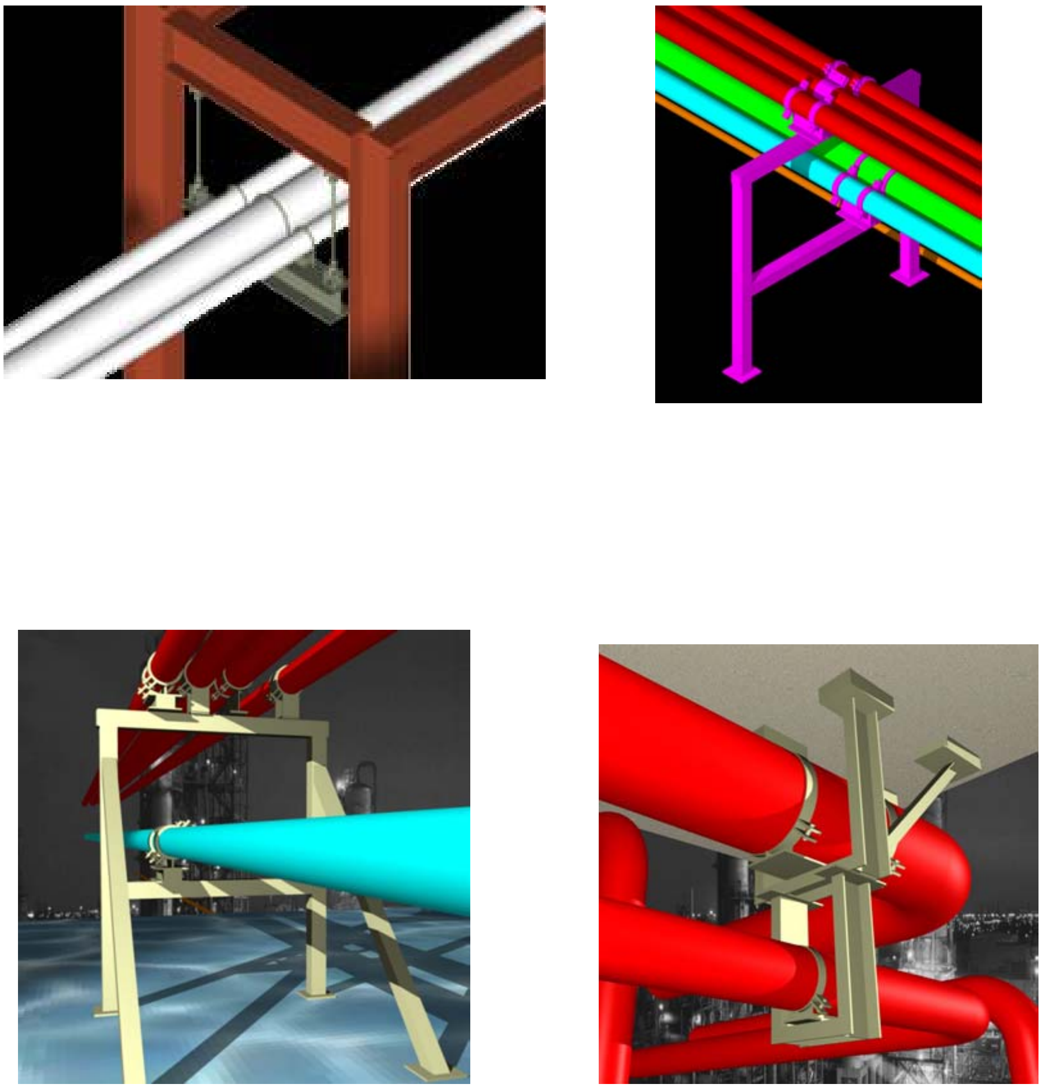


Figure 2.19: Multiple Pipe Supports

3 Pipe Fittings

Pipe fittings are items, other than pipes, that are a part of a pipework system. There are different fittings to perform different tasks:

- join together lengths of pipe—couplings, unions, nipples
- change the pipe size— reducers, bushings
- change the direction of a pipe run—elbows
- join or separate flows of fluid (*branch* the pipe)—tees and crosses
- control flow through pipes—valves, spades, caps, plugs
- connect pipes to equipment—flanges, couplings

Pipe fittings for ADGAS applications are described in the ADGAS Piping Specifications. International Standards for the dimensions and materials of the fittings are given for every application on the plant.

Valves are described in a later module in this course.

Pipe fittings are connected to pipes in different ways, depending on the size of the pipe and the pressure and temperature of the fluid it carries. ADGAS Piping Specifications also tell you how fittings are connected to the pipe for each application.

Fittings are described by:

- the job they do
- the way they are fitted to the pipe—screwed, compression or welded

3.1 Screwed Fittings

Low pressure pipelines, generally up to about 4-inch diameter, can use fittings that screw directly onto the pipe. This type of fitting can be removed to dismantle or re-route the pipe run. External threads cut on the ends of the pipe screw into internal threads in the fittings.

You learnt about threads and thread cutting in the module: *Drilling, Threading and Fitting* in this course. Pipe threads are fine threads, so as not to cut too deeply into the pipe wall. British Standard Pipe (BSP) thread, American National Thread (NPT) and Metric Fine series are used.

Many pipe threads are tapered so that the more you screw them in, the tighter they get. **Figure 3.1** shows male (external) and female (internal) tapered threads.

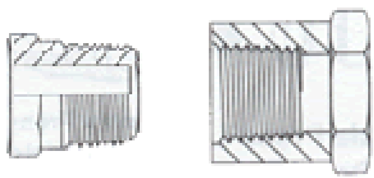


Figure 3.1: Tapered Threads

Tapered threads help to stop leaks at screwed joints.

Using a pipe-thread jointing compound or joint tape on the threads before assembly also reduces the risk of leaks. Jointing compound is a paste that seals, lubricates and protects threaded pipe and fittings. Joint tape is a thin PTFE (or *Teflon*) tape that is wrapped tightly around the thread to seal the joint, as shown in **Figure 3.2**.

Figure 3.2: PTFE Joint Tape

Examples of common screwed fittings for low-pressure piping systems are shown in **Tables 3.1** to **3.4**. The abbreviation used for a screwed fitting in the ADGAS Piping Specifications is **SCRD**.

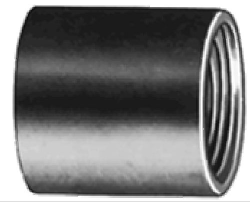
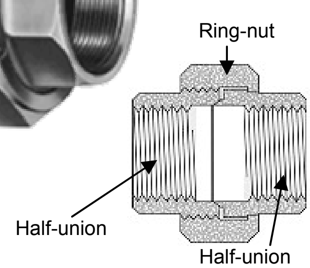
Fittings That Connect Pipe Lengths		
Name	**Purpose**	**Fitting**
Coupling	Connects two pipes of the same size.	
Bushing	Reduces internal thread diameter. E.g. used with a coupling to connect different size pipes.	
Nipple	Short length of pipe to connect between internally threaded items, e.g., equipment or other fittings.	  Plain Hexagonal
Reducer	Connects two pipes of different sizes.	
Union	Connects two pipes so that they can easily be disconnected without having to turn the pipe. The two halves of the union are attached to the pipes being connected. The outer ring-nut then joins the two union halves.	 

Table 3.1: Screwed Fittings 1

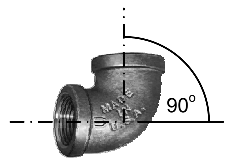
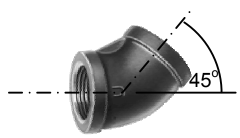
Fittings That Change Pipe Direction		
Name	**Purpose**	**Fitting**
90^{o} Elbow	Turns the pipe run through 90^{o}. 	
Street elbow	Turns the pipe through 90^{o} to connect to an internally threaded item.	
45^{o} Elbow	Turns the pipe run through 45^{o}. 	
The fittings shown in this table are used between pipes of the same size. Similar fittings are available that can be used between pipes of different sizes—reducing bends.		

Table 3.2: Screwed Fittings 2

To reduce the number of fittings, smaller pipe can be bent as described in **Section 6.2** of this module.

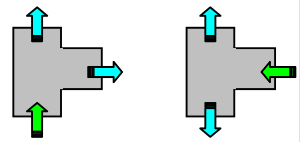
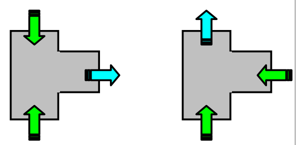
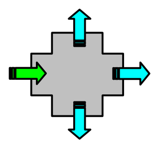
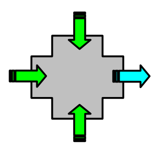
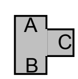
Fittings That Join or Separate Flows		
Name	**Purpose**	**Fitting**
Tee	Divides a single flow into two:  or joins two flows into one: 	
Cross	Divides a single flow into three:  or joins three flows into one: 	
The fittings shown in this table have branches of the same size. Similar fittings are available that can be used between pipes of different sizes. Branch sizes for a tee are given with the side-branch size given last, e.g., in the order AxBxC 		

Table 3.3: Screwed Fittings 3

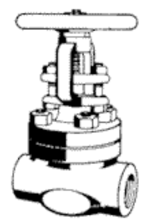
Fittings That Stop or Control Flow		
Name	**Purpose**	**Fitting**
Cap	Screws onto the end of a pipe to close it or *blank it off*.	
Plug	Screws into a fitting to *blank* it off.	
Valve	Controls flow by closing or opening the pipe. (Valves are described in detail in the next module of this course.)	

Table 3.4: Screwed Fittings 4

Now try **Exercise 4**

3.2 Compression Fittings

Compression fittings are used on small-diameter stainless steel, brass or copper tubing. They are only used on the plant for instrumentation hydraulic and air lines. Because Mechanical Maintenance Technicians do not work on instrumentation pipework, only a brief description is given in this module.

Compression fittings work by squeezing (compressing) a tapered ring called a *ferrule* or *olive* onto the outside of the pipe. The ring forms a seal between the fitting and the pipe when the compression fitting is tightened. **Figure 3.3** shows a typical brass compression fitting.

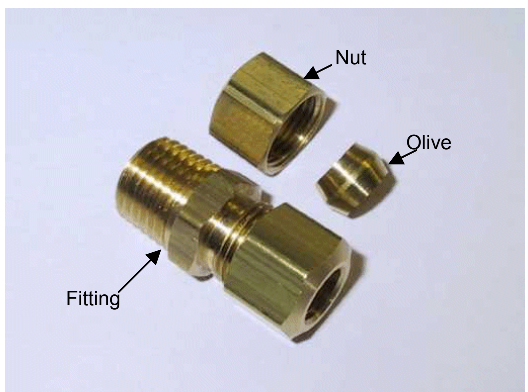


Figure 3.3: Compression Fitting

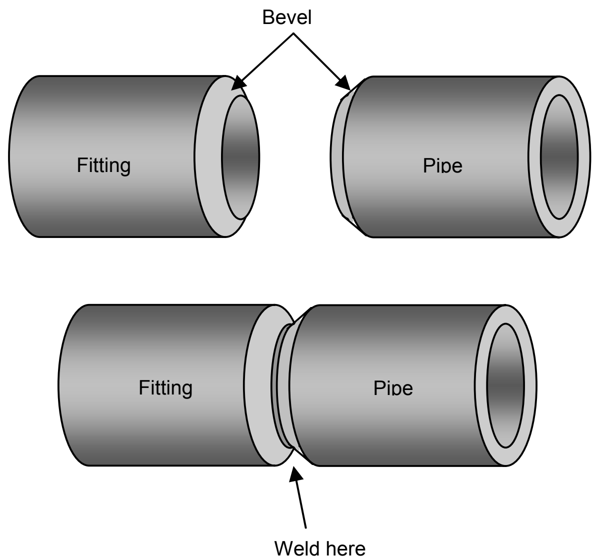
3.3 Welded Fittings

Welded fittings are used on high-pressure pipelines. Welded joints can take much higher pressures than screwed joints but they are permanent; you have to cut them off to remove them.

There are two types of welded joints on pipe fittings:

- butt-welded—used on any size of pipe
- socket-welded—usually up to $1^1/_2$ inch (38mm) pipe

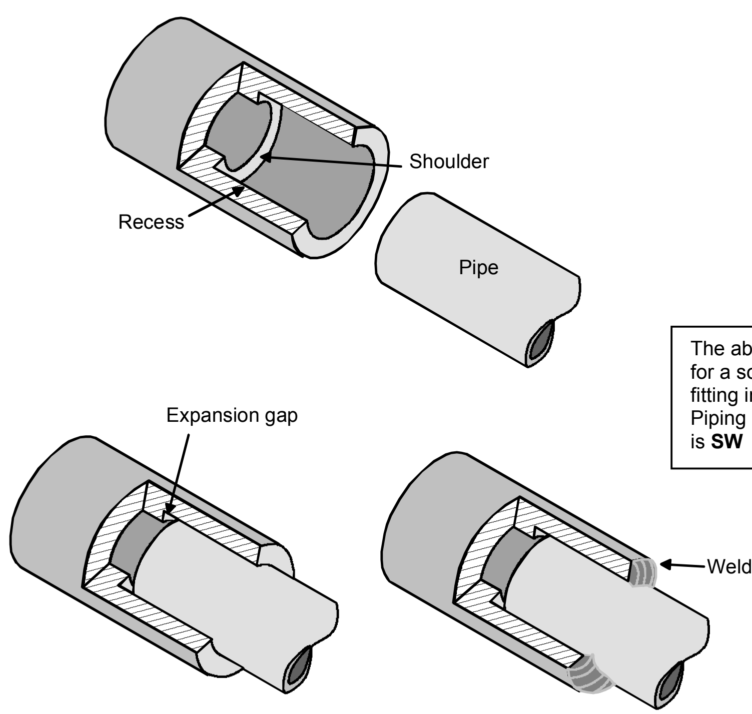
Butt-welding fittings have bevelled ends. The end of the pipe to be welded is also bevelled as shown in **Figure 3.4**.



The abbreviation used for a butt-welding fitting in the ADGAS Piping Specifications is **BW**

Figure 3.4: Butt-welding Joint

Socket-welding fittings slide over the end of the pipe as shown in **Figure 3.5**.



The abbreviation used for a socket-welding fitting in the ADGAS Piping Specifications is **SW**

Figure 3.5: Socket-welding Joint (Part-section)

The pipe expands when it gets hot. There must be a gap of about 2mm between the end of the pipe and the end of the recess in the fitting to allow for expansion. Without a gap, the end of the pipe would push against the shoulder when it expands.

Expansion during welding would move the pipe as the weld is being made. This could affect the strength of the welded joint. Expansion when in service would put unnecessary load on the joint.

Table 3.5 shows examples of common pipe fittings with welded joints.

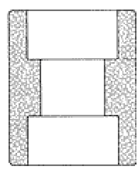
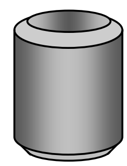
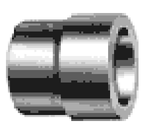
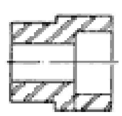
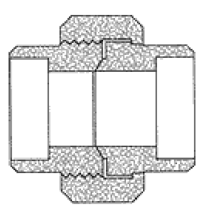
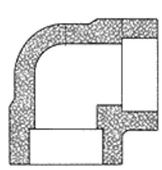
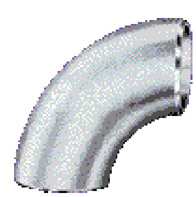
Welding Fittings		
Name	**Socket-welding SW**	**Butt-welding BW**
Coupling	 	
Reducer	  Concentric	 
Union	 	
90° Elbow	 	

Table 3.5(a): Welded Pipe Fittings

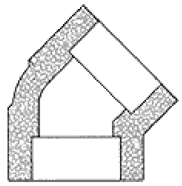
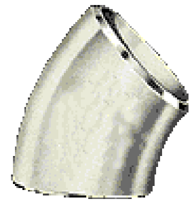
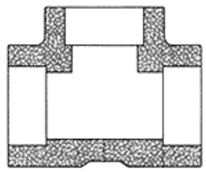
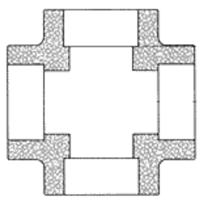
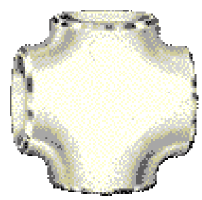
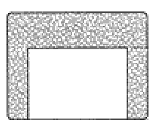
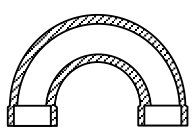
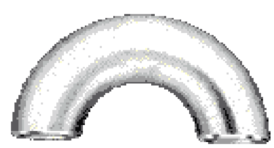
Welding Fittings		
Name	**Socket-welding SW**	**Butt-welding BW**
45° Elbow	 	
Tee	 	
Cross	 	
Cap	 	
Return	 	
Elbow, cross and tee fittings shown in this table have branches of the same size. Similar fittings are available that can be used between pipes of different sizes.		

Table 3.5(b): Welded Pipe Fittings

Socket-welding fittings are self-aligning—the pipe fits into the recess in the fitting before it is welded. Butt-welding fittings must be aligned for welding. **Figure 3.6** shows typical pipe alignment tools for butt-welding fittings. The fitting is *tack-welded* to the pipe with the alignment tool in place. It is then removed before completing the weld.

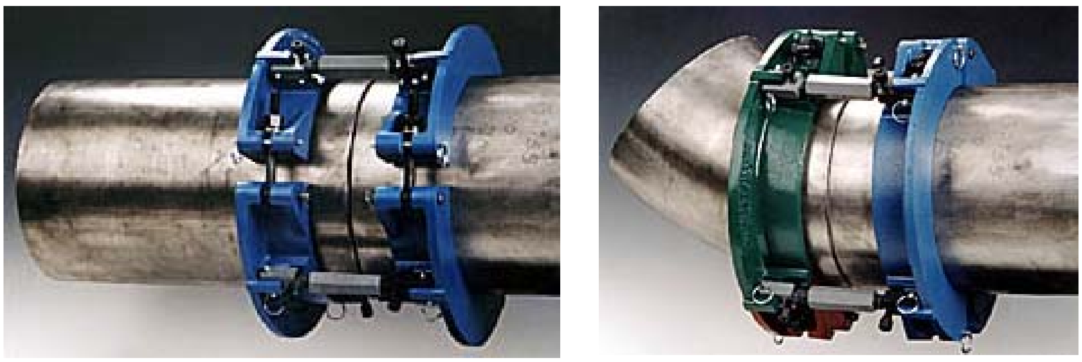


Figure 3.6: Pipe Alignment Tools

Figure 3.7 shows some medium-diameter butt-welded elbow fittings in a process plant.

Now try **Exercise 5**

Figure 3.7: Butt-welded Joints

3.4 Flanges

Flanges give temporary joints and can be used on high-pressure pipelines. A typical application of flanges is shown in **Figure 3.8**.

Figure 3.8: Flange Joints on Pipeline

It is most important to use the correct flange for the job. The correct flange to use depends on:

- pipe size
- fluid being carried
- pressure of the fluid
- temperature of the fluid

Flanges for ADGAS applications are described in the ADGAS Piping Specifications. The size and schedule number are listed in the specification.

Also listed in the specifications are:

- method of fixing the flange to the pipe, see **Table 3.6**
- type of flange face—the way they seal, see **Table 3.7**
- flange class—the dimensions of the flange to BS 1560—**Appendix E** shows class 600 (600#) flange dimensions as an example
- material—BS and ASTM standards for materials are listed

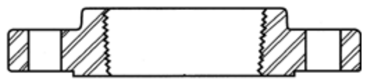
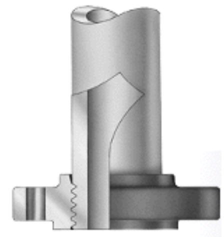
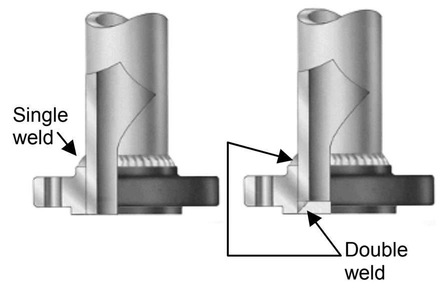
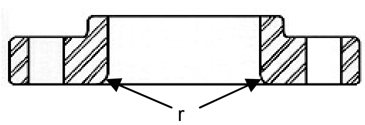
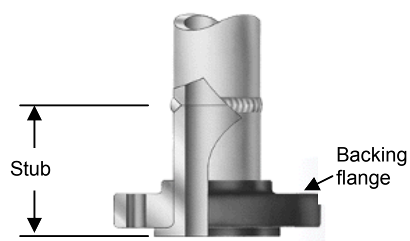
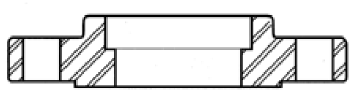
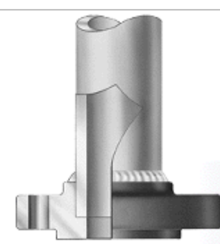
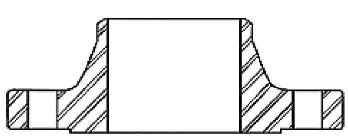
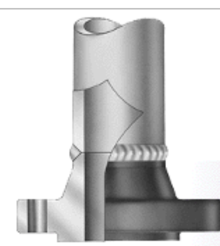
Flange to Pipe Fitting		
Name	**Flange Section Drawing**	**Part-section of Flange Assembly**
Screwed **SCRD**	 Screw onto taper thread on the pipe.	
Slip-on **SO**	 Fits over pipe and is *fillet welded* to it. May also be welded at the end of the pipe.	
Lap-joint	 Similar to slip-on flange but has a small radius r. A stub is butt-welded to the pipe. The backing flange is a sliding fit on the stub. The flange can be unbolted and slid back out of the way.	
Socket-welding **SW**	 Similar to other socket-welding fittings.	
Welding neck **WN**	 Neck is butt-welded to the pipe.	

Table 3.6: Methods of Fitting Flanges to a Pipe

The bold letters under flange name in the tables are the abbreviations used in the ADGAS Specification for methods of fixing flanges to pipes.

Flange faces must be flat and smooth. If they are not, they will leak. *Surface finish* is a measure of the smoothness and flatness of a surface. For low-temperature applications a very good surface finish is needed.

A joint is made between two flanges. Most flanges are fitted with a gasket. The gasket is clamped between the faces of the flanges. Its job is to reduce the chance of leakage.

Flange gaskets can be

- ring
- full face

Figure 3.9(a) shows typical ring- and full-face gaskets. Ring-gaskets fit inside the flange bolts. **Figure 3.9(b)** shows a ring gasket in place.

(a) Gaskets Types

(b) Ring-gasket Fitted

Figure 3.9: Flange Gaskets

Full-face gaskets cover the whole face of the flange. They have holes for the flange bolts to pass through. Gaskets are described in detail in a later module in this course.

The most common types of flange face joints are shown in **Table 3.7**

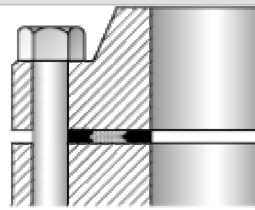
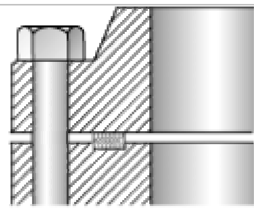
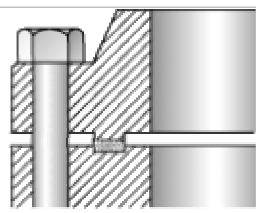
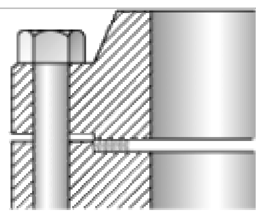
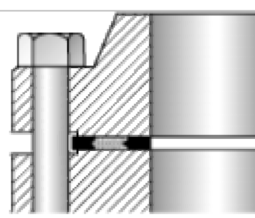
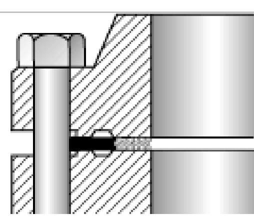
Flange Face Joints		
Name	**Half-section Through Flanges and Gaskets**	**Description**
Flat face **FF**		Both flanges have flat faces. The gasket may sit inside the flange bolts (ring-gasket), as shown, or be a full-face gasket with holes for the flange bolts.
Groove to flat		One flange is a flat-face flange; the other has an annular groove to take a ring-gasket.
Tongue and groove		One flange has a raised annular *spigot* (the tongue), the other a matching annular groove. A ring-gasket fits into the groove.
Male-female		The male flange has a raised *spigot* and the female a matching recess. A ring-gasket fits inside the female recess.
Raised face **RF**		Both flanges have raised faces giving relief on the outer edge.
Ring-type joint (API joint) **RTJ**		Both flanges have raised faces with an annular groove.

Table 3.7: Flange Faces

There are some flanges that perform special purposes. Three common types are:

- blind flange
- reducing flange
- orifice flange

These are shown in **Table 3.8**.

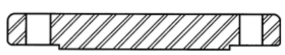
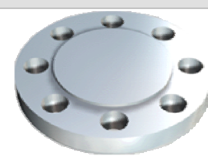
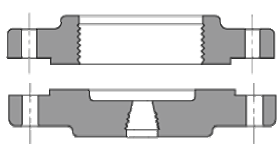
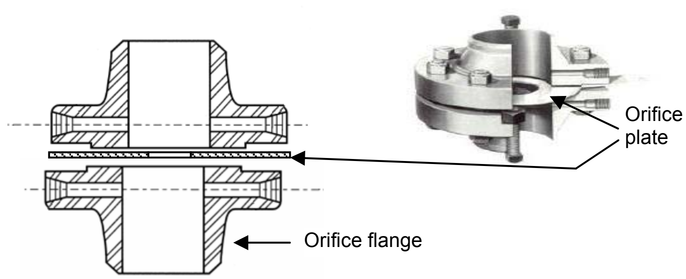
Special Flanges		
Name	**Flange**	**Purpose**
Blind	 	Blanking off
Reducing	 	Connecting pipes of different sizes. Screwed flanges shown in section drawing.
Orifice		Measuring flow rate from the pressure difference on either side of the orifice plate. Holes in the flange are pressure tappings.

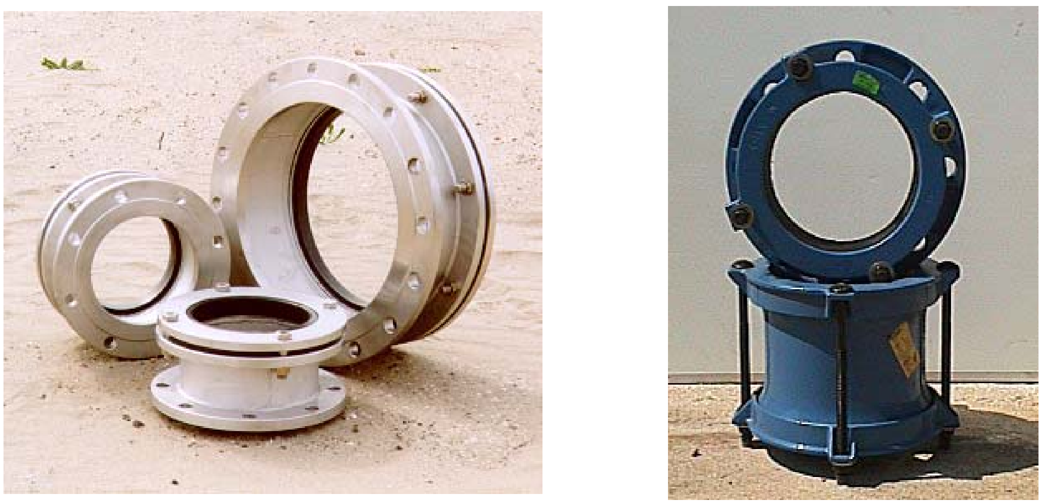
Table 3.8: Special Flanges

ADGAS uses BS 4882 to specify studs and nuts for most flanges on the plant. Studs are made of *high-tensile* steel for extra strength. **Appendix F** shows flange data for different classes of flange used on the plant.

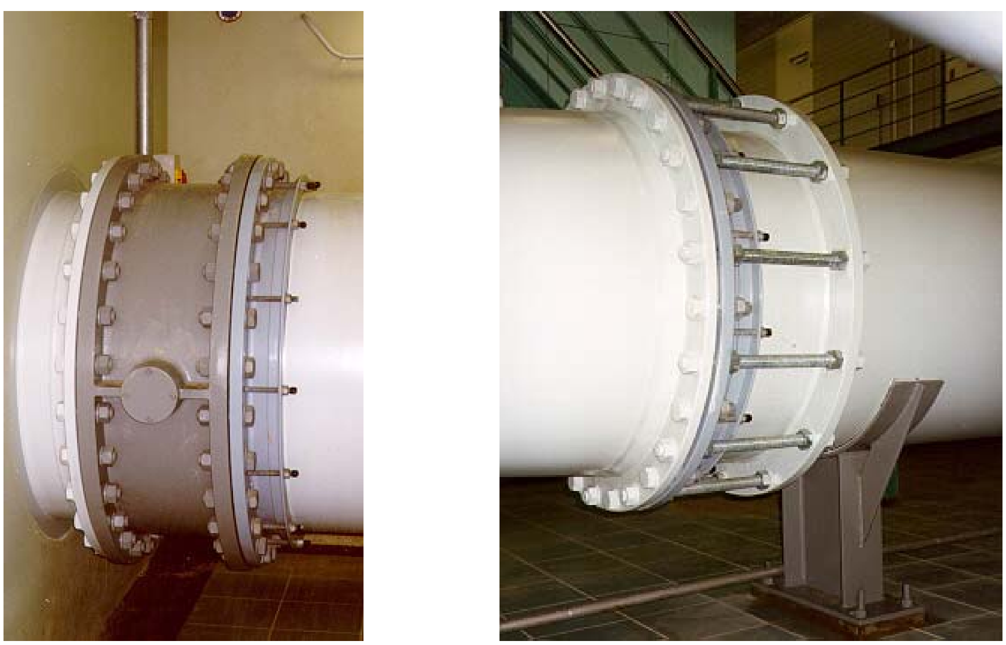
Now try **Exercise 6**

3.5 Flange Adapters

Flange adapters connect unflanged pipes or allow an unflanged pipe to be fitted to a flanged item. The adapter slides onto the pipe. Tightening the nuts squeezes a seal between the adapter and the pipe. Pipes joined using these adapters can not take axial pressure loading. They must be supported axially so that they can not be pushed out of the adapter by the fluid pressure. **Figure 3.10** shows examples of flange adapters.



(a) Pipe to Flange Adapters



(b) Two Designs of Pipe-to-flange Adapters Fitted

Figure 3.10: Flange Adapters

3.6 Spades

Spades, or blinds, are metal discs that fit between flanges in a pipeline. They isolate one section of piping from another. Spacers fit between the flanges when spades are not needed. When the pipe section is to be *spaded*, the spacer is removed and the spade fitted in its place. Spacers have an identifying hole in the lug, so you can see if a spacer or a spade is fitted.

Spades and spacers can be connected to make spading easier. These are called *spectacle spades* because they look like a pair of spectacles or glasses. One flange bolt passes through a hole between the spacer and the spade to act as a *pivot*. Both types of spades and spacers are shown in **Figure 3.11**.

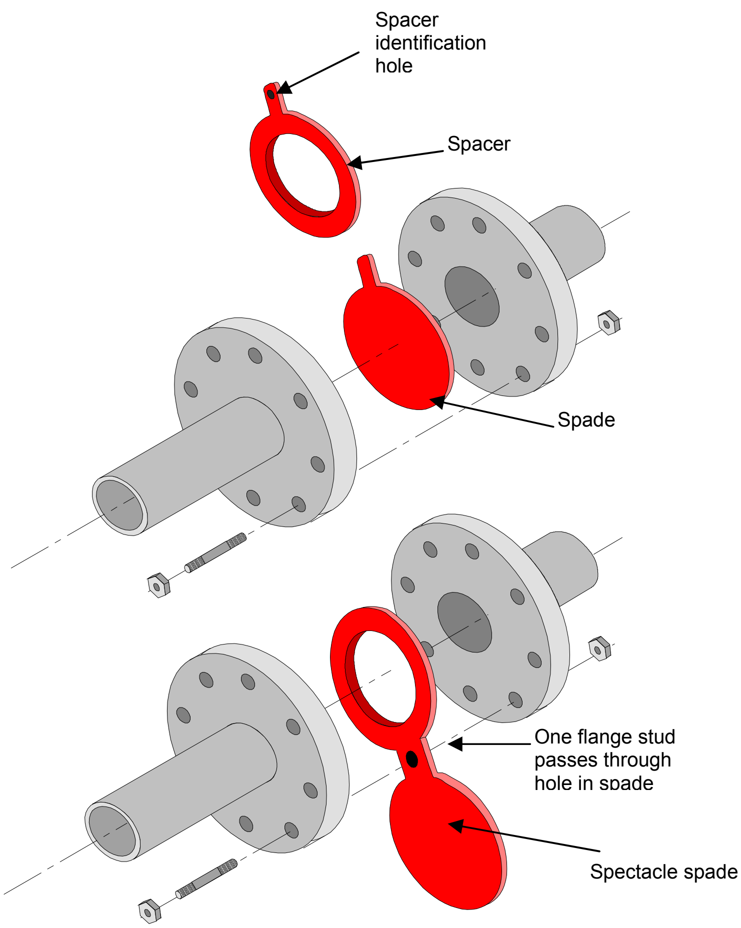


Figure 3.11: Spading

Gaskets, fitted between flanges and spacer or spade, are not shown in this figure.

Figure 3.12 shows two spectacle blinds or spades fitted in a pipeline. Both are fitted with the spacer in the line and the spade showing. You can see the spade section sticking out from between the flanges.

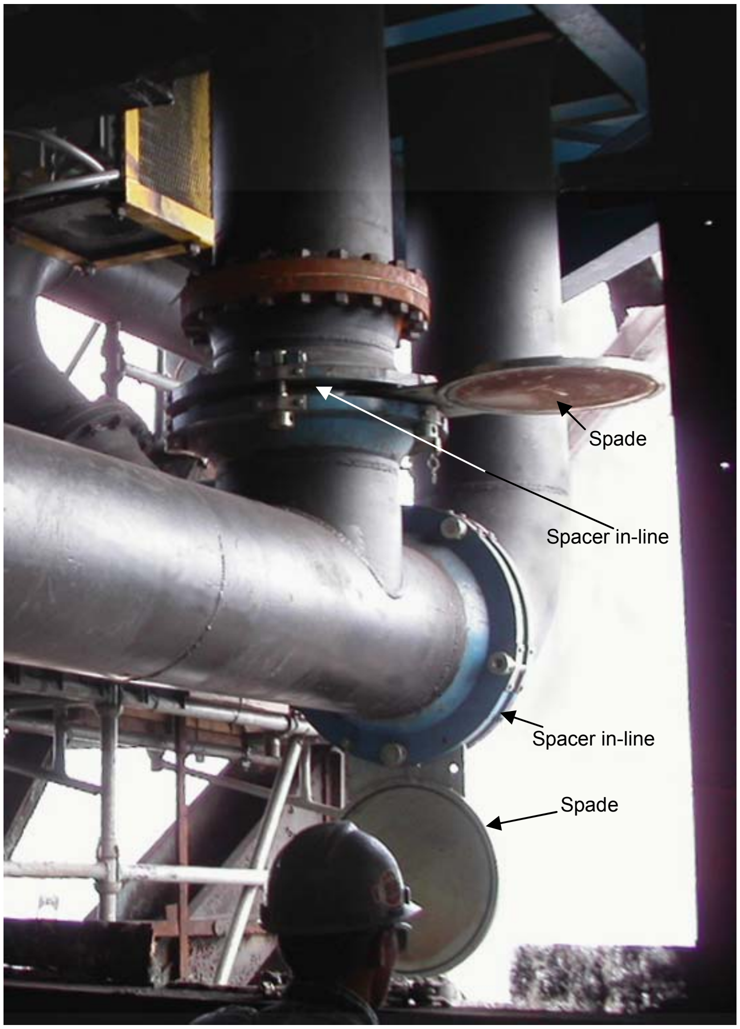


Figure 3.12: Spectacle Blinds or Spades

3.7 Spool Pieces

Spool pieces are short lengths of pipe with a flange at each end. They can be removed easily and are used to:

You have ***access*** to something when you can enter or get to it.

- connect between a pipeline and an item of plant—removing the spool piece gives *access* to the item
- allow blanking off of a pipe—when the spool piece is removed, blind flanges can be fitted
- re-route a flow—moving the spool piece from one pipeline to another as shown in **Figure 3.13** allows flow only in one line at a time.

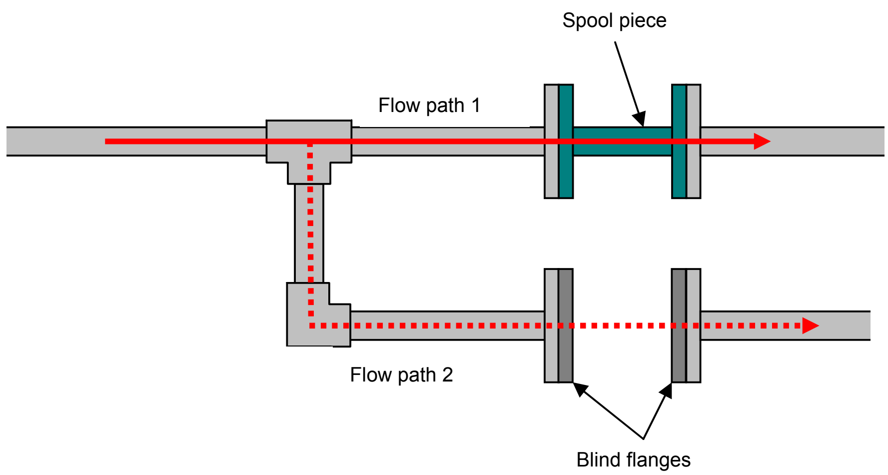


Figure 3.13: Spool Piece—Re-routing

Removing a spool piece and fitting blind flanges, as shown in the lower branch in **Figure 3.13**, is the best way to positively isolate a section of a pipeline. In this way there is no doubt that the line is blanked off.

3.8 Strainers

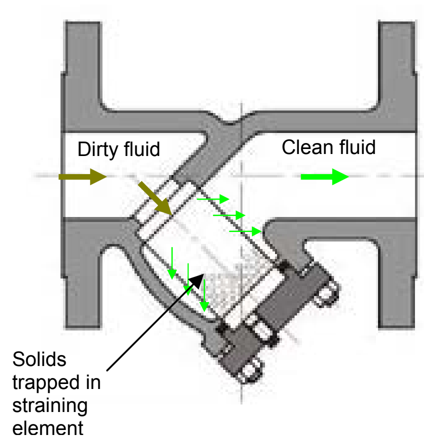
Strainers remove solids from the fluid flowing in the pipe. A strainer makes the fluid pass through a *straining element* that has very small holes. The smaller the holes, the smaller the solid particles it will trap.

The two most common types of strainer are:

- Y-type
- basket

Y-strainers have a straining element in a side branch that comes off at an angle, forming a letter Y. **Figure 3.14** shows a typical y-strainer, the fluid flow through it and a typical strainer element.

(a) Large Y-strainer



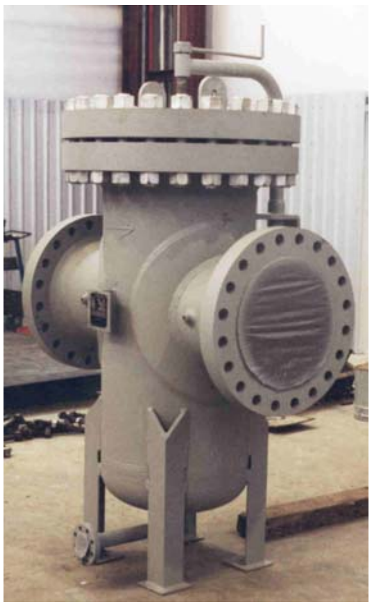
(b) Flow Through Y-strainer

(c) Strainer Element

Figure 3.14: Y-strainer

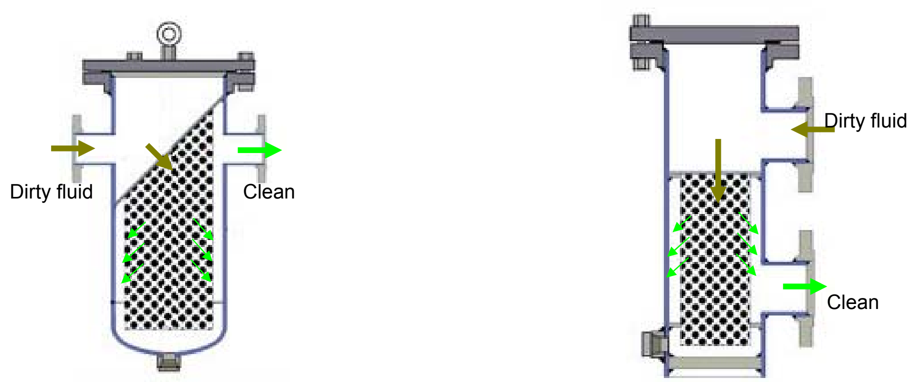
A cover gives access to the straining element for removal and cleaning or replacement.

Basket strainers work in a similar way but have a different shape. Basket strainers are shown in **Figure 3.15**.



(a) Inlet and Outlet on Opposite Sides

(b) Double (duplex) Strainer with Inlet and Outlet on Same Side



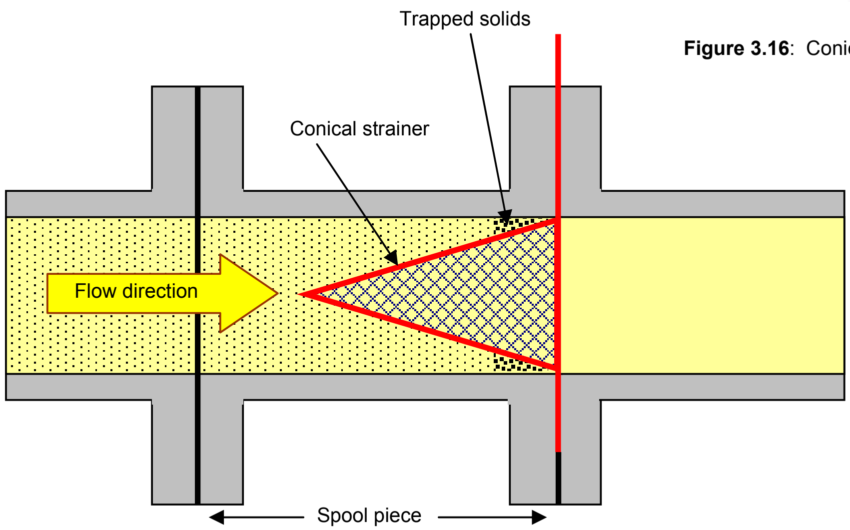
(c) Flow Through Basket Strainers

Figure 3.15: Basket Strainers

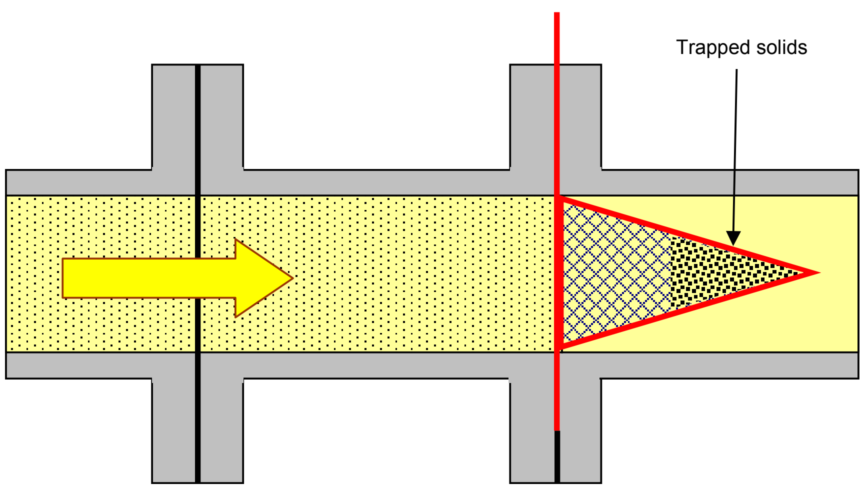
Another type of strainer used on the plant is the conical strainer shown in **Figure 3.16**. The straining element is pointed at one end, in the shape of a cone.

Conical strainers fit between flanges directly in the pipeline. Fit them in the direction shown in **Figure 3.17(a)**.

Figure 3.16: Conical Strainer



(a) Correct—Strainer Points Upstream



(b) Wrong—Strainer Points Downstream

Figure 3.17: Correct and Incorrect Fitting of Conical Strainer

With the strainer element pointing upstream, solid particles collect around the outside, next to the pipe wall, as shown in **Figure 3.17(a)**.

If you fit it the wrong way round, as shown in **Figure 3.17(b)**, solids collect in the point of the strainer. This blocks the strainer more quickly.

Conical strainers are often fitted into a pipeline for start-up after commissioning or major shutdown. They can then catch anything that may have got into the system when it is open.

They are also fitted at a compressor intake to make sure that no solids enter the compressor.

3.9 Steam Traps

Steam is used on the plant to drive steam turbines and to heat other fluids. Steam is just water that has been boiled. The process of changing water to steam is called *evaporation* and the process of changing steam back to water is called *condensation*. Heat is supplied to water to evaporate it and heat is taken out of steam to condense it.

Condensate is steam that has changed back to water. Condensate must not reach a turbine as water can damage the turbine rotors.

Steam traps separate condensate and air, etc., from steam. They allow the condensate to be drained off without letting steam escape. Escaping steam reduces plant efficiency.

In **Figure 3.18** there are six traps: two in the main steam line running along the top and one after each of the four items of equipment in the system. Condensate from the traps returns to the boiler through the feed pump.

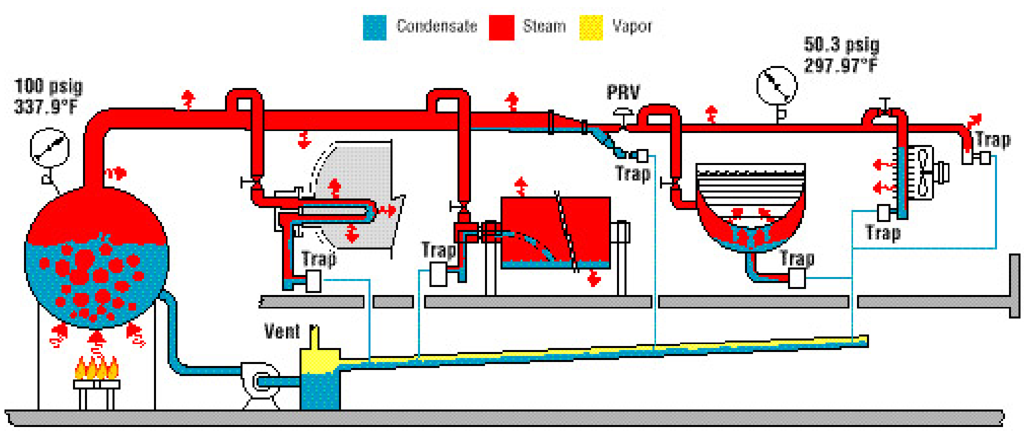


Figure 3.18: Typical Steam Trap Locations

There are four main types of steam trap:

- inverted bucket
- float
- thermostatic
- thermodynamic

Figure 3.19 shows an *inverted* bucket steam trap.

Inverted means up-side-down.

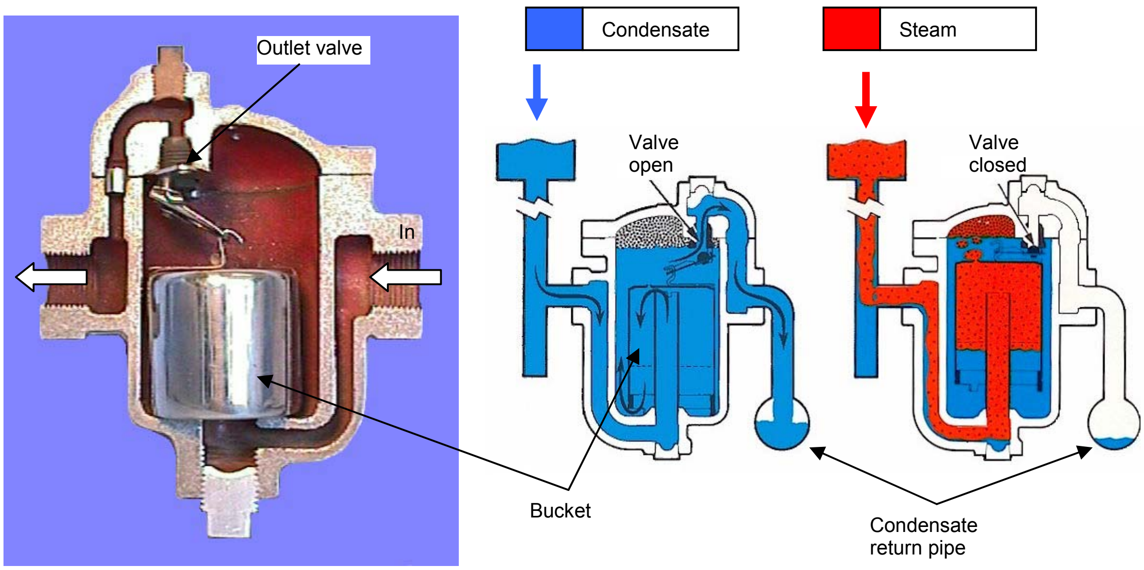


Figure 3.19: Inverted Bucket Steam Trap

The bucket is open at the bottom. When it is full of condensate, it sinks to the bottom of the trap, opening the outlet valve. The condensate can then flow through the outlet valve into the condensate return pipe.

When steam enters the trap it goes into the bucket. Steam in the bucket acts like air would: it makes the bucket float. When the bucket rises, it closes the outlet valve.

When the trapped steam condenses, the bucket sinks again, the valve opens and the condensate flows out.

A float-type steam trap works in the opposite way. The float contains air. When the trap is full of condensate, the float rises, opening the outlet valve. When steam enters it pushes the float down and the outlet valve closes.

Figure 3.20 shows a float steam trap.

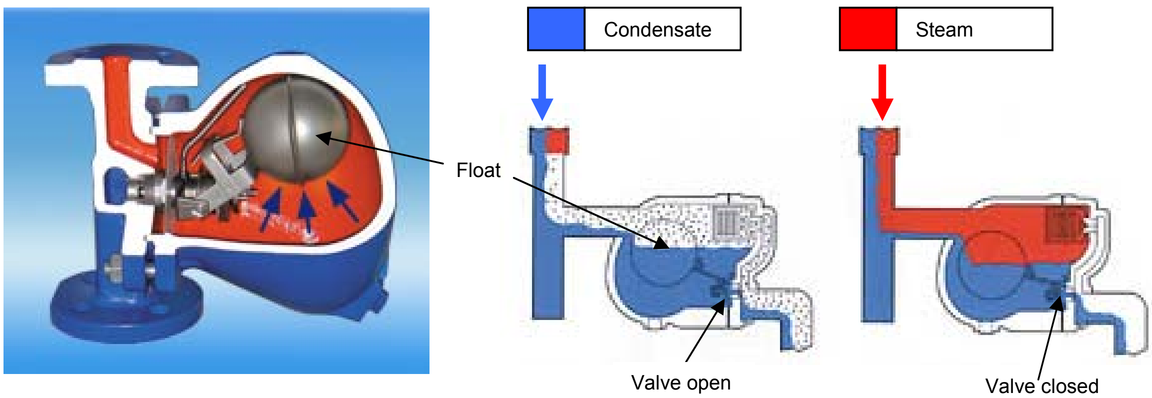


Figure 3.20: Float Steam Trap

Thermostatic steam traps are operated by the temperature difference between steam and condensate. Steam is at a higher temperature than condensate. The trap has a bellows inside, which is filled with liquid. The liquid expands when it gets hotter and contracts when it cools and this extends and compresses the bellows. The outlet valve opens when cooler condensate causes the bellows to compress. When hotter steam enters, the bellows extends, shutting the outlet valve. This is shown in **Figure 3.21**.

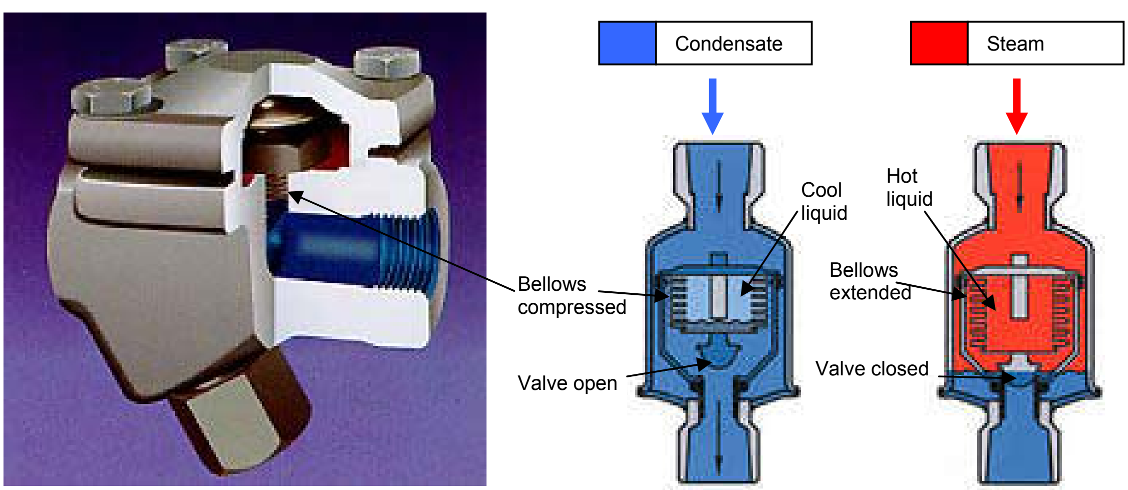


Figure 3.21: Thermostatic Steam Trap

Thermodynamic steam traps are small and simple. They are operated by a pressure difference. The outlet valve is a disc with a space above it. It stays open as long as condensate flows through the trap. When steam enters, the pressure above the disc valve increases, shutting it. **Figure 3.22** shows a thermodynamic steam trap.

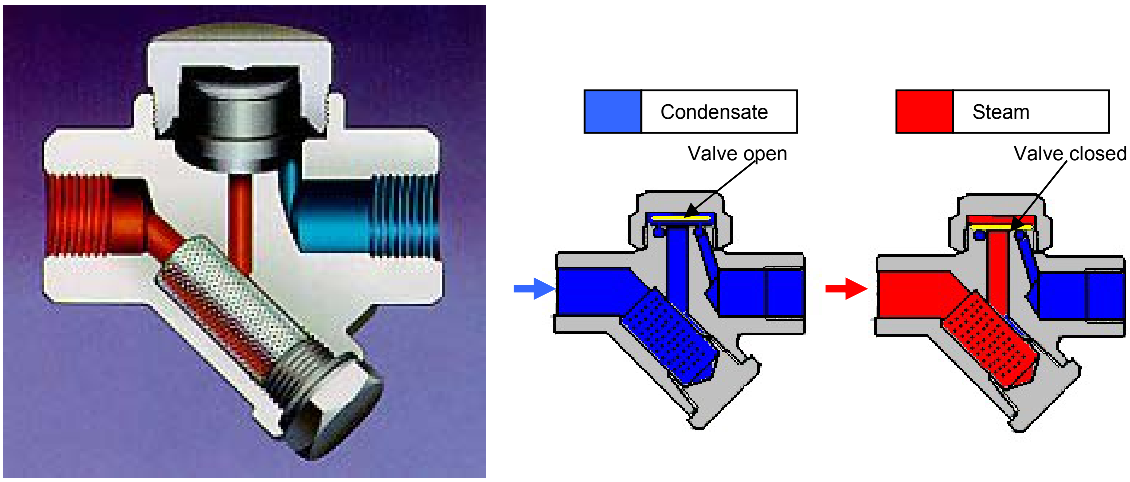


Figure 3.22: Thermodynamic Steam Trap

Now try **Exercise 7**

4 Pipe Expansion and Contraction

When things get hotter, they get bigger—they expand.

Gases expand the most—then come liquids—solids expand the least.

Solids expand so little that you can not see them getting bigger. The *coefficient of expansion* tells you how much one metre length of a material expands for every 1°C rise in temperature.

The coefficient of expansion of steel is 12 x 10^{-6}/°C. This means that when one metre of steel heats up by 1°C, it gets 12 x 10^{-6}m longer, or 12 thousandths of a millimetre—not much.

But, if you have a steel pipe 1000m (1km) long, it gets 1000 x 12 x 10^{-6}m = 12mm longer for just 1°C rise in temperature.

And if the 1km of pipe is at 10°C on a winter morning and you pass steam at 170°C through it, its temperature increases by 160°. It then expands by 160 x 12mm = 1920mm or 1.92m, which is a lot.

The expansion of a pipe depends on the temperature rise and the length of pipe. This is shown in **Figure 4.1**.

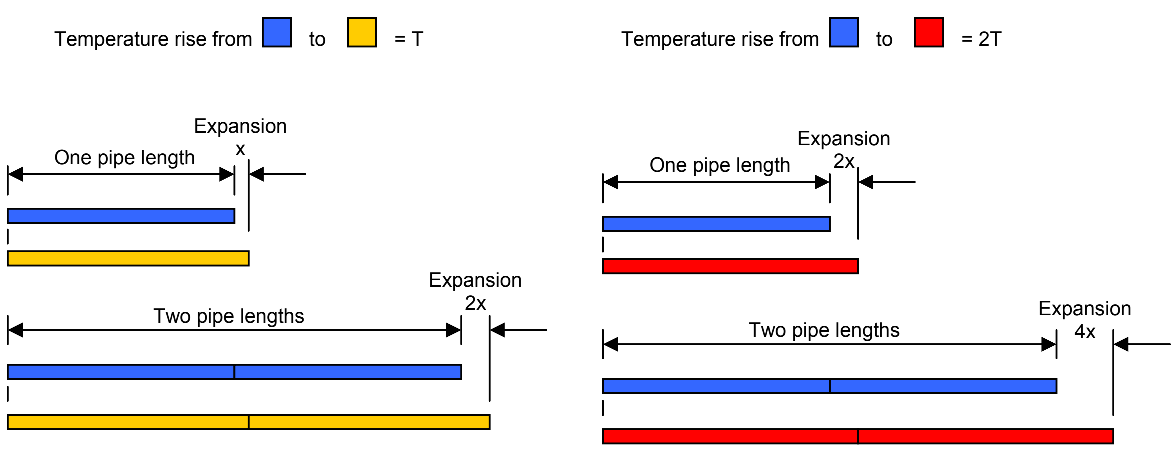


Figure 4.1: Heat Expansion

- The longer the pipe, the more it expands.
- the more the pipe's temperature increases, the more it expands

If you try to stop a gas from expanding by putting it in a sealed container, the gas pressure increases.

If you try to stop a liquid from expanding in the same way, it pushes with so much force that the container will burst.

If you try to stop a solid expanding, it will push with such a big force that something will be damaged. There are similar big forces if you try to stop a solid from getting smaller (contracting) when it cools.

A metal pipe expands when its temperature rises, and contracts when its temperature falls. The pipe temperature can change, because of the fluid it carries or because of a change in the weather,

In **Section 2.2** of this module you saw that some pipe supports are designed to allow pipes to expand and contract. They do not fix the pipe but allow some axial movement. This is fine if the pipe run is not straight, it can just bend a bit more as it gets hotter.

Bending a pipe is a lot easier than trying to stretch or squash it axially. The forces are a lot lower. If there is a straight pipe run between two fixed items of plant, there must be some way to allow for expansion and contraction of the pipe.

4.1 Expansion Joints

One way to allow for pipe expansion is to put extra bends in a pipe. These are called *expansion loops* and you will see them on the plant. **Figure 4.2(a)** shows expansion loops before fitting and in **Figure 4.2(b)** the loops are doing two jobs: allowing for pipe expansion and taking the pipe run over a road.

(a) Single-piece Expansion Loops

(b) Fabricated Expansion Loops

Figure 4.2: Expansion Loops

You can see expansion loops in many places on the ADGAS plant.

Another way to allow for expansion of pipes is to use expansion joints. Expansion joints can change length easily. They stop force being transmitted along the pipe run to flanges and equipment.

Metal *bellows* are the most common type of expansion joint. They work on the same principal as an expansion loop: that it is easier to bend something than to stretch or squash it. **Figure 4.3** shows examples of bellows expansion joints.

Figure 4.3: Bellows Expansion Joints

The metal of the bellows bends easily as the pipe expands or contracts as shown in **Figure 4.4**. This takes up changes in length of the pipe without any big forces on the flanges or equipment.

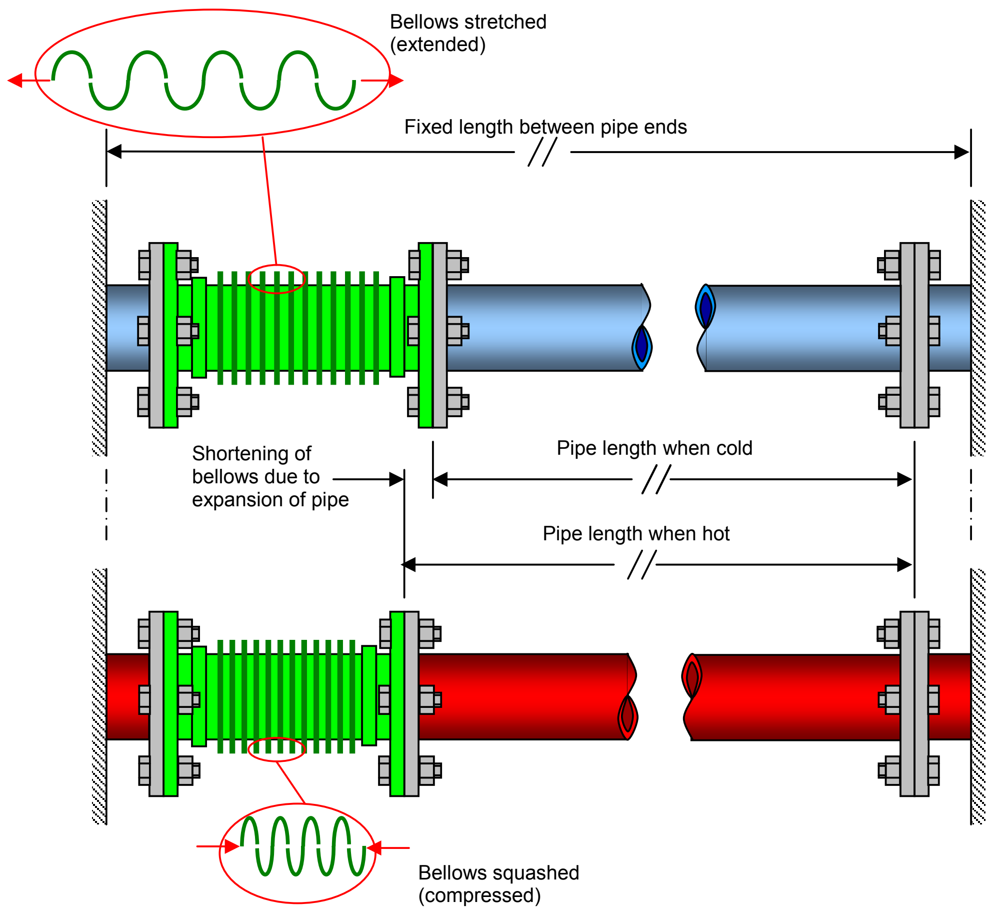


Figure 4.4: Action of a Bellows Expansion Joint

Rubber expansion joints have a *flexible* rubber section in place of the bellows. A typical rubber expansion joint is shown in **Figure 4.5**.

Something that is ***flexible*** bends easily.

Figure 4.5: Rubber Expansion Joint

Sliding or slip-type expansion joints work on a different principle. They have two tubular parts; one sliding inside the other. A seal stops leaks between these two parts. **Figure 4.6** shows a slip-type joint, with the outer tube sectioned, fitted into a pipeline.

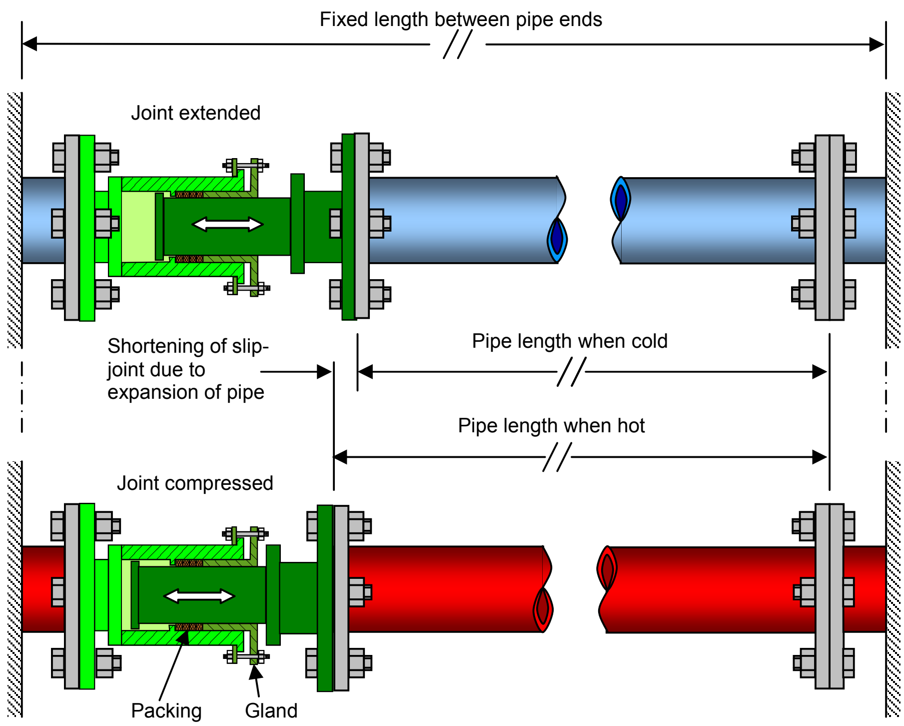


Figure 4.6: Action of Slip-type Expansion Joint

The seal between the two sliding tubes is made by a *gland* and *packing*. Glands and packing are described in a later module of this course.

Ball expansion joints allow some angular movement between pipes. A Section through a typical ball expansion joint is shown in **Figure 4.7**.

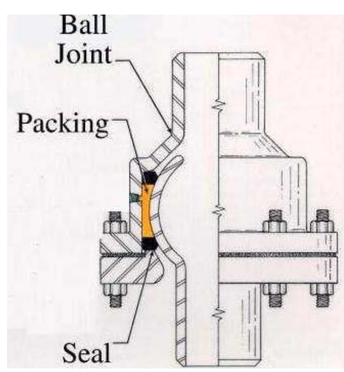


Figure 4.7: Ball Expansion Joint

5 Piping Drawings and Diagrams

Piping drawings and diagrams were introduced in the Basic Maintenance Technician Course module: *Drawings and Diagrams*.

There are two types of piping diagrams that you might have to use as a Mechanical Maintenance Technician:

- PFDs—Process Flow Diagrams
- P&IDs—Piping and Instrumentation Diagrams

Piping diagrams show the order in which the fluid passes through plant and equipment in a process. They are not drawn to scale and give you no idea of the size of plant and equipment or the distances between them.

There are also two types of piping drawings:

- isometric
- orthographic

Drawings indicate sizes and distances; they are drawn to scale. Piping drawings may show the layout of a complete piping system, part of the system or a single component.

5.1 P&IDs

PFDs and P&IDs are similar in many ways. P&IDs show a lot more detail about the equipment and piping and the instrumentation controlling the process. PFDs are simplified P&IDs. They show what is happening to the fluid as it passes through the process: the changes in temperature, pressure, etc.

PFDs are used mainly by plant operators. P&IDs are used by mechanical and instrumentation engineers and technicians.

As a mechanical maintenance technician, you will need to know where to find information about:

- identification numbers of items of plant and equipment
- location of isolation valves, etc., for an item of plant
- type of equipment: valves, pumps, etc.
- the types and sizes of pipes and fittings

All of this information may be shown on a P&ID. There is also a lot of other information about the instrumentation but this is not normally of interest to the mechanical technician.

P&IDs give information by using symbols, for plant and equipment, and notes, for identification numbers and sizes. The Symbols used on ADGAS P&IDs are shown on the ADGAS drawing number 100-AOA-2278, Revision 3. The information given on this drawing is shown in **Appendix G**.

The drawing shows abbreviations and symbols under different headings:

- Line Identification—the information shown on a P&ID that tells you about pipes and the fluid they carry (the *commodity*). The identification code at the top of this column is shown on all pipes in the P&ID. Line Identification also shows the types of line drawn to represent different types of pipeline.
- In-line Devices—symbols for some special pipe fittings and other items in the pipeline and the abbreviations that may be shown next to these symbols.
- Valves—symbols used to represent different types of valves and the abbreviations that are sometimes shown next to valve symbols.
- Pumps and Compressors
- Exchangers and Coolers—items of plant that transfer heat from one fluid to another.
- Column Internals—information about what is inside columns; also about insulation.
- Storage Tanks and Vessels—containers for fluids, sometimes under pressure.

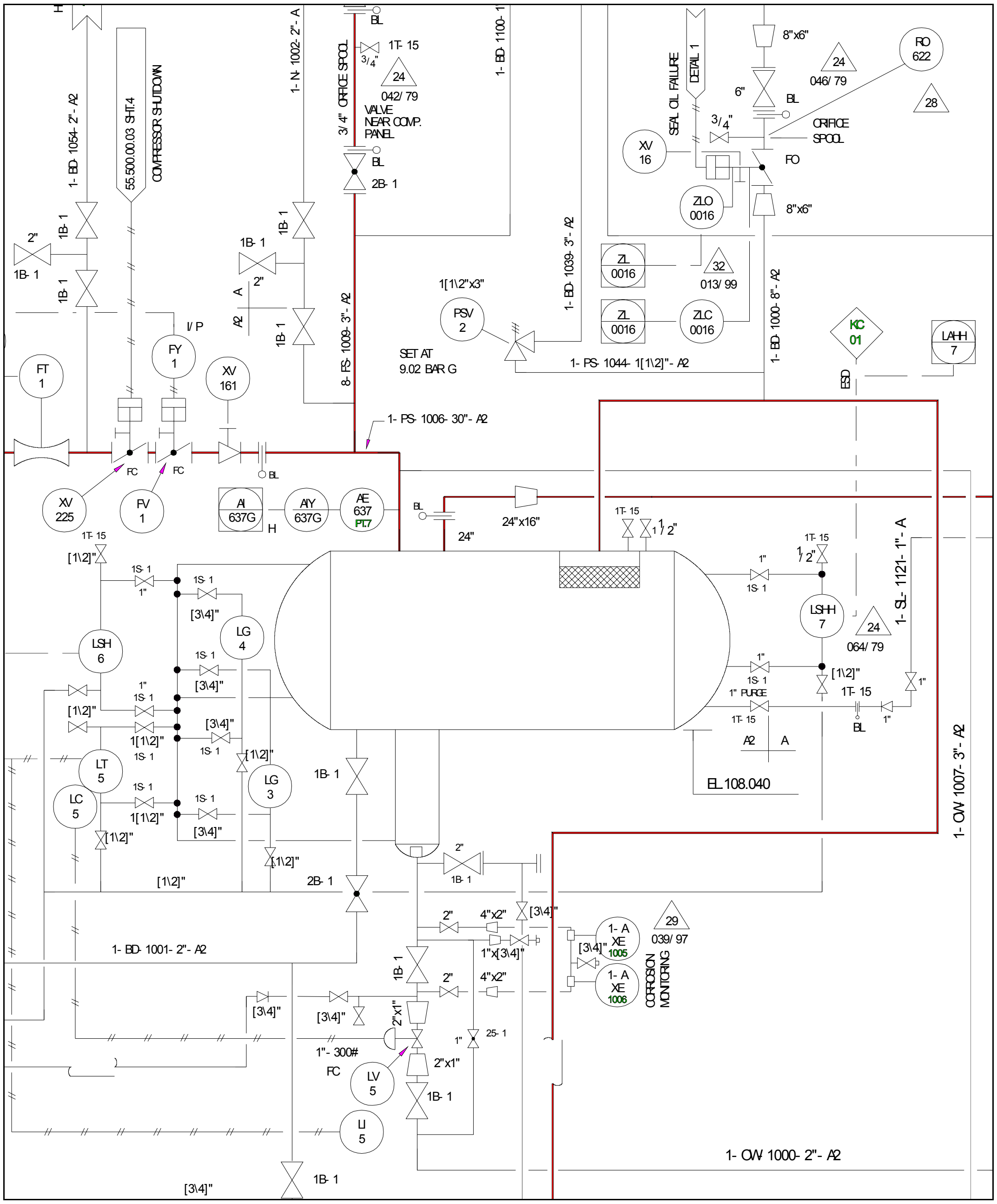
- Miscellaneous—things that do not easily fit under the other headings.
- Instrument Symbols—symbols and abbreviations to identify instruments and their locations.

Note that these are the symbols on ADGAS P&IDs. P&IDs not drawn by ADGAS may use symbols that are not exactly the same.

Figure 5.1 shows part of an ADGAS P&ID for Train I. Using the information in **Appendix G**, identify as much information as you can:

- interpret line identification codes
- line types—main process, other process, pneumatic
- valve types and sizes
- other fittings—types and sizes
- instrumentation lines and symbols

Now try **Exercise 8**



Detail from ADGAS Drg. No. 1-RA-2 Sheet 1A Rev.34

Figure 5.1: P&ID

5.2 Piping Isometrics

Isometric drawings are *pictorial projections*: they give a single view that tries to show the shape of an object as it appears; like a photograph. You learnt how to produce isometric drawings in the module *Drawings and Diagrams* in the Basic Maintenance Technician Course.

Piping isometrics show the shape, dimensions and direction in which a pipe is laid in the plant. Directions are given relative to North, South, East and West of the compass. Pipes are shown as lines and symbols are used for fittings etc. The direction of North is shown on the drawing. **Figure 5.2** shows a short section of pipe and the piping isometric drawing that represents it.

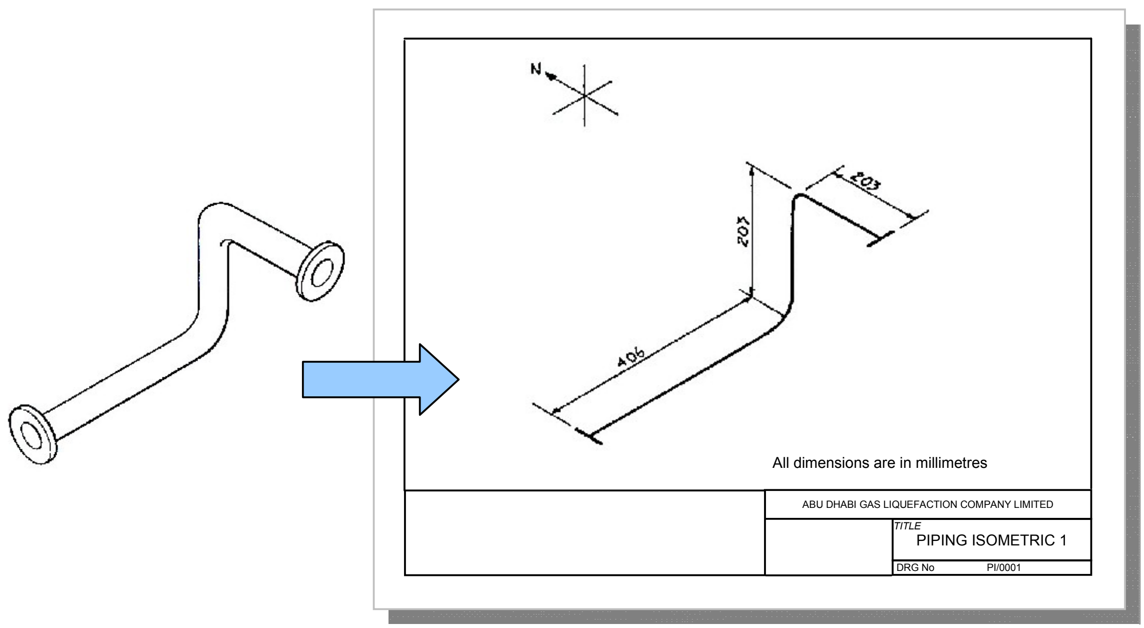


Figure 5.2: Piping Isometric—90° Bends

The short horizontal section of the pipe runs in a North-South. The longer horizontal section of the pipe runs in an East-West direction. The 203mm section between them runs vertically.

Note: The runway on Das Island runs in a North-South direction. The plant is at the North end of the island.

If no angle dimension is shown on a bend, the bend-angle is 90°.

Bends that are not at 90° are shown in **Figures 5.3** to **5.6**.

Angular dimensions may be given in degrees. A bend in the horizontal plane has HOR written after the angle. A bend in the vertical plane has VERT written after the angle as shown in **Figure 5.3**

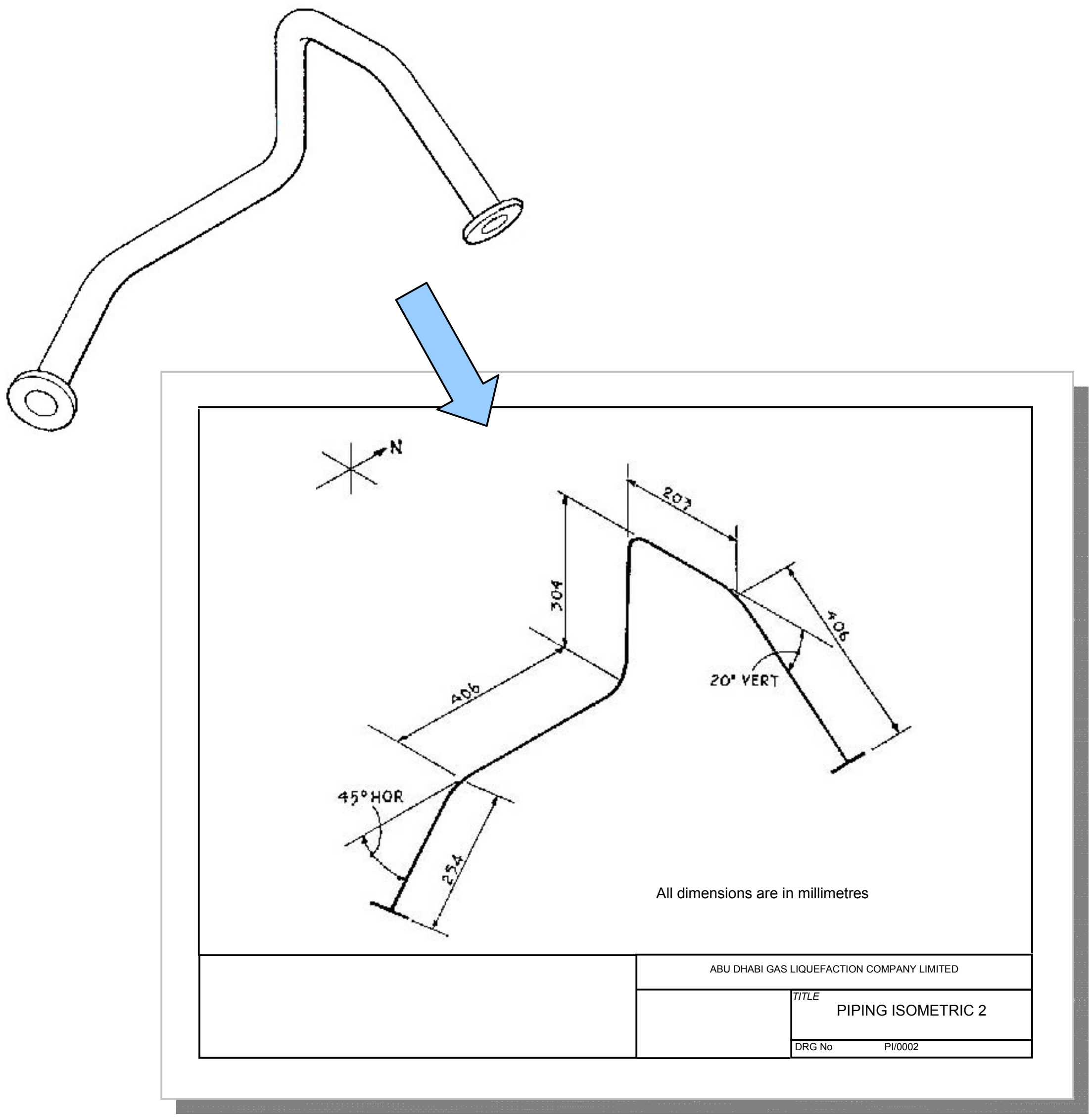


Figure 5.3: Piping Isometric—Angular Dimensions

Sometimes the bend angles are shaded in different directions to indicate horizontal and vertical bends. **Figure 5.4** shows the same section of piping again with the angular dimensions shaded.

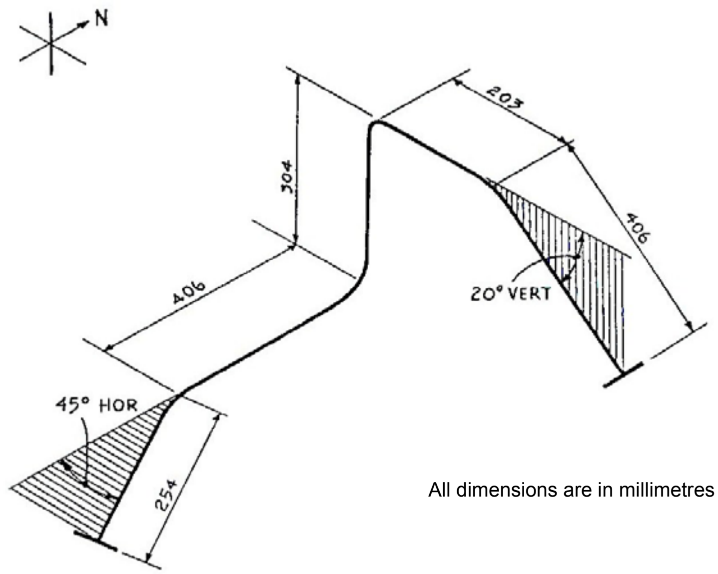


Figure 5.4: Piping Isometric—Shaded Angular Dimensions

Instead of giving angles, the pipe can be drawn as the long side of a right-angled triangle. The sides of the triangle are dimensioned as shown in **Figure 5.5**.

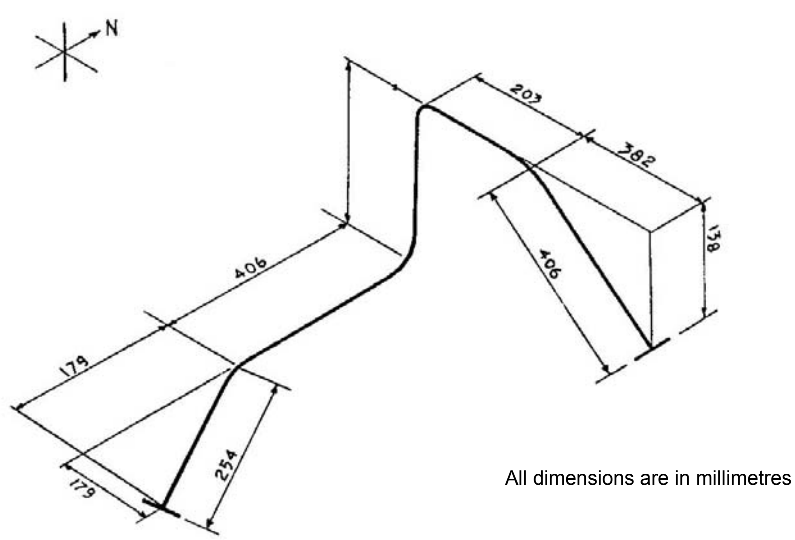


Figure 5.5: Piping Isometric—Linear Dimensions Only

If a bend is in the horizontal and vertical planes, as shown in **Figure 5.6**, it is drawn *boxed in*.

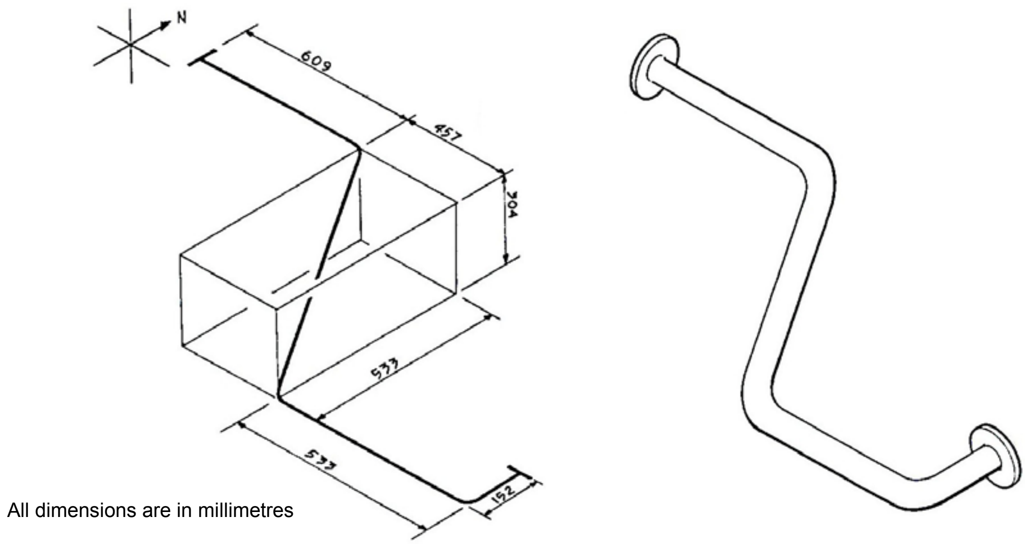


Figure 5.6: Piping Isometric— Bend in Two Planes

The *boxing* forms a rectangular block of thin extension lines with the pipe crossing diagonally from one corner to the other. Dimensions of the sides of the box are given instead of angles.

Many piping layout drawings show the heights of pipes measured from a datum, often ground level. These heights are called *elevations* and are shown in **Figure 5.7**.

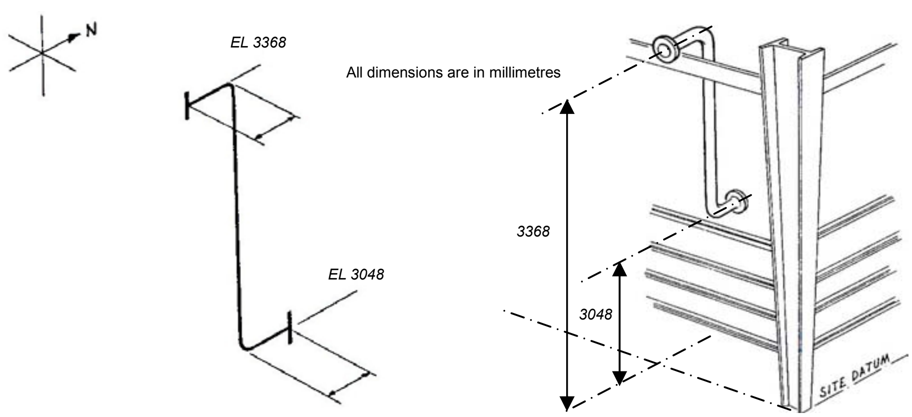
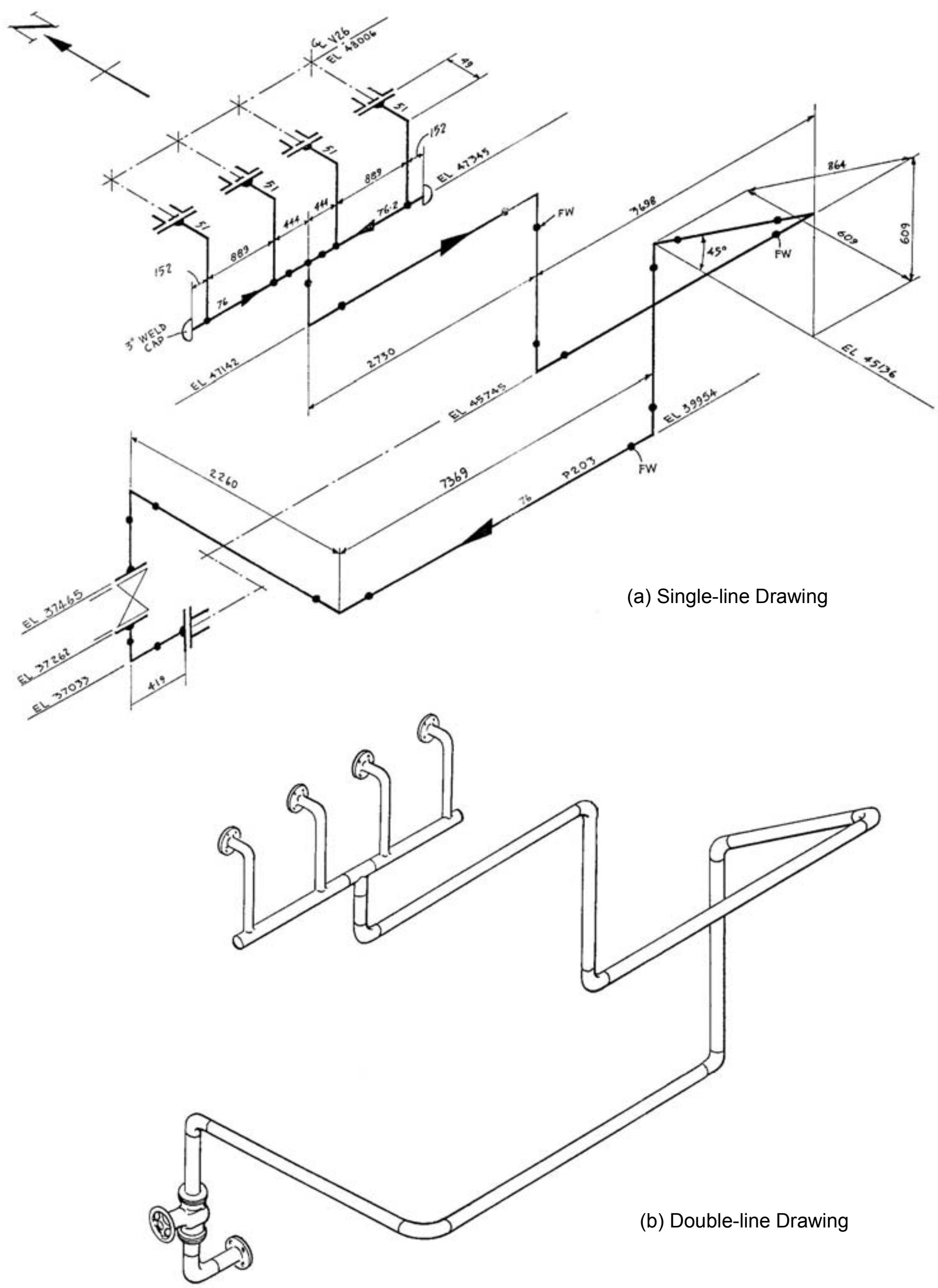


Figure 5.7: Pipe Elevations

Figures 5.2 to **5.7** show screwed or socket weld flanges at each end of the pipes. Piping drawings use many symbols for valves and equipment that are the same as those shown in **Appendix G** for P&IDs. Other symbols used on piping drawings are shown in **Appendix H**. **Figure 5.8(a)** shows a piping isometric containing some of these symbols. **Figure 5.8(b)** shows a double-line isometric of the same pipe system.



(a) Single-line Drawing

(b) Double-line Drawing

Figure 5.8: Piping Isometrics

A Bill of Materials (BoM) is often shown on a piping isometric. This lists all the materials: pipes, flanges fittings and valves, needed for the pipework shown in the drawing. **Figure 5.9** shows another example of a piping isometric with the BoM included.

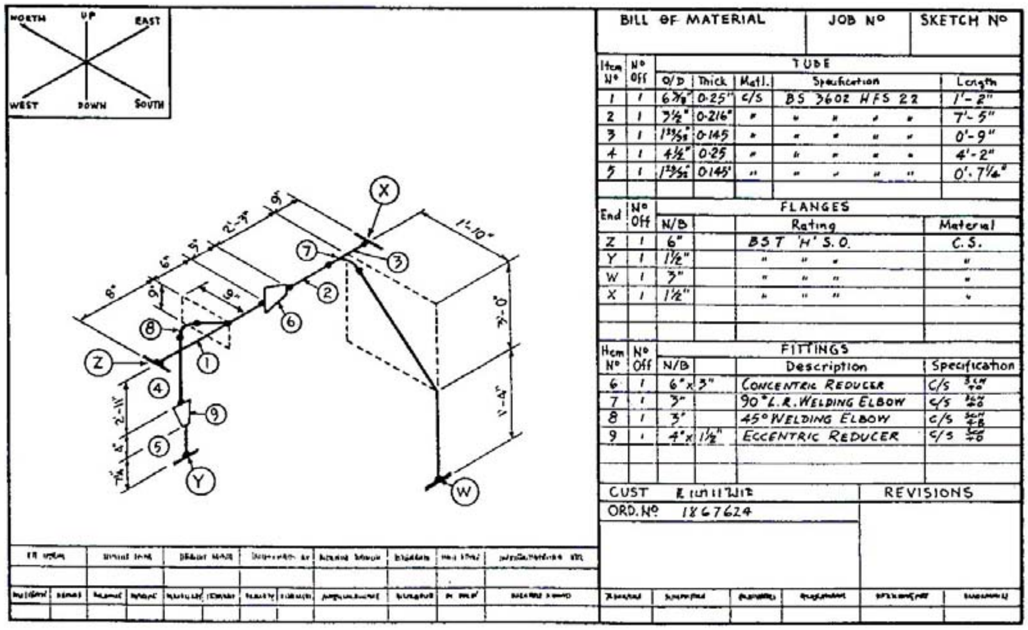


Figure 5.9: Bill of Materials

Item numbers and letters in the BoM refer to the numbered parts on the drawing. The BoM gives all the information needed to order pipes and fittings to make up the pipe run.

5.3 Piping Orthographics

Orthographic drawings generally show more than one view. Each view shows what is seen if you look from a different direction. You learnt about orthographic drawings in the module *Drawings and Diagrams* in the Basic Maintenance Technician Course.

The most common orthographic view used for piping drawings is the view seen when looking from above. This is called the *plan view* and piping drawings showing this view are called *piping plans* or *general arrangements*. Piping plans are often taken at different levels or *elevations* in the plant.

Special symbols used for piping plans are shown in **Table 5.1**.

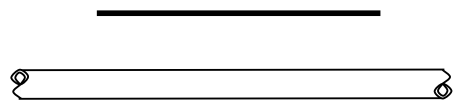
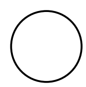
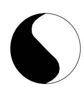
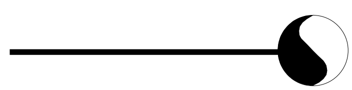
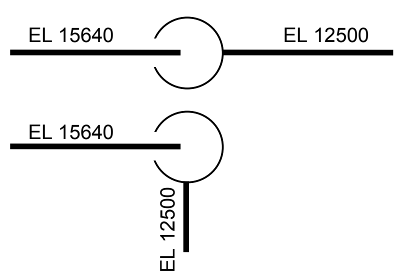
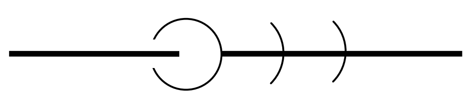
Symbol	Description
	Pipes of 22in diameter or smaller Pipes of 24in diameter or bigger
	End view of a pipe that bends downwards (away from the reader)
	End view of a pipe that bends upwards (toward the reader)
	A pipe that bends **down** through 90^{o}
	A pipe that bends **up** through 90^{o}
	A pipe that bends down through two 90^{o} angles to continue at a different elevation, as indicated
	A pipe that bends down through an angle other than 90^{o}

Table 5.1: Piping Plan Symbols

The set of piping plans or general arrangements shown in **Figure 5.10** show only one pipeline in Area J of a plant. A real set of piping plans shows all the pipelines in that part of the plant and would be much more complicated. The pipe run P208 connects vessel V26 at elevation 157ft 6in to vessel V27 at elevation 122ft 6in.

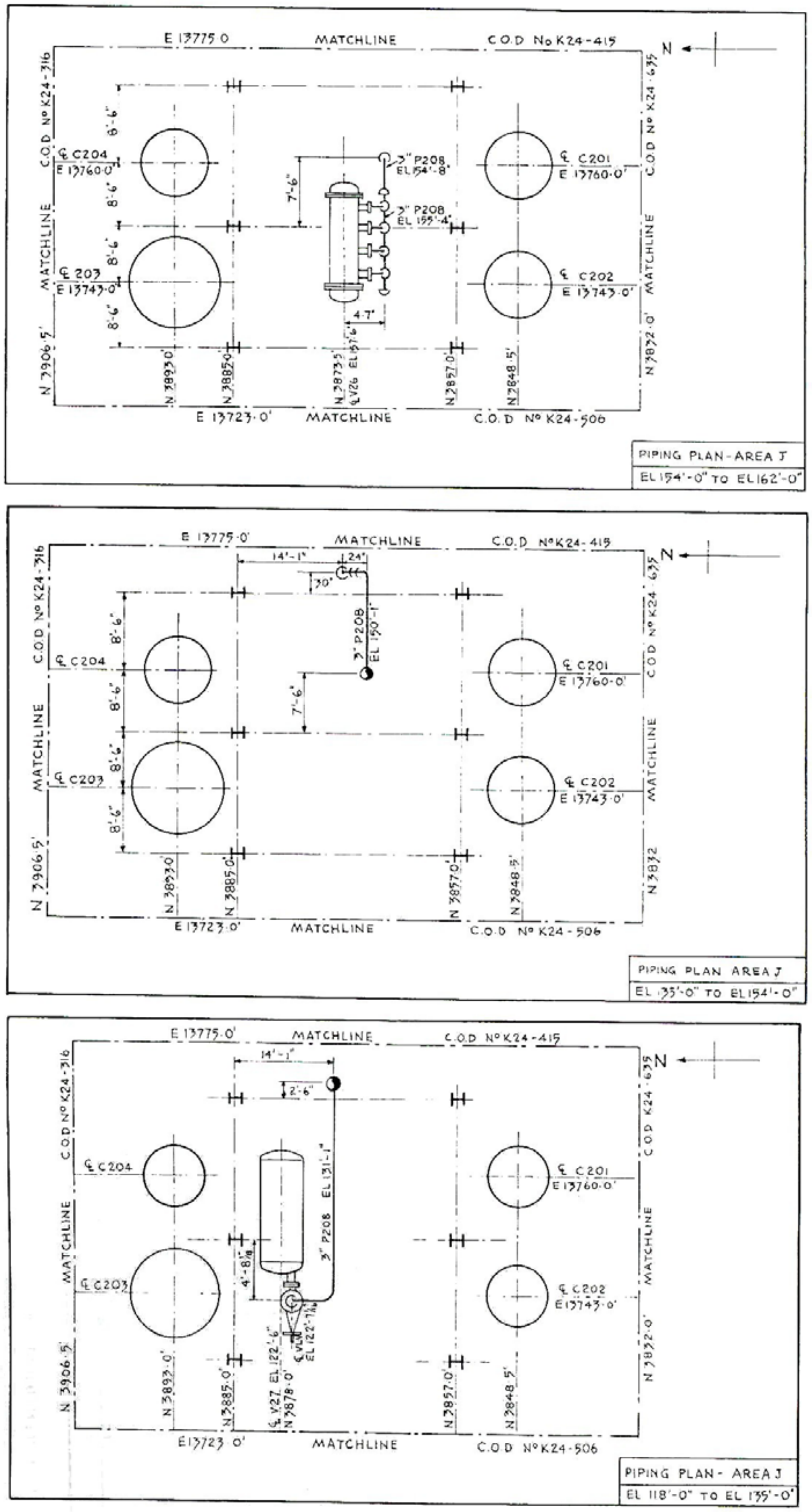


Figure 5.10: Piping Plans

Each plan shows:

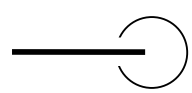
- the range of pipe elevations shown on that plan
- distances East and North from a datum point in the plant
- pipeline identification numbers—P208 in this simple plan
- centrelines of other plant and equipment —columns C201 to 204, vessels V26 and 27 in this plan
- matchlines, showing where the piping plan for the next area of plant continues
- the drawing number of the *adjoining* piping plan—c.o.d. (continued on drawing) followed by the drawing number of the adjoining plan

Adjoining means next to or joined to.

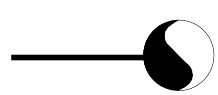
In the top plan, elevations 154ft to 162ft, vessel V26 is connected to the 3in pipe run P208 through four flanges. The centre line of V26 is at elevation 157ft 6in lying in an East-West direction. The flanges connect through bends to a short 3in pipe that is part of the P208 pipe run. It is at elevation 155ft 4in and is blanked off at each end. The main P208 run connects to the bottom of this blanked-off pipe, then runs horizontally East for 7ft 6in at elevation 154ft 8in. This part of the run is:

157ft 6in – 154ft 8in = 2ft 10in below the centre line of vessel V26.

The pipe then bends down through 90^{o} to a lower elevation, shown by the symbol :



Notice that on the next elevation this vertical section of pipe is shown as it drops toward the lower elevation by the symbol:



In **Figure 5.11** you can see an isometric of this piping system. Use this to help you to interpret the information given in the three piping plans in **Figure 5.10**.

Now try **Exercise 9**

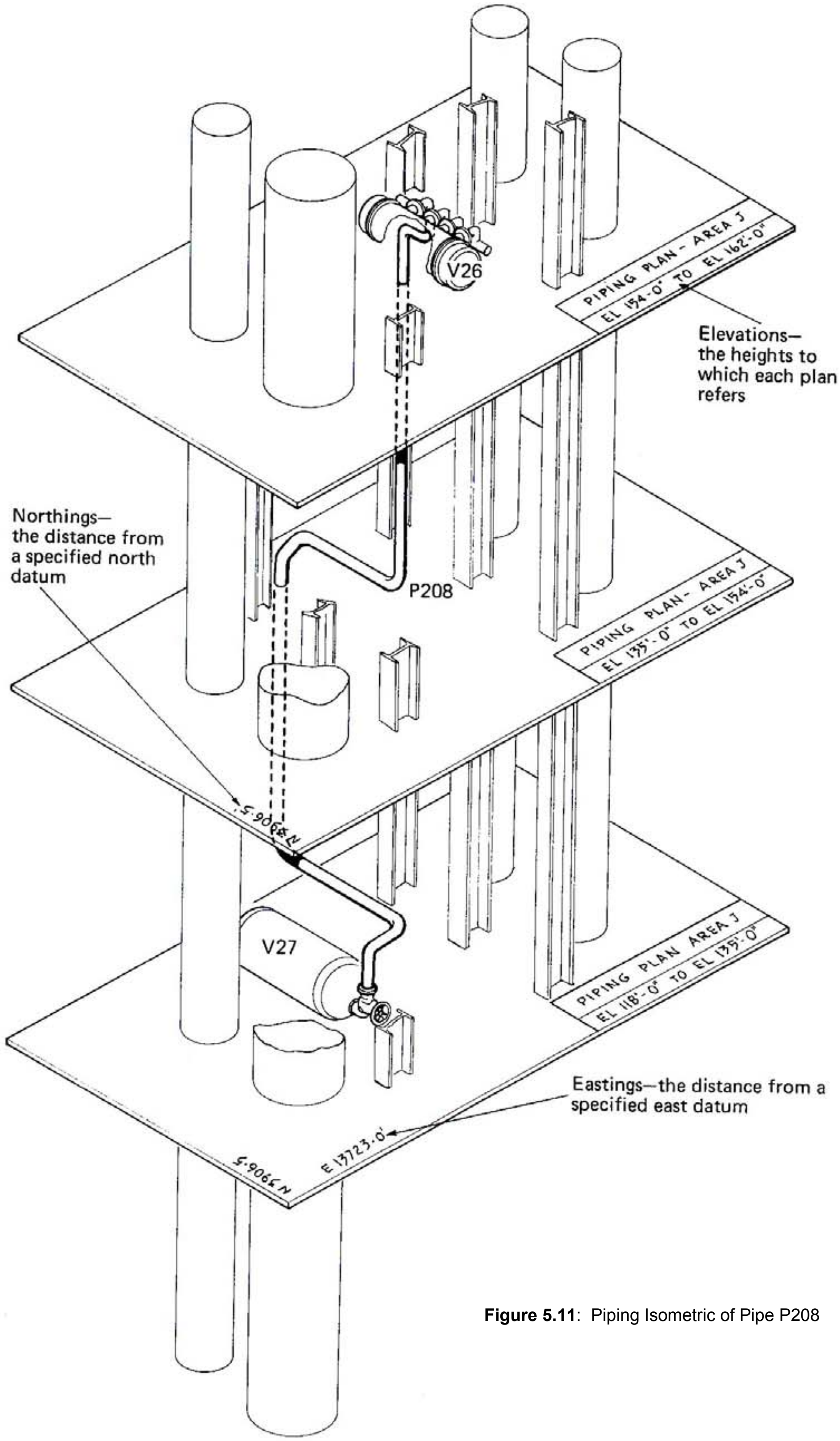


Figure 5.11: Piping Isometric of Pipe P208

6 Pipe Fitting

Pipe fitting includes cutting to length, threading, bending and joining pipe lengths. In this section you will learn to:

- cut pipe threads
- bend small-diameter carbon steel pipe
- manually tighten flanges

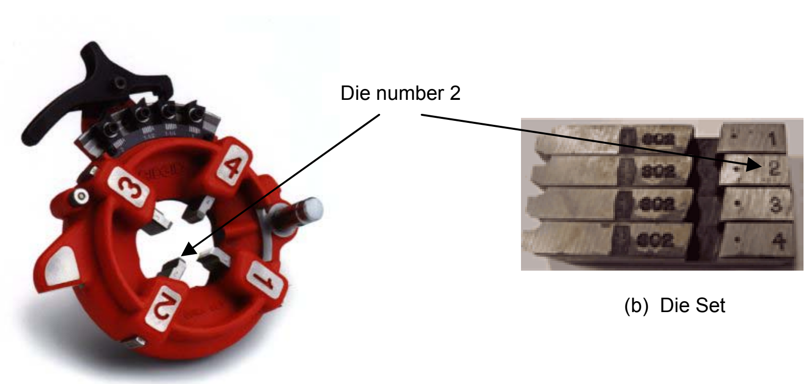
6.1 Cutting Pipe Threads

You learnt about threads and how to cut them using taps and dies in the module *Drilling, Threading and Fitting* in this course. Cutting threads on pipes is a special application of cutting external threads using dies.

Pipe threads are fine threads. Coarse threads are too deep and cut too far into the pipe wall. This would make the pipe weak. They are usually taper threads: British Standard Pipe Taper (BSPT) thread or American National Thread (NPT).

Pipe threads are cut using a set of separate dies that fit into a die head. There are usually four separate dies, each with one cutting edge. The dies are marked with the type of thread and the range of pipe diameters they can be used for.

They are also numbered, e.g. 1 to 4, and they fit into slots in the head that are marked with the same numbers as shown in **Figure 6.1**.



(b) Die Set

(a) Die Head

Figure 6.1: Pipe-thread Dies

A bar fits into the head so that you can apply enough torque to turn it to cut the thread. The head has a *ratchet* drive that you can reverse to break off the swarf. You can move the dies radially in the head to take a light first cut, a deeper second cut and so on until you reach the correct diameter. You can then move them outwards enough to slide the die carefully off the pipe without having to unscrew it.

Now try **Exercise 10**

6.2 Pipe Bending

It is often easier, and cheaper, to bend pipes to shape than to use elbow fittings.

Another advantage of bending pipes is that fluid flows around a long, smooth bend more easily than through an elbow. You learnt about fluid friction in the module *Bearings* in this course. There is friction between a fluid and the pipes and fittings it flows through. Friction in pipes wastes power used to pump the fluid.

The disadvantage with a bend is that it takes up more space than an elbow.

You can bend small diameter pipe in the workshop. Pipe benders can produce a smooth bend with no wrinkles on the inside of the curve. **Figure 6.2** shows what is meant by a wrinkled bend.

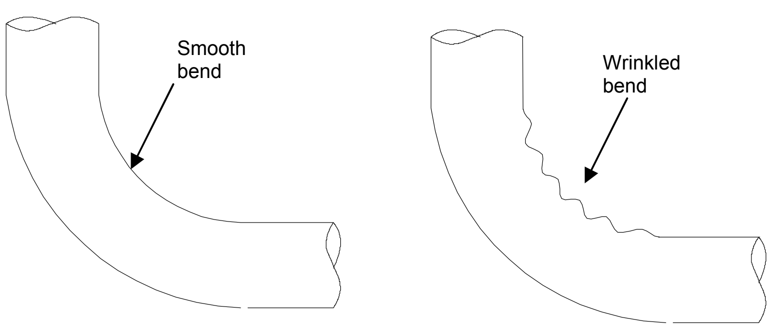


Figure 6.2: Smooth and Wrinkled bends

Manual pipe benders may be ram or lever operated.

Figure 6.3 shows a ram-type pipe bender with a simplified drawing showing its operation.

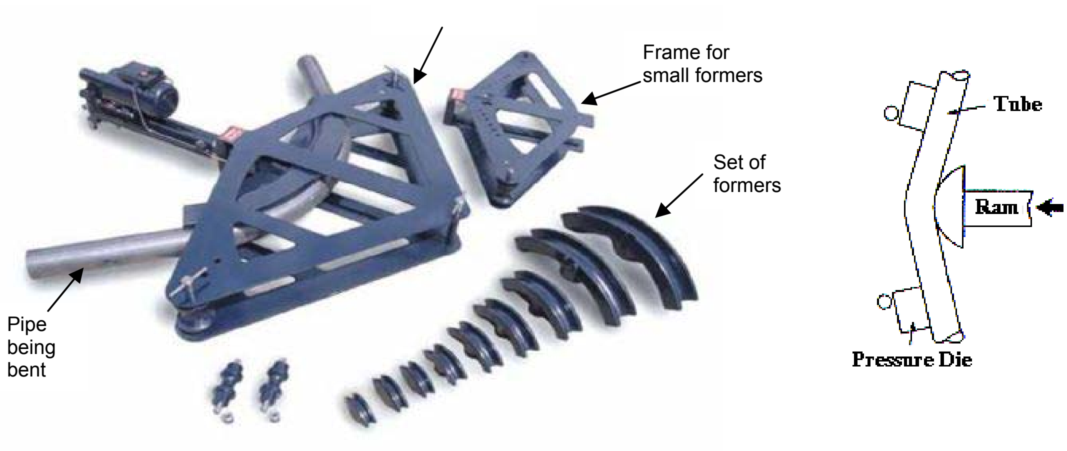


Figure 6.3: Hydraulic Ram Pipe Bender

The ram-type bender uses hydraulic pressure to push a former of the required radius into the pipe. This works on the same principle as a hydraulic car jack. Oil is pumped from a cylinder that has a small diameter piston. It is pumped into another cylinder that has a larger diameter piston, as shown in **Figure 6.4**.

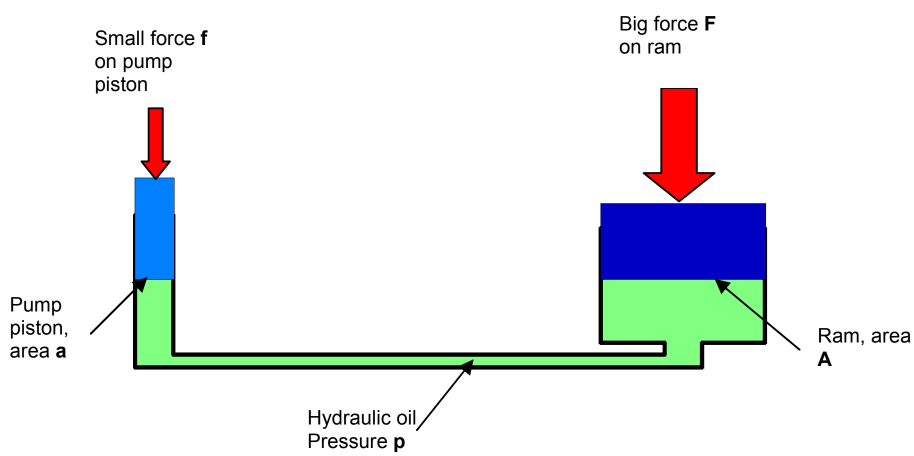


Figure 6.4: Hydraulic Ram Theory

To understand how a hydraulic ram multiplies the force you use, you will need to remember some of the mathematics you have learnt.

Remember: $\boxed{\textbf{pressure = force/area}}$

Pushing on the smaller pump piston raises the oil pressure to **p** = **f**/**a**

The same oil pressure pushes on the bigger ram piston. To find the force pushing on the ram you re-arrange the pressure equation to give: force = pressure x area

So, the force with which the oil pushes on the ram is: **F** = **p** x **A**

But **p** = **f**/**a**, so **F** = **f**/**a** x **A**

= **f** x **A**/**a**

If the ram area **A** is twice as big as the piston area **a**, then **A**/**a** = 2 and **F** = **f** x **2**. The force on the ram is twice the force with which you push on the pump piston.

The hydraulic ram multiplies the force by the ratio of the areas **A**/**a**.

Hydraulic pipe benders can bend carbon steel pipe up to 50mm diameter. You can bend carbon steel pipes up to 12mm diameter with compression-type benders. **Figure 6.5** shows a compression-type pipe bender with a set of formers.

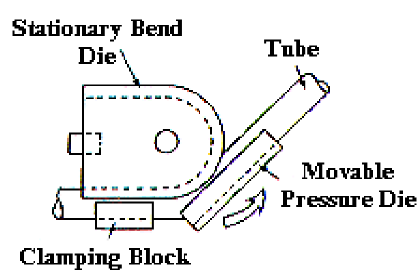


Figure 6.5: Compression Pipe Bender

Now try **Exercise 11**

6.3 Tightening Flanges

Flanges must give a *pressure-tight* joint. To do this the correct flanges must be used for the job. The flange types, classes and materials for all applications are given in the ADGAS Piping Specifications.

The correct gaskets must be fitted between the flanges. These are also given in the Piping Specifications.

Lastly, you must tighten the flange studs correctly. This is to make sure that the force holding the flanges together is correct and that it is evenly distributed around the flange faces.

Whenever you assemble mating faces that are secured with a number of screws, bolts or studs, make sure that nuts are tightened:

- a little at a time—so that force between the flanges increases gradually
- in the correct order—so that force between the flanges increases evenly
- to the correct torque— to give the correct force between the flanges

After cleaning the flange faces and inserting the gasket between them, finger-tighten all the nuts on the studs.

Next tighten the nuts a little more using the correct order of tightening—the *tightening sequence*. Always tighten both nuts on the same diameter before moving to the next diameter.

The simplest example of a tightening sequence is that for the four-stud flange shown in **Figure 6.6**.

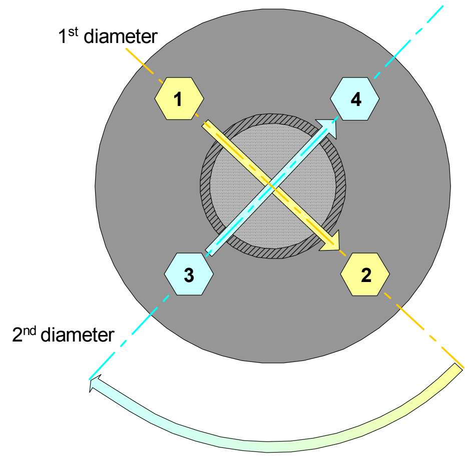


Figure 6.6: Four-stud Tightening Sequence

The nuts in **Figure 6.6** are numbered in the order you tighten them. First tighten the two nuts on diameter 1; then the two nuts on diameter 2.

Be *systematic* when following a tightening sequence. If there are many studs it is easy to forget one.

To be ***systematic*** is to have a system or method that you can always follow.

One system is to always move **clockwise** from one diameter to the next. In **Figure 6.6**, the nuts on each diameter are shown in different colours. First tighten nut 1, then nut 2 on the first (yellow) diameter, then move clockwise to the second (blue) diameter and tighten nuts 3 and 4 as shown.

If there are more than four studs, follow the same procedure. Tighten the nuts on one diameter at a time and move clockwise to the next diameter. Start as if you are tightening a four-stud flange. Then continue in the order shown in **Figure 6.7**.

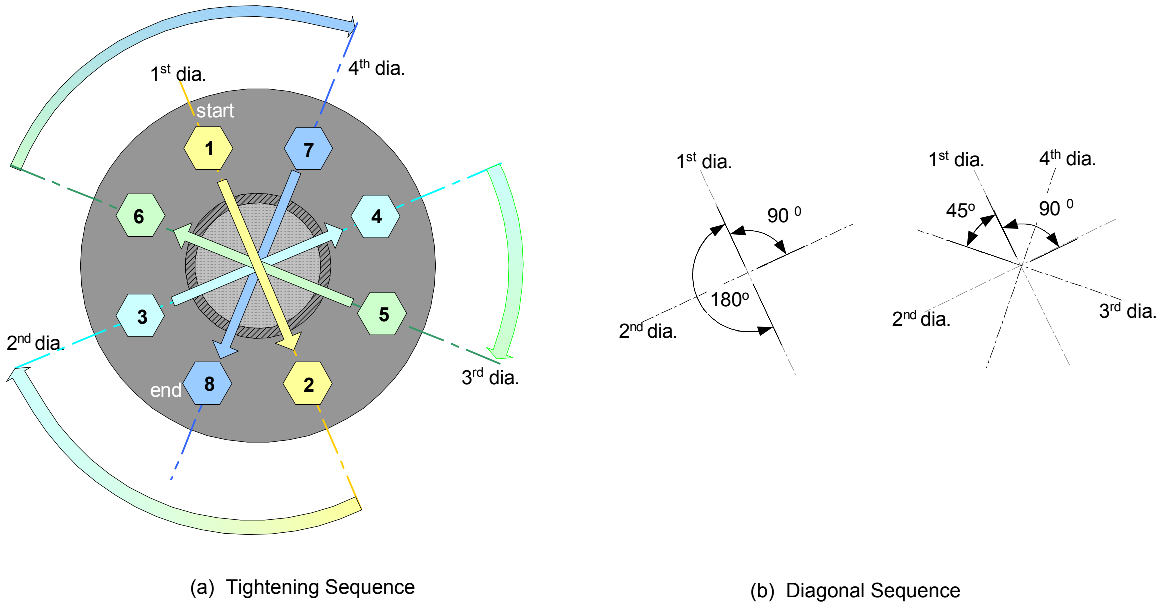


Figure 6.7: Eight-stud Tightening Sequence

Choose the first diameter; in the figure it is the vertical diameter.

The second diameter is at 90° to the first, as before.

The third and fourth diameters cut the 90° angles in half, making 45° angles.

Which nut you call Nut 1 depends on how the flanges come together on assembly. If the flange faces are not quite parallel, leaving a gap on one side as shown in **Figure 6.8**, make Nut 1 the nut where the gap is biggest. Tighten this first nut until the flange faces are brought together, then start the normal tightening sequence.

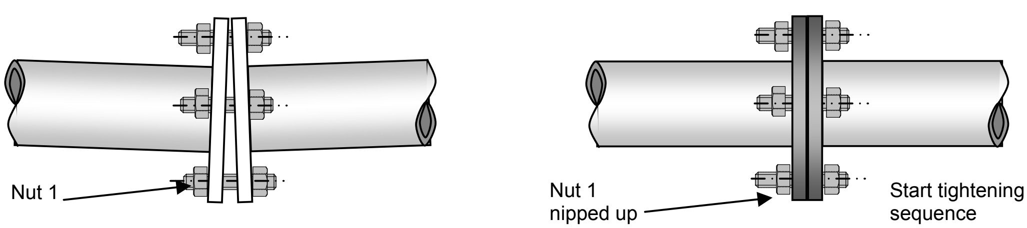


Figure 6.8: Choosing Nut 1

If the faces are parallel you can choose any nut to be Nut 1.

If there are more than eight studs, follow the same procedure. For example, for 16 studs:

- tighten the first eight nuts in the same way as for an eight-stud flange, tightening both nuts on each diameter before moving to the next diameter
- tighten the nuts on the remaining four diameters (5th to 8th), tightening both nuts on each diameter before moving to the next diameter as before
- work systematically from one diameter to another; a possible sequence is shown in **Figure 6.9**

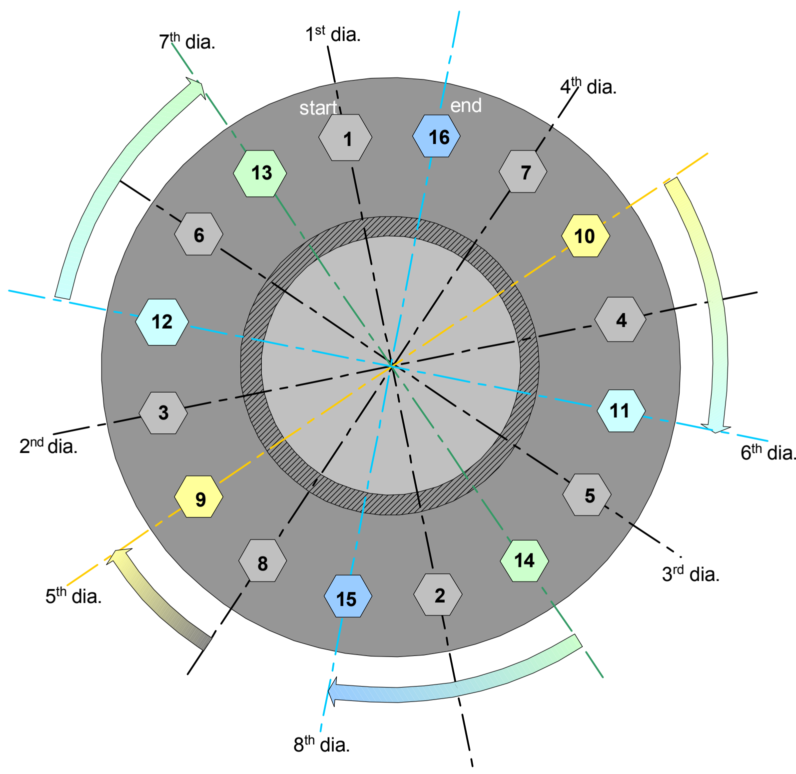


Figure 6.9: Tightening a Sixteen-stud Flange

Repeat the tightening sequence until you reach the correct torque for the flange. The number of times you have to go round the nuts depends on the final torque and the type of gasket fitted.

When you reach the correct torque, it is good practice to go around all the nuts one more time at the same torque setting. This time simply move from one nut to the next around the circle. This is to make sure that you have not missed any.

Manufacturers' manuals give torque values for flange nuts.

Torque values are not given for all flanges on the plant. When they are not given, you have to learn by experience how much to tighten them. It is important to tighten them all to about the same torque. If you do not have a torque wrench, this is another skill that comes with experience and practice.

When you tighten a flange, it is most important to tighten so that the flange does not leak. You do that by following the tightening procedure described. When you loosen a flange, your safety is the most important thing.

Loosening flange nuts can be a safety hazard. Wear the correct PPE and take all necessary precautions.

Before loosening a flange you must have the necessary permits. The section of pipe you are to work on must be isolated and de-pressurised. Even then it is possible that some fluid under pressure is trapped in the pipe. Always start loosening the nuts that are on the side of the flange farthest away from you and toward the bottom of the flange. If you are working with someone else, make sure that you both stand on the same side of the flange. If the pipeline is pressurised, the fluid will escape where the nuts are loosened. Make sure that any pressurised fluid that escapes is directed away from you, not towards you.

Do not remove nuts before separating the flange faces. Loosen the nuts farthest from you first. Make sure the flange is *split* on the side farthest from your face before you remove any nuts.

Now try **Exercise 12**

7 Summary

In this module you have learnt about many of the components used in piping systems. You have learnt their purposes and seen how they are fitted.

You know how pipes and many of the fittings are specified and how important it is to use the correct components, as listed in the ADGAS Piping Specifications and detailed in National and International Standards.

You have seen how temperature changes cause expansion and contraction of pipework and why it is important to allow for this in a piping system. You have also looked at the need for the insulation of pipes carrying cold as well as hot fluids. These are practical applications of some of the theory you learnt during earlier stages of your training.

Finally, you have had more practice at interpreting piping drawings and diagrams and have learned some practical pipe fabrication and fitting skills.

8 Glossary

Here are some words used in this module that might be new to you. You will find these words in *coloured italics* in the notes. There is a short definition in a box near the word in the notes.

Word	First Used on Page:	Part of Speech	Meaning	Example of Use
Access	47	noun	An entrance or way or reaching something	Never block an access, you may stop people escaping in emergency or stop the fire service from entering.
Adjoining	73	adjective	Next to and joined with	There is an open sitting area and a swimming pool adjoining the Oasis Club.
Available	18	adjective	There to be used or free to do something	If we arrange a meeting for tomorrow, will you be available?
Flexible	59	adjective	Easy to change shape—from the verb *flex*, which means to bend	Most plastics are more flexible than metals.
Interpret	7	verb	To explain the meaning	If you find an English word you do not know, find someone who can interpret it for you
Inverted	53	adjective	Turned over; up-side-down	The car went off the road, rolled three times and ended up completely inverted.
Isolate	7	verb	Keep separate from other things	It is sometimes necessary to isolate a sick person so that others are not infected.
Permanent	22	adjective	Lasting for ever, or at least for a very long time	I live on Das Island while I am working but my permanent home is in Abu Dhabi
Structure	21	noun	Something that is built, usually to take load	The top rooms in the TS accommodation are supported on a steel structure
Systematic	80	adjective	Making a good plan and working to it	If you are systematic in your work you will find that you make fewer mistakes.
Temporary	22	adjective	Not lasting for ever	Temporary traffic lights are used on Das Island when men are working on the roads.

Appendix A

ADGAS Pipeline Identification Colour Coding

Outer colour bands based on BS1710.

Colours conform to BS 4800.

IDENTIFICATION COLOUR CODES

PIPELINE INDENTIFICATION COLOUR CODING

All of the pipelines are colour coded.

PIPE CONTENT	IDENTIFICATION COLOUR	SAFETY COLOUR CODE	IDENTIFICATION COLOUR
SOUR GAS	YELLOW OCHRE	RED	YELLOW OCHRE
SWEET GAS	YELLOW OCHRE	GREEN	YELLOW OCHRE
SOUR FLARE GAS	YELLOW OCHRE	VIOLET	YELLOW OCHRE
SWEET FLARE GAS	YELLOW OCHRE	BLUE	YELLOW OCHRE
PROPANE	YELLOW OCHRE	BLACK	YELLOW OCHRE
MCR	YELLOW OCHRE	WHITE	YELLOW OCHRE
PLANT AIR	LIGHT BLUE	WHITE	LIGHT BLUE
INSTRUMENT AIR	LIGHT BLUE	BLACK	LIGHT BLUE
HALON / CO_2	LIGHT BLUE	GREEN	LIGHT BLUE
NITROGEN	LIGHT BLUE	ORANGE	LIGHT BLUE
OXYGEN	LIGHT BLUE	RED	LIGHT BLUE
HYPOCHLORITE	LIGHT BLUE	VIOLET	LIGHT BLUE
LUBE OIL	BLACK	GREEN	BLACK
HYDRAULIC OIL	BLACK	PURPLE	BLACK
DIESEL OIL	BLACK	WHITE	BLACK
SOUR OIL	BLACK	RED	BLACK
SEA WATER C.W. INLET	GREEN	WHITE	GREEN
DIRTY CONDENSATE	GREEN	YELLOW	GREEN
CLEAN CONDENSATE	GREEN	RED	GREEN
SEA WATER C.W. OUTLET	GREEN	ORANGE	GREEN
PROCESS / JACKET WATER	GREEN	BROWN	GREEN
POTABLE WATER	GREEN	LIGHT BLUE	GREEN
SOUR WATER	GREEN	PURPLE	GREEN
BOILER FEED WATER	GREEN	YELLOW OCHRE	GREEN
DESALINATED WATER	GREEN	BLACK	GREEN
DEMINERALISED WATER	GREEN	VIOLET	GREEN
FIRE WATER		RED	
FOAM (FIRE-FIGHTING)	RED	YELLOW OCHRE	RED
STEAM		SILVER GREY	
STEAM CONDENSATE	SILVER GREY	GREEN	SILVER GREY
K_2CO_3 CARBONATE	YELLOW	VIOLET	YELLOW
UCON + ANTIFOAM	YELLOW	RED	YELLOW
DI - ETHANOLAMINE (DEA)	YELLOW	LIGHT BLUE	YELLOW
OCENOL ANTIFOAM	YELLOW	PURPLE	YELLOW
ACID	VIOLET	WHITE	VIOLET
ALKALIS	VIOLET	BLACK	VIOLET

Appendix B ADGAS Piping Specification A

SHEET 1 OF 2

ADGAS PIPING SPECIFICATION 'A'

ISSUE 3 DATE: MAY 1995

SERVICE: GENERAL PROCESS, SWEET FUEL GAS, LP STEAM, LIGHT DISTILLATE AND H F O, UTILITY AIR, INST. AIR, NITROGEN, PROPANE, CARBONATE SOLUTIONS

DESIGN CODE	CORROSION ALLOWANCE 0.05"	RATING 150# RF CARBON STEEL

SERVICE LIMITS: (BASED ON FLANGES)																		
	TEMPERATURE °C	38	50	75	100	125	150	175	200	225	250	260	275	300	325	350	375	400
	PRESSURE BARG	20	19	19	18	16.75	16	15	14.0	13	12	12	11	10	9.3	8.4	7.4	6.5

NOTES:

1. WALL THICKNESS FOR 20" NB PIPE & ABOVE TO BE CALCULATED (SEE ALSO BECHTEL SUPPLEMENT L2).
2. FABRICATION AND INSPECTION TO BP GS 118-5.
3. CARBON CONTENT OF ALL STEEL TO BE LIMITED TO 0.25 PERCENT MAX.
4. N D T REQUIREMENTS TO BE ADVISED BY CORROSION AND INSPECTION DEPARTMENT.
5. WELDS TO BE STRESS RELIEVED ON CARBONATE & DEA DUTIES TO BP GS 118-5.
6. ALL METALLIC MATERIALS USED ON CARBONATE, DEA & SOUR GAS DUTIES TO N A C E SPEC. MR-01-75 LATEST REV.
7. PARALLEL SLIDE GATE VALVES TO BE USED ONLY IN STEAM LINES OUTSIDE PROCESS AREAS.
8. STEAM SERVICE VALVES 8" & ABOVE TO HAVE INTEGRAL TYPE BYPASS.
9. SERVICE TEMP. OF SOFT SEAT BALL VALVES TO BE LIMITED TO 250°C MAX.
10. WN FLANGES TO BE USED ONLY FOR FTG TO FTG PURPOSE & STEAM LINES WITHIN PROCESS AREAS.
11. BURIED LINES TO BE COATED AND WRAPPED TO BP STD 144.
12. WHERE LINES ARE STRESS RELIEVED DO NOT USE SW VALVES. USE FLANGED VALVES SPEC. AS FOR 2" FLANGED.

COMPONENT	SIZE	DESIGN & MATERIAL SPECIFICATION	REMARKS
GATE VALVES	1½" & BELOW	800 # FS SW BS 5352, MATL. BS 1503. 221-430, 13% CR. TRIM	NOTE 12
	2" - 12"	150# RF BS 1414, MATL. CS BS 1504-161 GR 480, 13% CR. TRIM	NOTE 8
	14" - 42"	AS ABOVE WITH BEVEL GEAR OPERATION	NOTE 8
	2" - 6"	150# RF PARALLEL SLIDE, MATL. CS BS 1504-161 GR. 480, 13% CR. TRIM	NOTE 7
	8" - 12"	AS ABOVE WITH INTEGRAL BYPASS	NOTE 8
	14" & ABOVE	AS ABOVE WITH INTEGRAL BYPASS AND GEAR OPERATION	
GLOBE VALVES	1½" & BELOW	800 # FS SW BS 5352, MATL. BS 1503-221-430, 13% CR. TRIM	NOTE 12
	2" - 8"	150# RF BS 1873, MATL. CS BS 1504-161 GR 480, 13% CR. TRIM	
	8"	AS ABOVE WITH INTEGRAL BYPASS	NOTE 8
CHECK VALVES	1½" & BELOW	800 # FS SW PISTON TYPE BS 5352, MATL. BS 1503-221-430, 13% CR. TRIM	NOTE 12
	2" - 24"	150# RF SWING TYPE BS 1868, MATL. CS BS 1504-161 GR 480, 13% CR. TRIM	
PLUG VALVES	2" - 4"	150# RF BS 5353, MATL. CS BS 1504-161 GR. 480	
	6" - 24"	AS ABOVE WITH GEAR OPERATION	
BALL VALVES	2" - 8"	150# RF FULL PORT BS 5351, MATL. CS BS 1504-161 GR. 480, PTFE SEALS, SS BALL	NOTE 9
VENT & DRAIN VALVES	1½" & BELOW	800# FS GATE OESW/OESCRD API, BS 5352, MATL. BS 1503-221-430, 13% CR. TRIM	NOTE 12
	1½" & BELOW	800# FS SW LUBRICATED PLUG VALVES BS 5353 REG. PATTERN, LEVER OP., MATL. BS 1503-221-430	

ADGAS PIPING SPECIFICATION 'A'

ISSUE 0 DATE: JULY 1993

COMPONENT	SIZE	WT.	DESIGN & MATERIAL SPECIFICATION	REMARKS
PIPING	1½" & BELOW	SCH. 80	MATL. CS SMLS. API 5L GR. B OR ASTM A 106 GR. B	
	2" - 6"	SCH. 40		
	8" - 16"	SCH. 30		
	18"	$^3/_8$" THK		
	20" & ABOVE	NOTE 1	MATL. API 5L, GR. B	
B. W. FITTINGS	2" - 6"	SCH. 40	DIMS. BS 1640, PART 3, MATL. GR. WPB/ASTM A 234 GR. WPB	
	8" - 16"	SCH. 30		
	18"	$^3/_8$" THK		
	20" - 24"	NOTE 1		
FLANGES (GEN.)	ALL		150# SO RF BS 1560, MATL. ASTM A 105 OR BS 1503-221-430	Note 10
	2" - 6"	SCH. 40	150# WN RF BS 1560, MATL. ASTM A 105 OR BS 1503-221-430	
	8" - 16"	SCH. 30		
	18"	STD		
	20" - 24"	NOTE 1		
FLANGES (ORIFICE)	2"	SCH. 40	300# WN RF BS 1560, MATL. ASTM 105 OR BS 1503-221-430	
	8" - 16"	SCH. 30		
SPADES	1" - 16"	--	150# REVERSIBLE SPADE — TO BP STD DRG. S-0755M, MATL.BS 1501-151, GR. 400 OR 430	
	18" - 48"		150# RING & SPADE SET — TO BP STD DRG. S-0755M, MATL.BS 1501-151, GR. 400 OR 430	
BOLTING			BS 4882, GR. B7 STUDS, GR. 2H NUTS	
GASKETS			150# RING TYPE FOR FLANGES TO BS-1560, MATL, BS 1832, $^1/_{16}$" THK CAF GRAPHITED	
SW FITTINGS	1½" & BELOW		3000# DIMS. & MATL. BS 3799, GR. WPA/WPB	
		SCH. 160	NIPPLES — API 5L, GR. B OR ASTM A 106 GR. B	
		SCH. 80	SWAGE NIPPLES — BS 3799, GR. WPA/WPB	
SCRD. FITTINGS				
SOCKOLETS	1½" & BELOW	--	3000# MATL. ASTM A 105	
WELDOLETS	2" - 4"	SCH. 40	MATL. ASTM A 105	

HEADER SIZES (IN INCHES)	1 & SMLR	1½	2	3	4	6	8	10	12
1 & SMLR	T								
1½	S	T							
2	S	S	T						
3	S	S	W	T					
4	S	S	W	W	T				
6	S	S	W	W	W	T			
8	S	S	W	W	W	UB	T		
10	S	S	W	W	W	UB	UB	T	
12	S	S	W	W	W	UB	UB	UB	T
14	S	S	W	W	W	UB	UB	UB	UB
16	S	S	W	W	W	UB	UB	UB	UB
18	S	S	W	W	W	UB	UB	UB	UB

BRANCH SIZES (INCHES)

BRANCH REINFORCEMENT

T = TEE

UB = UNREINFORCED BRANCH

S = SOCKOLET

W = WELDOLET

NOTE: FOR BRANCH DETAILS REFER TO BECHTEL STD DRG: AL-865

Appendix C Pipe Schedules

Nominal	O.D. (in)	PIPE SCHEDULES WALL THICKNESS (in)														
		5s	5	10s	10	20	30	40s & Std	40	60	80s & E.H.	80	100	120	140	160
1/8	.405		.035	.049	.049			.068	.068		.095	.095				
1/4	.540		.049	.065	.065			.088	.088		.119	.119				
3/8	.675		.049	.065	.065			.091	.091		.126	.126				
1/2	.840	.065	.065	.083	.083			.109	.109		.147	.147				.187
3/4	1.050	.065	.065	.083	.083			.113	.113		.154	.154				.218
1	1.315	.065	.065	.109	.109			.133	.133		.179	.179				.250
1 1/4	1.660	.065	.065	.109	.109			.140	.140		.191	.191				.250
1 1/2	1.900	.065	.065	.109	.109			.145	.145		.200	.200				.281
2	2.375	.065	.065	.109	.109			.154	.154		.218	.218				.343
2 1/2	2.875	.083	.083	.120	.120			.203	.203		.276	.276				.375
3	3.500	.083	.083	.120	.120			.216	.216		.300	.300				.437
3 1/2	4.000	.083	.083	.120	.120			.226	.226		.318	.318				
4	4.500	.083	.083	.120	.120			.237	.237	.281	.337	.337		.437		.531
4 1/2	5.000							.247			.355					
5	5.563	.109	.109	.134	.134			.258	.258		.375	.375		.500		.625
6	6.625	.109	.109	.134	.134			.280	.280		.432	.432		.562		.718
7	7.625							.301			.500					
8	8.625	.109	.109	.148	.148	.250	.277	.322	.322	.406	.500	.500	.593	.718	.812	.906
9	9.625							.342			.500					
10	10.750	.134	.134	.165	.165	.250	.307	.365	.365	.500	.500	.593	.718	.843	1.000	1.125
11	11.750							.375			.500					
12	12.750	.156	.165	.180	.180	.250	.330	.375	.406	.562	.500	.687	.843	1.000	1.125	1.312
14	14.000	.156		.188	.250	.312	.375	.375	.437	.593	.500	.750	.937	1.093	1.250	1.406
16	16.000	.165		.188	.250	.312	.375	.375	.500	.656	.500	.843	1.031	1.218	1.437	1.593
18	18.000	.165		.188	.250	.312	.437	.375	.562	.750	.500	.937	1.156	1.375	1.562	1.781
20	20.000	.188		.218	.250	.375	.500	.375	.593	.812	.500	1.031	1.280	1.500	1.750	1.968
24	24.000	.218		.250	.250	.375	.562	.375	.687	.968	.500	1.218	1.531	1.812	2.062	2.343
26	26.000				.312	.500		.375			.500					
28	28.000				312	.500	.625	.375								
30	30.000	.250		.312	.312	.500	.625	.375			.500					
32	32.000				.312	.500	.625	.375	.688		.500					
34	34.00				.312	.500	.625	.375	.688							
36	36.000				.312		.625	.375	.750		.500					

Appendix D Standard Wire Gauge Tables

Below is a list of conversions between the British Standard Wire Gauge (SWG), inches and centimetres.

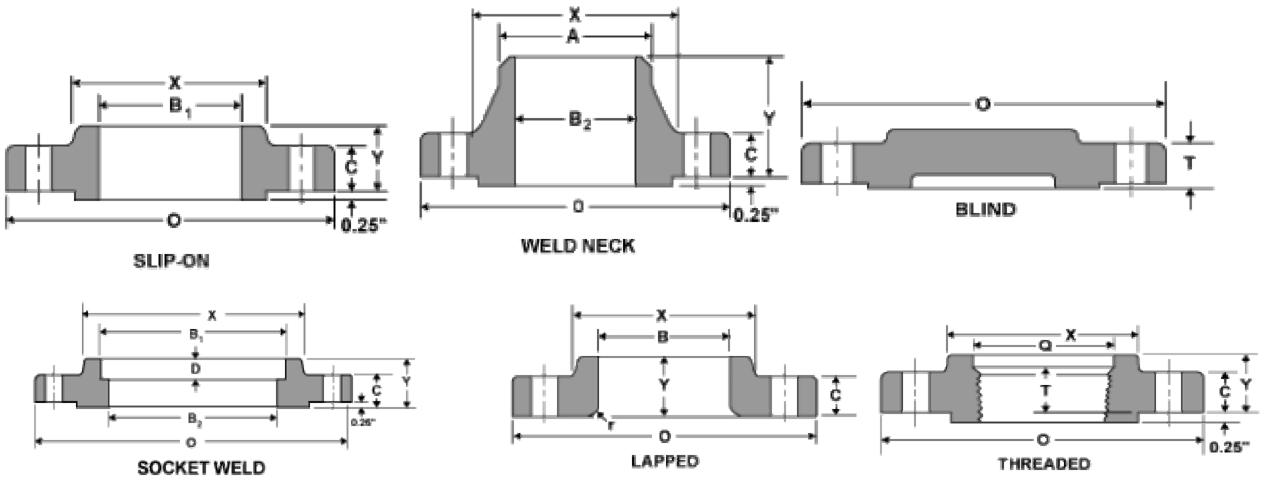
Warning: Do not confuse these with American Wire Gauge (AWG - sometimes known as 'Brown & Sharpe').

Standard Wire Gauge		
SWG	inches	cm
0	.324	.823
1	.300	.762
2	.276	.701
3	.252	.640
4	.232	.589
5	.212	.538
6	.192	.488
7	.176	.447
8	.160	.406
9	.144	.366
10	.128	.325
11	.116	.295
12	.104	.264
13	.092	.234
14	.080	.203
15	.072	.183
16	.064	.163
17	.056	.142
18	.048	.122
19	.040	.102
20	.036	.0914
21	.032	.0813
22	.028	.0711
23	.024	.0610
24	.022	.0559

Standard Wire Gauge		
SWG	inches	cm
25	.020	.0508
26	.018	.0457
27	.0164	.0417
28	.0149	.0378
29	.0136	.0345
30	.0124	.0315
31	.0116	.0295
32	.0108	.0274
33	.0100	.0254
34	.0092	.0234
35	.0084	.0213
36	.0076	.0193
37	.0068	.0173
38	.0060	.0152
39	.0052	.0132
40	.0048	0.0122
41	.0044	.0112
42	.004	.0102
43	.0036	.0091
44	.0032	.0081
45	.0028	.0071
46	.0024	.0061
47	.0020	.0051
48	.0016	.0041
49	.0012	.0030
50	.0010	.0025

Appendix E Standard Flange Dimensions—BS 1560

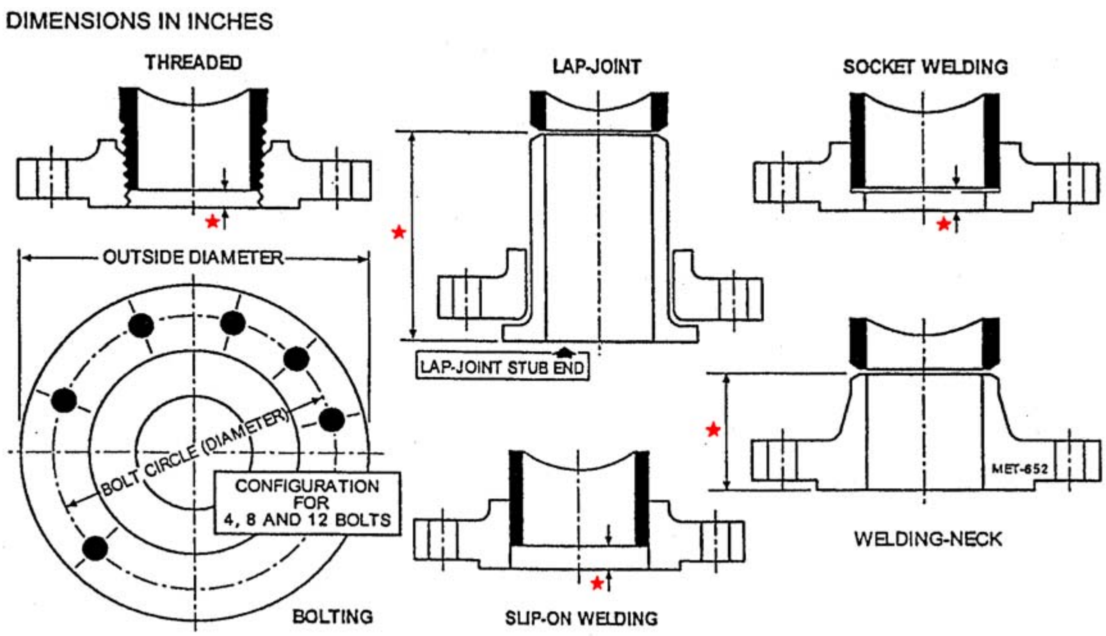
Class 600 (600#) flanges. Dimensions in inches.



Pipe Size	O	C	X	A	Y	Y	Y	T	B1	B	B2	r	Q
	Outside Diameter of Flange	* Thickness of Flange, Minimum	** Diameter of Hub	Diameter of Weld Neck	Threaded Slip-On	Lap-Joint	Weld Neck	Thread Length Threaded Flange, Minimum	Slip-On, Minimum	Lap-Joint, Minimum	Weld Neck / Socket Weld	Lap-Joint Flange Radius	Counter-bore Threaded Flange, Minimum
1/2	3.75	0.56	1.50	0.84	0.88	0.88	2.06	0.62	0.88	0.90	.546	0.12	0.93
3/4	4.62	0.62	1.88	1.05	1.00	1.00	2.25	0.62	1.09	1.11	.742	0.12	1.14
1	4.88	0.69	2.12	1.32	1.06	1.06	2.44	0.69	1.36	1.38	.957	0.12	1.41
1 1/4	5.25	0.81	2.50	1.66	1.12	1.12	2.62	0.81	1.70	1.72	1.28	0.19	1.75
1 1/2	6.12	0.88	2.75	1.90	1.25	1.25	2.75	0.88	1.95	1.97	1.50	0.25	1.99
2	6.50	1.00	3.31	2.38	1.44	1.44	2.88	1.12	2.44	2.46	1.94	0.31	2.50
2 1/2	7.50	1.12	3.94	2.88	1.62	1.62	3.12	1.25	2.94	2.97	2.32	0.31	3.00
3	8.25	1.25	4.62	3.50	1.81	1.81	3.25	1.38	3.57	3.60	2.90	0.38	3.63
3 1/2	9.00	1.38	5.25	4.00	1.94	1.94	3.38	1.56	4.07	4.10	3.36	0.38	4.13
4	10.75	1.50	6.00	4.50	2.12	2.12	4.00	1.62	4.57	4.60	3.83	0.44	4.63
5	13.00	1.75	7.44	5.56	2.38	2.38	4.50	1.88	5.66	5.69	4.81	0.44	5.69
6	14.00	1.88	8.75	6.63	2.62	2.62	4.62	2.00	6.72	6.75	5.76	0.50	6.75
8	16.50	2.19	10.75	8.63	3.00	3.00	5.25	2.25	8.72	8.75	7.63	0.50	8.75
10	20.00	2.50	13.50	10.75	3.38	4.38	6.00	2.56	10.88	10.92	9.75	0.50	10.88
12	22.00	2.62	15.75	12.75	3.62	4.62	6.12	2.75	12.88	12.92	11.75	0.50	12.94
14	23.75	2.75	17.00	14.00	3.69	5.00	6.50	2.88	14.14	14.18	13.00	0.50	14.19
16	27.00	3.00	19.50	16.00	4.19	5.50	7.00	3.06	16.16	16.19	15.00	0.50	16.19
18	29.25	3.25	21.50	18.00	4.62	6.00	7.25	3.12	18.18	18.20	17.00	0.50	18.19
20	32.00	3.50	24.00	20.00	5.00	6.50	7.50	3.25	20.20	20.25	19.00	0.50	20.19
24	37.00	4.00	28.25	24.00	5.50	7.25	8.00	3.62	24.25	24.25	23.00	0.50	24.19

Appendix F Flange Data

The data on the following pages uses the dimensions shown below. The dimensions in the Flange Type rows of the tables are those shown below with a red star.



CLASS 150 FLANGE DATA • DIMENSIONS INCLUDE 0.06" RAISED FACE ON FLANGES (except lap-joint) •• DIMENSIONS INCLUDE 0.06" GAP FOR WELDING - REFER TO CHART 2.2 **TABLE F-1**

NOMINAL PIPE SIZE: NPS	1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
OUTSIDE DIAMETER	3.5	3.88	4.25	5	6	7.5	9	11	13.5	16	19	21	23.5	25	27.5	32
FLANGE TYPE — ★ END OF PIPE TO FACE OF FLANGE or LAP JOINT STUB END • — WELD-NECK	1.88	2.06	2.19	2.44	2.5	2.75	3	−3.5	4	4	4.5	5	5	5.5	5.69	6
SLIP-ON	Wall thickness of pipe + 0.06-inch															
SOCKET• •	0.31	0.25	0.25	0.31	0.38	0.44										
THREADED	0.06	0.06	0	0.25	0.31	0.19	0.25	0.38	0.44	0.50	0.56					
L-J STUB END — ANSI	3	3	4	4	6	6	6	6	8	10	10	12	12	12	12	12
L-J STUB END — MSS	2	2	2	2	2.5	2.5	3	3.5	4	5	6	6	6	6	6	6
BORE: WELD-NECK & SOCKET	0.62	0.82	1.05	1.61	2.07	3.07	4.03	6.07	7.98	10.02	12	[Order to match pipe ID]				
BOLTING — BOLTS PER FLANGE	4	4	4	4	4	4	8	8	8	12	12	12	16	16	20	20
BOLT CIRCLE DIAMETER	2.38	2.75	3.12	3.88	4.75	6	7.5	9.5	11.75	14.25	17	18.75	21.25	22.75	25	29.5
DIAMETER OF BOLT	1/2	1/2	1/2	1/2	5/8	5/8	5/8	3/4	3/4	7/8	7/8	1	1	1 1/8	1 1/8	1 1/4
STUDBOLT THREAD length - except lap-joint: Note 5 — RF	2.25	2.5	2.5	2.75	3.25	3.5	3.5	4	4.25	4.5	4.75	5.25	5.25	5.75	6.25	6.75
STUDBOLT THREAD length - except lap-joint: Note 5 — RJ	-	-	3	3.25	3.75	4	4	4.5	4.75	5	5.25	5.75	5.75	6.25	6.75	7.25

CLASS 1500 FLANGE DATA

• DIMENSIONS INCLUDE 0.25" RAISED FACE ON FLANGES (except lap-joint)
•• DIMENSIONS INCLUDE 0.06" GAP FOR WELDING - REFER TO CHART 2.2

TABLE F-5

		1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
NOMINAL PIPE SIZE: NPS		1/2	3/4	1	1 1/2	2	3	4	6	.8	10	12	14	16	18	20	24
OUTSIDE DIAMETER		4.75	5.12	5.88	7	8.5	10.5	12.25	15.5	19	23	26.5	29.5	32.5	36	38.75	46
FLANGE TYPE: ★ END OF PIPE TO FACE OF FLANGE or LAP JOINT STUB END •	WELD-NECK	2.62	3	3.12	3.5	4.25	4.88	5.12	7	8.62	10.25	11.38	12	12.5	13.12	14.25	16.25
	SLIP-ON	Wall thickness of pipe + 0.06-inch															
	SOCKET••	1.19	1.25	1.44	1.44	1.88											
	THREADED	0.38	0.31	0.31	0.38	0.62	0.50	0.62	0.88	0.94	0.94	1					
	L-J STUB END ANSI	3	3	4	4	6	6	6	8	8	10	10	12	12	12	12	12
	L-J STUB END MSS	2	2	2	2	2.5	2.5	3	3.5	4	5	6	6	6	6	6	6
BORE: WELD-NECK & SOCKET		Order to match Internal Diameter of pipe															
BOLTING	BOLTS PER FLANGE	4	4	4	4	8	8	8	12	12	12	16	16	16	16	16	16
	BOLT CIRCLE DIAMETER	3.25	3.5	4	4.88	6.5	8	9.5	12.5	15.5	19	22.5	25	27.75	30.5	32.75	39
	DIAMETER OF BOLT	3/4	3/4	7/8	1	7/8	1 1/8	1 1/4	1 3/8	1 5/8	1 7/8	2	2 1/4	2 1/2	2 3/4	3	3 1/2
	STUDBOLT THREAD length - except lap-joint: Note 5 RF	4.25	4.5	5	5.5	5.75	7	7.75	10.25	11.5	13.25	14.75	16	17.5	19.5	21.25	24.25
	STUDBOLT THREAD length - except lap-joint: Note 5 RJ	4.25	4.5	5	5.5	5.75	7	7.75	10.5	12.75	13.5	15.25	16.75	18.5	20.75	22.25	25.5

CLASS 2500 FLANGE DATA

• DIMENSIONS INCLUDE 0.25" RAISED FACE ON FLANGES (except lap-joint)

TABLE F-6

		1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
NOMINAL PIPE SIZE: NPS		1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
OUTSIDE DIAMETER		5.25	5.5	6.25	8	9.25	12	14	19	21.75	26.5	30					
FLANGE TYPE: ★ END OF PIPE TO FACE OF FLANGE or LAP JOINT STUB END •	WELD-NECK	3.12	3.38	3.25	4.62	5.25	6.88	7.75	11	12.75	16.75	18.5					
	SLIP-ON	Wall thickness of pipe + 0.06-inch															
	SOCKET	Not available in this class															
	THREADED	0.31	0.44	0.31	0.69	0.88	0.5	0.62	0.88	0.94	1.06	1					
	L-J STUB END ANSI	3	3	4	4	6	6	6	8	8	10	10					
	L-J STUB END MSS	2	2	2	2	2.5	2.5	3	3.5	4	5	6					
BORE: WELD-NECK		Order to match Internal Diameter of pipe															
BOLTING	BOLTS PER FLANGE	4	4	4	4	8	8	8	8	12	12	12					
	BOLT CIRCLE DIAMETER	3.5	3.75	4.25	5.75	6.75	9	10.75	14.5	17.25	21.25	24.38					
	DIAMETER OF BOLT	3/4	3/4	7/8	1 1/8	1	1 1/4	1 1/2	2	2	2 1/2	2 3/4					
	STUDBOLT THREAD length - except lap-joint: Note 5 RF	4.75	5	5.5	6.75	7	8.75	10	13.5	15	19.25	21.25					
	STUDBOLT THREAD length - except lap-joint: Note 5 RJ	4.75	5	5.5	6.75	7	9	10.25	14	15.5	20	22					

CLASS 300 FLANGE DATA

• DIMENSIONS INCLUDE 0.06" RAISED FACE ON FLANGES (except lap-joint)
•• DIMENSIONS INCLUDE 0.06" GAP FOR WELDING - REFER TO CHART 2.2

TABLE F-2

			1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
NOMINAL PIPE SIZE: NPS			1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
OUTSIDE DIAMETER			3.75	4.62	4.88	6.12	6.5	8.25	10	12.5	15	17.5	20.5	23	25.5	28	30.5	36
FLANGE TYPE	★ END OF PIPE TO FACE OF FLANGE or LAP JOINT STUB END •	WELD-NECK	2.06	2.25	2.44	2.69	2.75	3.12	3.38	−3.88	4.38	4.62	5.12	5.62	5.75	6.25	6.38	6.62
		SLIP-ON	Wall thickness of pipe + 0.06-inch															
		SOCKET ••	0.56	0.62	0.62	0.62	0.69	0.94										
		THREADED	0.06	0.06	0	0.25	0.44	0.25	0.38	0.62	0.69	0.75	0.75					
		L-J STUB END ANSI	3	3	4	4	6	6	6	8	8	10	10	12	12	12	12	12
		L-J STUB END MSS	2	2	2	2	2.5	2.5	3	3.5	4	5	6	6	6	6	6	6
BORE: WELD-NECK & SOCKET			0.62	0.82	1.05	1.61	2.07	3.07	4.03	6.07	7.98	10.02	12	[Order to match pipe ID]				
BOLTING	BOLTS PER FLANGE		4	4	4	4	4	4	8	12	12	16	16	20	20	24	24	24
	BOLT CIRCLE DIAMETER		2.62	3.25	3.5	4.5	5	6.62	7.88	10.62	13	15.25	17.75	20.25	22.5	24.75	27	32
	DIAMETER OF BOLT		1/2	5/8	5/8	3/4	5/8	3/4	3/4	3/4	7/8	1	1 1/8	1 1/8	1 1/4	1 1/4	1 1/4	1 1/2
	STUDBOLT THREAD length - except lap-joint: Note 5	RF	2.5	3	3	3.5	3.5	4.25	4.5	4.75	5.5	6.25	6.75	7	7.5	7.75	8	9
		RJ	3	3.5	3.5	4	4	4.75	5	5.5	6	6.75	7.25	7.5	8	8.25	8.75	10

CLASS 600 FLANGE DATA

• DIMENSIONS INCLUDE 0.25" RAISED FACE ON FLANGES (except lap-joint)
•• DIMENSIONS INCLUDE 0.06" GAP FOR WELDING - REFER TO CHART 2.2

TABLE F-3

			1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
NOMINAL PIPE SIZE: NPS			1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
OUTSIDE DIAMETER			3.75	4.62	4.88	6.12	6.5	8.25	10	12.5	15	17.5	20.5	23	25.5	28	30.5	36
FLANGE TYPE	★ END OF PIPE TO FACE OF FLANGE or LAP JOINT STUB END •	WELD-NECK	2.31	2.5	2.69	3	3.12	3.5	3.38	−3.88	4.38	4.62	5.12	5.62	5.75	6.25	6.38	6.62
		SLIP-ON	Wall thickness of pipe + 0.06-inch															
		SOCKET ••	0.81	0.88	0.88	0.94	1.06	1.31										
		THREADED	0.38	0.31	0.31	0.44	0.69	0.50	0.62	0.88	0.94	0.94	1					
		L-J STUB END ANSI	3	3	4	4	6	6	6	8	8	10	10	12	12	12	12	12
		L-J STUB END MSS	2	2	2	2.	2.5	2.5	3	3.5	4	5	6	6	6	6	6	6
BORE: WELD-NECK & SOCKET			Order to match Internal Diameter of pipe															
BOLTING	BOLTS PER FLANGE		4	4	4	4	8	8	8	12	12	16	20	20	20	20	24	24
	BOLT CIRCLE DIAMETER		2.62	3.25	3.5	4.5	5	6.62	8.5	11.5	13.75	17	19.25	20.75	23.75	25.75	28.5	33
	DIAMETER OF BOLT		1/2	5/8	5/8	3/4	5/8	3/4	7/8	1	1 1/8	1 1/4	1 1/4	1 3/8	1 1/2	1 5/8	1 5/8	1 7/8
	STUDBOLT THREAD length - except lap-joint: Note 5	RF	3	3.5	3.5	4.25	4.25	5	5.75	6.75	7.5	8.5	8.75	9.25	10	10.75	11.25	13
		RJ	3	3.5	3.5	4.25	4.25	5	5.75	6.75	7.75	8.5	8.75	9.25	10	10.75	11.5	13.25

CLASS 900 FLANGE DATA

• DIMENSIONS INCLUDE 0.25" RAISED FACE ON FLANGES (except lap-joint)

TABLE F-4

NOMINAL PIPE SIZE: NPS			1/2	3/4	1	1 1/2	2	3	4	6	8	10	12	14	16	18	20	24
OUTSIDE DIAMETER			4.75	4.12	5.88	7	8.5	9.5	11.5	15	18.5	21.5	24	25.25	27.75	28	33.75	41
FLANGE TYPE: ★ END OF PIPE TO FACE OF FLANGE or LAP JOINT STUB END •	WELD-NECK		2.62	3	3.12	3.5	4.25	4.25	4.75	5.75	6.62	7.5	8.12	8.62	8.75	9.25	10	11.75
	SLIP-ON		Wall thickness of pipe + 0.06-inch															
	SOCKET		Not available in this class															
	THREADED		0.62	0.69	0.69	0.81	0.06	0.50	0.62	0.88	0.94	1	1					
	L-J STUB END	ANSI	3	3	4	4	6	6	6	8	8	10	10	12	12	12	12	12
		MSS	2	2	2	2	2.5	2.5	3	3.5	4	5	6	6	6	6	6	6
BORE: WELD-NECK & SOCKET			Order to match Internal Diameter of pipe															
BOLTING	BOLTS PER FLANGE		4	4	4	4	8	8	8	12	12	16	20	20	20	20	20	20
	BOLT CIRCLE DIAMETER		3.25	3.5	4	4.88	6.5	7.5	9.25	12.5	15.5	18.5	21	22	24.25	27	29.5	35.5
	DIAMETER OF BOLT		3/4	3/4	7/8	1	7/8	7/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 1/2	1 1/2	1 7/8	2	2 1/2
	STUDBOLT THREAD length - except lap-joint: Note 5	RF	4.25	4.5	5	5.5	5.75	5.75	6.75	7.5	8.75	9.25	10	10.75	11.25	12.75	13.75	17.25
		RJ	4.25	4.5	5	5.5	5.75	5.75	6.75	7.75	8.75	9.25	10	11	11.5	13.25	14.25	18

Appendix G ADGAS Standard P&ID Symbols—Trains I and II

Line Identification

9 - BD - 1019 - 3"- A1

- PIPING CLASSIFICATION
- LINE SIZE
- LINE NUMBER
- COMMODITY
- PLANT NUMBER

LINE NUMBERS GIVEN ARE FOR TRAIN 1 E, 9-BD-1019-3"-A1
LINE NUMBERS FOR TRAIN 2 WILL HAVE 2 SUBMITTED FOR THE FIRST NUMBER ie, 9-BD-2019-3"-A1

COMMODITY SYMBOLS

PROCESS

PS	- PROCESS HYDROCARBONS	(SOUR & WET)
PW	- PROCESS HYDROCARBONS	(SWEET & WET)
PD	- PROCESS HYDROCARBONS	(SWEET & DRY)
MR	- MIXED REFRIGERANT	
S	- SULPHUR	
LNG	- LIQUID NATURAL GAS	
PR/C3	- PROPANE	
C4	- BUTANE	
C5	- PENTANE	

STEAM

SU	- UTILITY STEAM	15 P.S.I.G.
SL	- LOW PRESSURE STEAM	60 P.S.I.G.
SB	- BOILER FEED WATER HEATING STEAM	125 P.S.I.G.
SS	- SULPHUR PLANT STEAM	200 P.S.I.G.
SM	- MEDIUM PRESSURE STEAM	500 P.S.I.G.
SH	- HIGH PRESSURE STEAM	900 P.S.I.G.

CONDENSATE

- CC - CONDENSATE FROM CONDENSERS (COLD)
- CH - HOT CONDENSATE

AIR

- AI - INSTRUMENT AIR
- AD - PURGE AIR
- AS - AIR (SERVICE)
- BA - BREATHING AIR
- AP - PROCESS AIR
- AU - UTILITY AIR

WATER

- WB - BOILER FEED WATER
- WC - COOLING WATER (SEA WATER)
- WU - COOLING WATER (FRESH FOR JACKETS)
- WD - DRINKING WATER
- WF - FIRE WATER
- WP - PROCESS & PUMP FLUSHING WAER
- WR - RAW WATER (DESALINATED)
- WT - TREATED WATER (DEMINERALISED)
- WU - UTILITY WATER
- WV - WATER VAPOUR

FUEL

- FG - FUEL GAS (SWEET & DRY)
- FS - FUEL GAS (SOUR & DRY)

MISCELLANEOUS

- BB - BOILER BLOWDOWN
- BD - BLOWDOWN (FLARE)
- CO - CONTROL OIL
- K - CHEMICALS
- LO - LUBE OIL
- N - NITROGEN
- NP - LINES WITHIN NITROGEN PLANT
- OW - OILY WATER
- SO - SEAL OIL

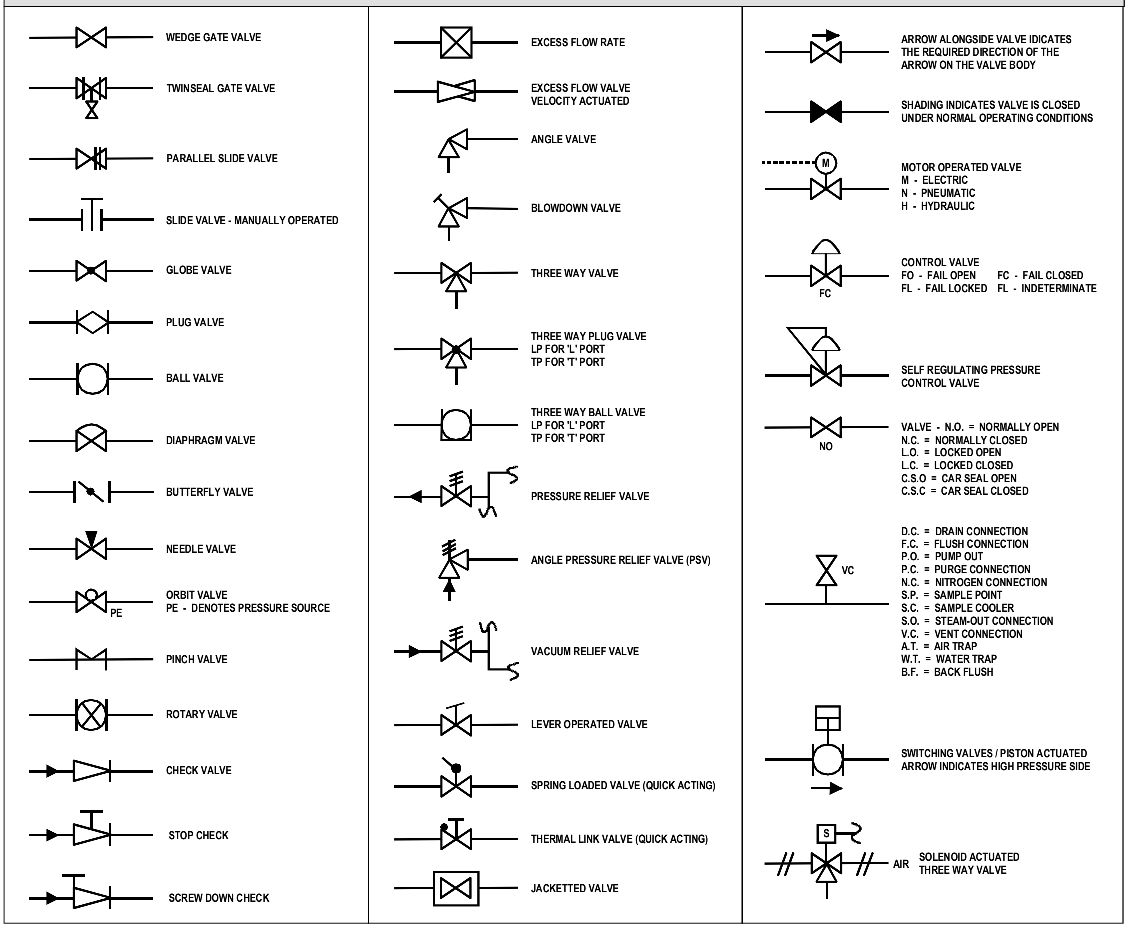
Line symbols

- PROCESS LINE / PRESSURE LINE INSTRUMENT LINE / MISC. CONNECTION
- MAIN PROCESS LINES
- PACKAGE UNIT LIMIT
- JUNCTION / CONNECTION
- INSULATED LINE (HOT) PP - PERSONNEL PROTECTION C - COLD INSULATION A - ACOUSTIC
- INSULATED LINE ST - STEAM TRACED E - ELECTRIC TRACED
- STEAM JACKETED LINE
- PNEUMATIC SIGNAL
- CAPILLARY TUBING
- ELECTRICAL SIGNAL
- SOFTWARE LINK
- SURFACE INSULATION (HOT) PP - PERSONNEL PROTECTION C - COLD INSULATION A - ACOUSTIC
- FLOW ARROW (DIRECTION OF FLOW)
- LIMIT OF SPECIFICATION / INSULATION OR RESPONSIBILITY
- C — BOILER CODE
- SR — STRESS RELIEVED
- 12 — STREAM NUMBER
- FLOW SHEET CONTINUATION NUMBER (PIPING)
- FLOW SHEET CONTINUATION NUMBER (INST)
- PULLMAN KELLOG DRG. / P&ID No.
- TIE IN NUMBER ON PULLWAN KELLOG DRGS. FOR NEW TANK FARM (PROJ. 550)
- FILIPPO FOCHI DRG. FOR NSI PROJECT

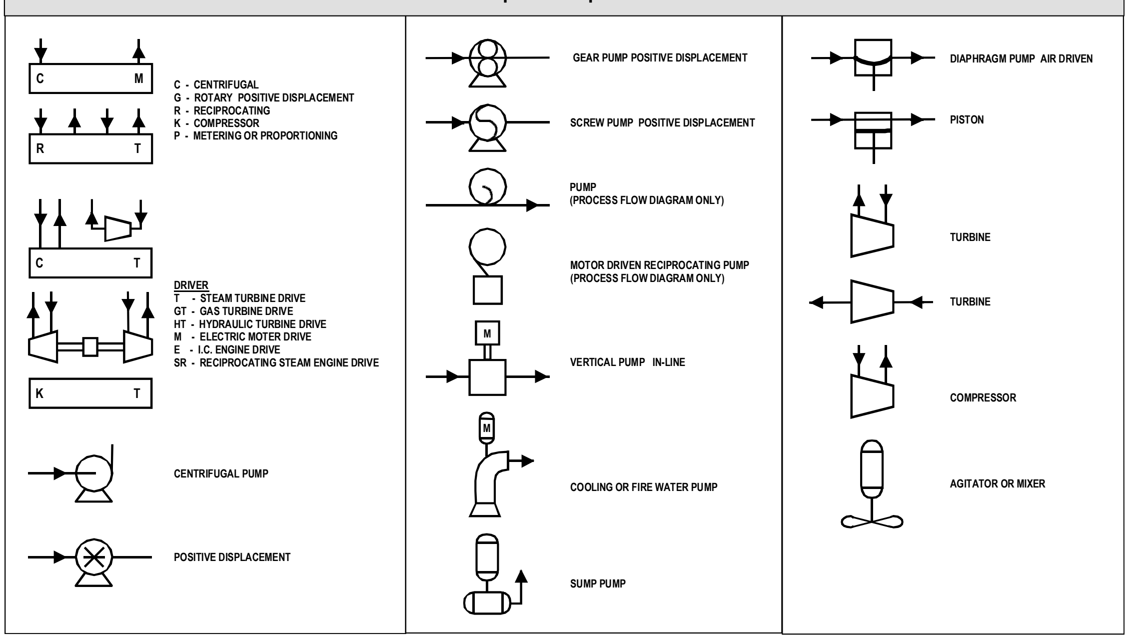
In Line Devices

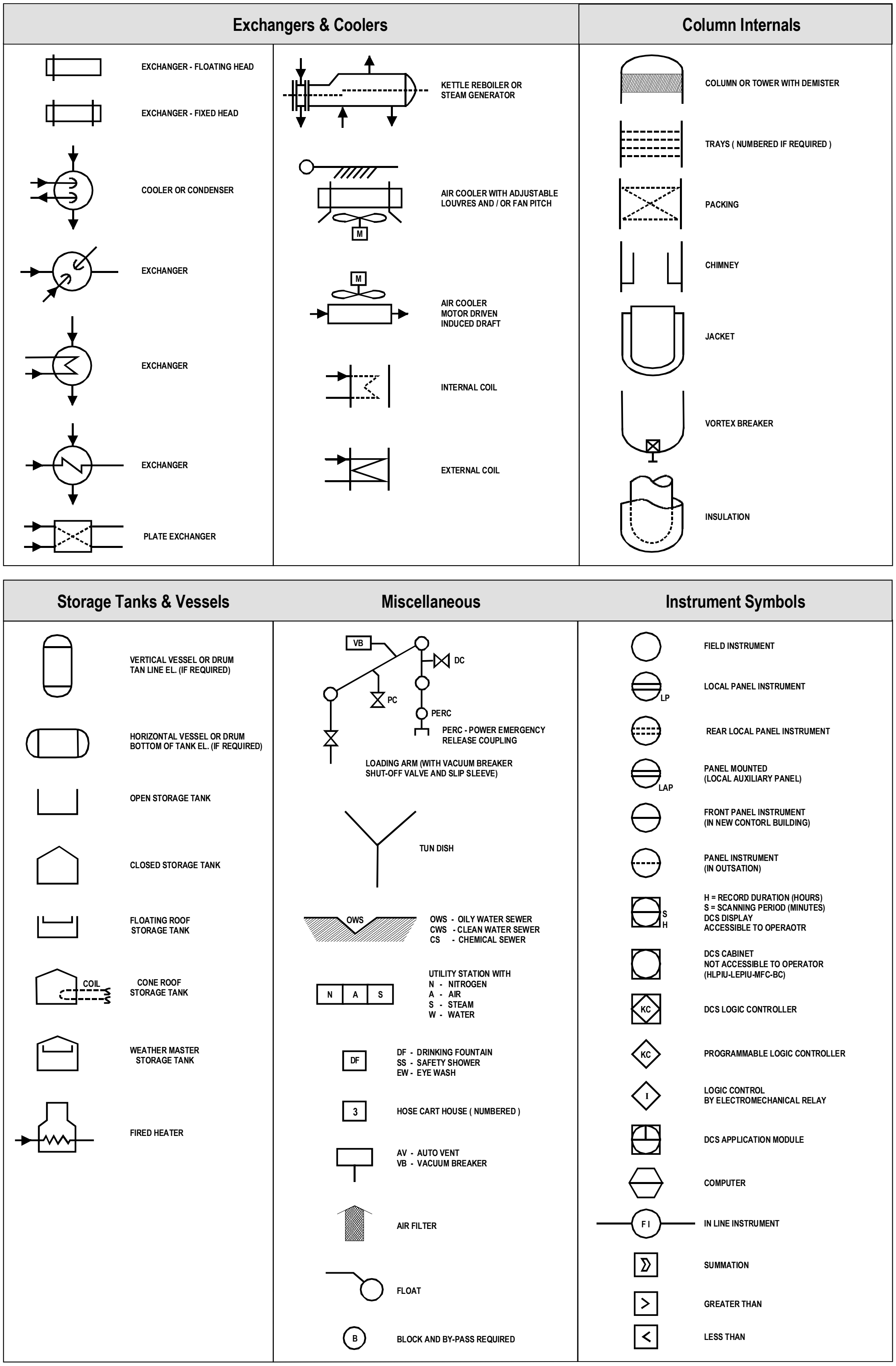
- REDUCER
- BREAK FLANGES
- ORIFICE SPOOL
- REMOVABLE SPOOL
- ORIFICE PLATE FLOW MEASURING WITH ORIFICE FLANGE SET OR FLOW RESTRICTING
- ORIFICE CAPSULE (FLOW MEASURING)
- BURSTING DISC (PSE)
- IF — INSULATING FLANGE (ELECTRICALLY)
- BL — A PIPING LOCATION SUITABLE FOR BLINDING
- SPECTACLE BLIND (TOP RING SHADED INDICATES BLIND INSTALLED)
- QUICK ACTING LINE BLIND (HAMER OR EQUAL)
- UNION BLIND
- FLEXIBLE COUPLING
- VICTAULIC COUPLING
- EXPANSION JOINTS OR BELLOWS
- IN-LINE STRAINER WITH REMOVABLE SPOOL
- 'Y' TYPE STRAINER
- SIMPLEX STRAINER
- DUPLEX STRAINER
- FILTER
- FILTER WITH DRAIN & VENT VALVES
- FLAME ARRESTOR
- ST 1 - 5, TYPE No. REQ'D — ST - STEAM TRAP (REPRESENTS THE COMPLETE ASSEMBLY OF TRAP BLOCK VALVES & BY-PASS) T - GENERAL TRAP S - SEPARATOR CD - CONTINOUS DRAIN AT - TRAP FOR NON CONDENSABLES
- VENT PIPE ATMOSPHERIC
- SPRAY NOZZLE
- HOSE CONNECTOR
- FLEXIBLE HOSE & COUPLING
- HOSE CONNECTION FEMALE
- FLEXIBLE HOSE FLANGED ENDS
- FIRE HYDRANT TWO HOSE CONNECTION
- T — ELEVATED OSCILATING FIREWATER MONITOR (TOWER MOUNTED)
- INJECTOR OR EJECTOR
- EJECTOR OR EDUCTOR
- VENTURI TUBE
- IN-LINE MIXER
- PITOT TUBE
- EXHAUST HEAD ATMOSPHERIC
- LG — LG - LEVEL GAUGE SG - SIGHT GLASS
- FI — ROTAMETER

Valves

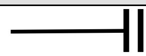
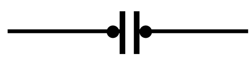
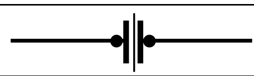
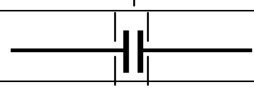
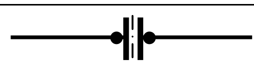
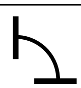
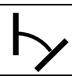
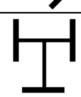
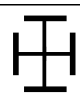
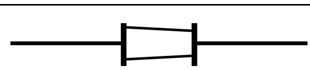
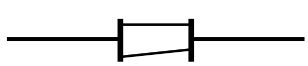
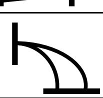


Pumps & Compressors




Exchangers & Coolers
EXCHANGER - FLOATING HEAD
EXCHANGER - FIXED HEAD
COOLER OR CONDENSER
EXCHANGER
EXCHANGER
EXCHANGER
PLATE EXCHANGER
KETTLE REBOILER OR STEAM GENERATOR
AIR COOLER WITH ADJUSTABLE LOUVRES AND / OR FAN PITCH
M
M
AIR COOLER MOTOR DRIVEN INDUCED DRAFT
INTERNAL COIL
EXTERNAL COIL
Column Internals
COLUMN OR TOWER WITH DEMISTER
TRAYS (NUMBERED IF REQUIRED)
PACKING
CHIMNEY
JACKET
VORTEX BREAKER
INSULATION
Storage Tanks & Vessels
VERTICAL VESSEL OR DRUM TAN LINE EL. (IF REQUIRED)
HORIZONTAL VESSEL OR DRUM BOTTOM OF TANK EL. (IF REQUIRED)
OPEN STORAGE TANK
CLOSED STORAGE TANK
FLOATING ROOF STORAGE TANK
COIL
CONE ROOF STORAGE TANK
WEATHER MASTER STORAGE TANK
FIRED HEATER
Miscellaneous
VB
DC
PC
PERC
PERC - POWER EMERGENCY RELEASE COUPLING
LOADING ARM (WITH VACUUM BREAKER SHUT-OFF VALVE AND SLIP SLEEVE)
TUN DISH
OWS
OWS - OILY WATER SEWER
CWS - CLEAN WATER SEWER
CS - CHEMICAL SEWER
N A S
UTILITY STATION WITH
N - NITROGEN
A - AIR
S - STEAM
W - WATER
DF
DF - DRINKING FOUNTAIN
SS - SAFETY SHOWER
EW - EYE WASH
3
HOSE CART HOUSE (NUMBERED)
AV - AUTO VENT
VB - VACUUM BREAKER
AIR FILTER
FLOAT
B
BLOCK AND BY-PASS REQUIRED
Instrument Symbols
FIELD INSTRUMENT
LP
LOCAL PANEL INSTRUMENT
REAR LOCAL PANEL INSTRUMENT
LAP
PANEL MOUNTED (LOCAL AUXILIARY PANEL)
FRONT PANEL INSTRUMENT (IN NEW CONTORL BUILDING)
PANEL INSTRUMENT (IN OUTSATION)
S
H
H = RECORD DURATION (HOURS)
S = SCANNING PERIOD (MINUTES)
DCS DISPLAY
ACCESSIBLE TO OPERAOTR
DCS CABINET
NOT ACCESSIBLE TO OPERATOR
(HLPIU-LEPIU-MFC-BC)
KC
DCS LOGIC CONTROLLER
KC
PROGRAMMABLE LOGIC CONTROLLER
I
LOGIC CONTROL BY ELECTROMECHANICAL RELAY
DCS APPLICATION MODULE
COMPUTER
F I
IN LINE INSTRUMENT
SUMMATION
GREATER THAN
LESS THAN

Appendix H Standard Piping Drawing Symbols

Symbol Single-line drawings	Description
	Blind flange
	Welding-neck flanges
	Slip-on flanges
	Spaded flanges
	Lap-joint flanges
	Screwed or socket-welding flanges
	Orifice flange
	X=M; Y=F male-female X=MT; Y=G tongue and groove
	Flanged 90^{o} elbow
	Flanged 45^{o} elbow
	Flanged tee
	Flanged cross
	Flanged concentric reducer
	Flanged eccentric reducer
	Flanged 90^{o} reducing elbow

Exercises