

# ●●● POWER ENGINEERING

## Fourth Class

Edition 3.5

### Introductory Fluid Handling Technology

Part A

Unit A-7



**PanGlobal**  
Partner in Education

Published by PanGlobal Training Systems Ltd.  
Publishers of Power Engineering Learning Materials

The material in this series is aligned with the SOPEEC Fourth Class Syllabus,  
dated November 2017, and the IPECC Curriculum, November 2017.

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Printed in Canada

Fourth Class - Part A - Unit A-7 - Introductory Fluid Handling Technology

Edition 3.5, September 2024

ISBN13: 978-1-77251-263-2 (Part A Print Set)

ISBN13: 978-1-77251-264-9 (Part A Ebook Set)

ISBN13: 978-1-77251-279-3 (Unit A7 Print)

ISBN13: 978-1-77251-280-9 (Unit A7 Ebook)

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4th Class Edition 3.5 • Part A

# UNIT A-7

## INTRODUCTORY FLUID HANDLING TECHNOLOGY

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## UNIT INTRODUCTION

Piping and valves are essential components in an energy plant. Without them the plant simply could not operate. Imagine the veins in the human body. While the heart may be responsible for keeping a person alive, the veins allow the heart to provide blood to vital organs. If the veins clog, they can cause very serious problems for the heart and for overall health. The same can be said for the pipes within a plant.

The two chapters in this unit will discuss:

- The different types of piping materials
- The need for thermal expansion joints
- Physical phenomena such as water hammer
- Thermal insulation used on piping
- The different types of valves, and their construction and operation

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## UNIT RATIONALE

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It is essential for Power Engineers to be aware of the details in the power plant. It is for this reason that piping and its accessories are such an important part of this study. Knowing how piping systems operate, why they are needed, and how different materials behave, the Power Engineer can make wise decisions on how to choose and maintain both piping and valves. This promotes safe and efficient power plant operation.





# CHAPTER 1

## Introduction to Energy Plant Piping Systems

### LEARNING OUTCOME

*When you complete this chapter you should be able to:*

*Discuss the basic types of piping, piping connections, supports, and drainage devices used in industry.*

### LEARNING OBJECTIVES

*Here is what you should be able to do when you complete each objective:*

- 1. State the applications for the most common materials and identify the sizes of commercial pipe.*
- 2. Describe methods of connection for screwed, flanged, and welded pipe; identify fittings and their markings.*
- 3. Describe methods and devices used to allow for pipe expansion and support.*
- 4. Explain the methods used to promote good drainage of steam pipes, including the installation and maintenance of steam traps, to reduce the effects of water hammer.*
- 5. Explain the requirements, materials, and methods for insulating pipe.*





## CHAPTER INTRODUCTION

Piping is used in power plants to convey fluids to and from their place of usage, and is integral to plant operation. Plants could not operate without piping.

It is important to understand the different piping requirements for the various fluids used. This includes selection of:

- a) The most suitable piping materials
- b) The proper pipe sizes for the volumes transferred
- c) The most appropriate methods of connection
- d) The most appropriate fittings

A power plant is a potentially dangerous environment if it is not treated with the respect it deserves. Power Engineers must be aware of the potential risks with piping and piping accessories. For example, if unidentified fittings are used, they are likely low quality. Low quality fittings may explode causing considerable damage to property and loss of life. This chapter will cover in detail the different types of fittings, different ways of connecting piping, and the advantages and disadvantages of each method.

The concept of thermal expansion and why piping requires expansion joints will be discussed. As well, the different kinds of pipe supports used within industry will be discussed.

Condensate within piping can cause serious problems for steam plants. This chapter will cover the need to remove condensate from steam piping, and the types of devices used to perform this task.

Finally, the need for piping insulation will be discussed. Insulation is critical for both cold temperature and high temperature piping, to prevent unwanted heat transfer. As well, insulation protects plant personnel from exposure to hazardous temperatures.

## OBJECTIVE 1

*State the applications for the most common materials and identify the sizes of commercial pipe.*

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## PIPING MATERIALS

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Materials used to manufacture pipe must suit the operating conditions of the piping system. Guidance in material selection can be obtained by referring to standard piping codes. For example, the **ASME Piping Codes** (B31.1, B31.3, and others) address:

- Power piping
- Process piping
- Gas piping
- Air piping
- Refrigeration piping systems

These codes will help to select material that is safe under anticipated operating conditions of pressure, temperature, and corrosion.

Some of the materials most commonly used for power plant piping include steel, cast iron, brass, and copper.

**Steel** is the most common piping material. Steel pipe is manufactured in two main categories — seamless and welded. Forged steel is used for welded fittings, while cast steel is primarily used for special applications.

**Cast Iron** has high resistance to corrosion and abrasion. It is used for ash handling systems, sewage lines, and underground water lines. However, it is brittle and is not suitable for pressurized service. It is made in different grades, such as gray cast iron and white cast iron.

**Malleable iron** and **ductile iron** are commonly used for screwed fittings, where the greater strength of steel fittings is not required.

**Brass and Copper** (and other copper alloys) are non-ferrous materials. They are used in power plants in instrumentation and water services, where extreme pressure and temperature are not prime considerations.

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## COMMERCIAL PIPE SIZES

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Commercial pipe is manufactured in standard sizes, each having a unique diameter and wall thickness. Tables for the various pipe sizes list these dimensions. An example is shown in Table 1. Refer to this table when reading the following explanations.

### Nominal Pipe Size

The **diameter** of standard piping is loosely designated by its **Nominal Pipe Size**. The word “nominal” means “only in name.” This means that the actual size of the pipe will be different than the nominal size.



There are two systems used to designate nominal pipe size.

1. The Imperial System uses an “**NPS**” (Nominal Pipe Size) number, which indicates inches. Table 1 lists NPS numbers in the first column, from NPS 1/2 to NPS 30.
2. The equivalent metric system assigns a “**DN**” (**diametre nominal**) number, which indicates millimeters. This is shown in the second column of Table 1.

Nominal pipe size is an approximate indication of pipe diameter. Up to and including NPS 12 (DN 300) pipe, the number represents the **nominal inside diameter** of the pipe. For NPS 14 (DN 350) and larger pipe, the number represents the **actual outside diameter** of the pipe.

Column three of Table 1 shows the corresponding Outside Diameter (in mm) for each size of pipe. In all cases, this number represents the actual outside diameter.

**Note:** The DN numbers do NOT exactly match the outside diameters, as seen in Table 1.

## Wall Thickness

There are two systems used to designate the wall thickness of the different sizes of pipe. An older method lists pipe as Standard (S), Extra strong (XS), or Double extra strong (XXS).

A newer method, that replaced the older method, uses **Schedule Numbers** to designate wall thickness. Starting with the thinnest, these numbers range from Schedule 10 up to Schedule 160. Schedule 40 roughly corresponds to standard (S) thickness, Schedule 80 roughly corresponds to extra strong (XS), and Schedule 160 roughly corresponds to double extra strong (XXS).

It is important to understand that, regardless of the Schedule, for any given nominal pipe size, the outside diameter stays the same. Therefore, the inside diameter will get smaller as the wall thickness increases.

For example, Table 1 shows that for the NPS 6 (DN 150) pipe the outside diameter is 168.28 mm (or 6.63 in). Since the outside diameter never changes, the actual inside diameter can be determined by the formula:

$$d = D - 2t$$

Where

d = inside diameter

t = wall thickness (in the Tables, the upper number in the boxes below each Schedule)

D = outside diameter (see column three)

### Example

For a standard wall thickness, the actual inside diameter of an NPS 6 (DN 150) pipe is:

$$d = 168.28 - (2 \times 7.11) = 154.06 \text{ mm}$$



Table 1 lists the dimensions and the mass per metre in kilograms of different sizes of steel pipe with varying wall thicknesses.

Table 1 – Dimensions and Masses of Steel Pipe														
Nominal Pipe Size NPS (inches)	Metric Designation DN (mm)	Outside Diameter (mm)	SCHEDULE											
			10	20	30	Std. wall.	40	60	Extra Strong	80	100	140	160	Double Extra Strong
1/2	15	21.34	-----	-----	-----	2.77	2.77	-----	3.73	3.73	-----	-----	4.78	7.74
			-----	-----	-----	1.26	1.26	-----	1.61	1.61	-----	-----	1.92	2.53
3/4	20	26.67	-----	-----	-----	2.87	2.87	-----	3.91	3.91	-----	-----	5.56	7.82
			-----	-----	-----	1.67	1.67	-----	2.17	2.17	-----	-----	2.87	3.61
1	25	33.40	-----	-----	-----	3.38	3.38	-----	4.55	4.55	-----	-----	6.35	9.09
			-----	-----	-----	2.48	2.48	-----	3.21	3.21	-----	-----	4.20	5.41
1 1/4	32	42.16	-----	-----	-----	3.56	3.56	-----	4.85	4.85	-----	-----	6.35	9.70
			-----	-----	-----	3.36	3.36	-----	4.43	4.43	-----	-----	5.57	7.70
1 1/2	40	48.26	-----	-----	-----	3.68	3.68	-----	5.08	5.08	-----	-----	7.14	10.15
			-----	-----	-----	4.02	4.02	-----	5.37	5.37	-----	-----	7.18	7.70
2	50	60.33	-----	-----	-----	3.91	3.91	-----	5.54	5.54	-----	-----	8.74	11.07
			-----	-----	-----	5.39	5.39	-----	7.42	7.42	-----	-----	11.00	13.35
2 1/2	65	73.03	-----	-----	-----	5.16	5.16	-----	7.01	7.01	-----	-----	9.53	14.02
			-----	-----	-----	8.56	8.56	-----	11.32	11.32	-----	-----	14.79	20.25
3	80	88.90	-----	-----	-----	5.74	5.74	-----	7.62	7.62	-----	-----	11.13	15.24
			-----	-----	-----	13.46	13.46	-----	15.15	15.15	-----	-----	21.16	27.47
3 1/2	90	101.60	-----	-----	-----	5.74	5.74	-----	8.08	8.08	-----	-----	-----	-----
			-----	-----	-----	13.46	13.46	-----	18.49	18.49	-----	-----	-----	-----
4	100	114.30	-----	-----	-----	6.02	6.02	-----	8.56	8.56	-----	-----	13.49	17.12
			-----	-----	-----	15.95	15.98	-----	22.14	22.14	-----	-----	33.27	40.70
5	125	141.30	-----	-----	-----	6.55	6.55	-----	9.53	9.53	-----	-----	15.88	19.05
			-----	-----	-----	21.61	21.61	-----	30.71	30.71	-----	-----	48.71	56.98
6	150	168.28	-----	-----	-----	7.11	7.11	-----	10.97	12.70	15.09	20.62	23.01	22.23
			-----	-----	-----	28.04	28.04	-----	42.23	64.13	75.18	100.15	110.39	111.47
8	200	219.08	-----	6.35	7.04	8.18	8.18	10.31	12.70	12.70	15.09	20.62	23.01	22.23
			-----	33.05	36.51	42.20	42.20	52.66	64.13	64.13	75.18	100.15	110.39	111.47
10	250	273.05	-----	6.35	7.80	8.18	8.18	10.31	12.70	12.70	15.09	20.62	23.01	22.23
			-----	41.44	36.51	42.20	42.20	52.66	64.13	64.13	75.18	100.15	110.39	111.47
12	300	323.85	-----	6.35	8.38	9.53	10.31	14.27	12.70	17.48	21.44	28.58	33.32	25.40
			-----	49.34	64.69	73.25	79.16	108.13	106.55	130.82	158.44	206.45	236.88	185.57
14	350	355.60	6.35	7.92	9.53	9.53	11.13	15.09	12.70	19.05	23.83	31.75	35.71	-----
			54.26	77.39	92.46	80.65	96.66	125.50	106.55	156.86	193.22	251.59	279.52	-----
16	400	406.40	6.35	7.92	9.53	9.53	12.70	16.66	12.70	21.44	26.19	36.53	40.49	-----
			62.15	77.39	92.49	92.49	122.33	158.89	122.33	201.69	243.62	330.33	362.27	-----
18	450	457.20	6.35	7.92	11.13	9.53	14.27	19.05	12.70	23.83	29.36	39.67	45.24	-----
			70.07	87.25	121.28	104.33	154.82	204.22	138.12	252.37	307.36	405.31	455.98	-----
20	500	508.00	6.35	9.53	12.70	9.53	15.09	20.62	12.70	26.19	32.54	44.45	50.01	-----
			77.93	116.17	153.90	116.17	181.66	245.94	153.90	308.71	378.52	504.15	560.18	-----
24	600	609.60	6.35	9.53	14.27	9.53	17.48	24.61	12.70	30.96	38.89	52.37	59.54	-----
			93.72	139.85	208.10	139.85	252.99	341.33	185.74	438.02	543.02	714.07	800.99	-----
30	750	762.00	7.92	12.70	15.88	<b>9.53</b>	-----	-----	12.70	-----	-----	-----	-----	-----
			117.40	232.83	289.81	<b>175.6</b>	-----	-----	232.83	-----	-----	-----	-----	-----

**Note:** Upper figures are wall thickness in millimetres.

Lower figures are mass per metre in kilograms.



## OBJECTIVE 2

*Describe methods of connection for screwed, flanged, and welded pipe; identify fittings and their markings.*

## METHODS OF CONNECTING PIPE

There are three general methods used to join or connect lengths of pressure piping.

1. Threaded pipe and screwed connections
2. Flanges
3. Welded joints

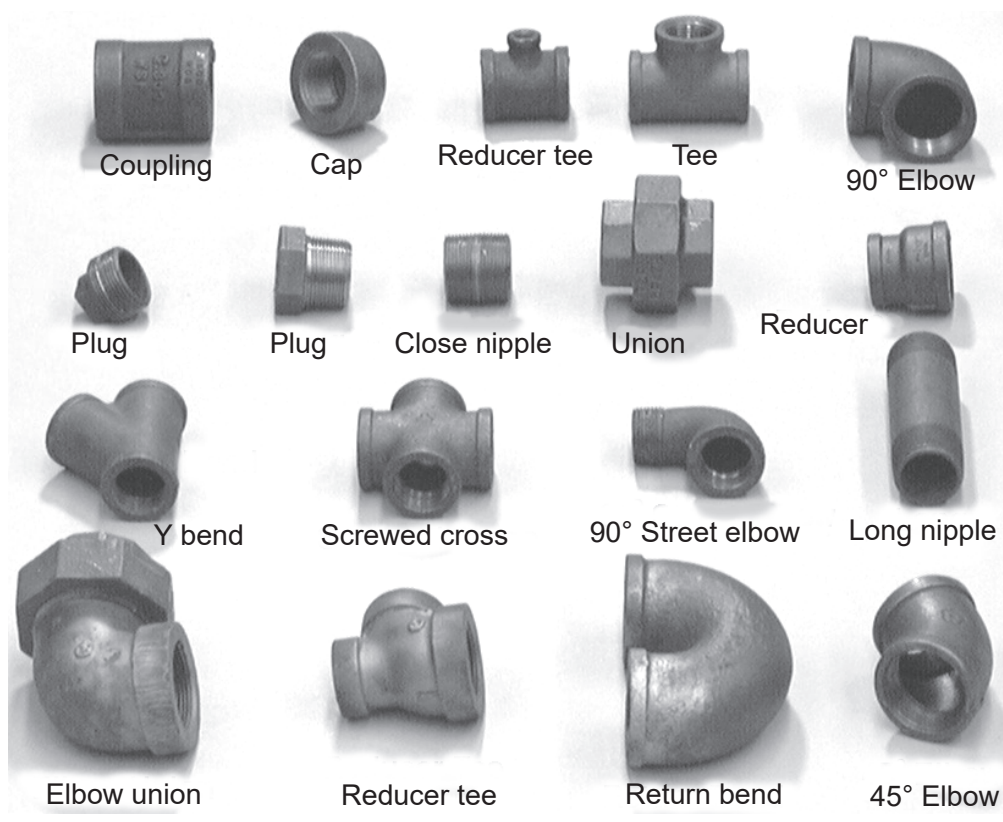
### Screwed Connections

With this method, threads are cut into the pipe at each end, and screwed fittings such as unions, couplings, and elbows are used to join the lengths. This method is generally used for pipe sizes less than DN 50 (NPS 2) for low and moderate pressures.

The advantage of this method is that the piping can be easily assembled or disassembled. However, the threaded connections are subject to leakage and the strength of the pipe is reduced when threads are cut in the pipe wall.

Figure 1 illustrates various screwed fittings that may be used when fabricating a pipe system.

**Figure 1 – Threaded Pipe Fittings**



**Figure 2 – Threaded Bushing**

**Bushing**

The purpose of the fittings illustrated in Figures 1 and 2 are as follows:

**Elbows** - for making angle turns in piping.

**Nipples** - for making close connections. They are threaded at both ends. A “close” nipple is threaded for almost its entire length.

**Couplings** - for connecting two pieces of pipe of the same size in a straight line.

**Unions** - for providing an easy method for dismantling piping. A union is made of two pieces that are joined together by a large nut, which is equipped with wrenching flats.

**Tees** and **Crosses** - for making branch line connections at 90°.

**Y-bends** - for making branch line connections at 45°.

**Return Bends** - for reversing direction of a pipe run.

**Plugs** and **Caps** – for closing off open pipe ends or fittings. Plugs have male (external) threads and caps have female (internal) threads.

**Bushings** - The male end fits into a coupling, tee or elbow fitting. The smaller pipe is then screwed into the female end. The smaller connection may be tapped eccentrically to permit free drainage of water.

**Reducers** - for reducing pipe size. Reducers have two female connections into which the different sized pipes fit. They may also be made with one connection eccentric to facilitate drainage of water.

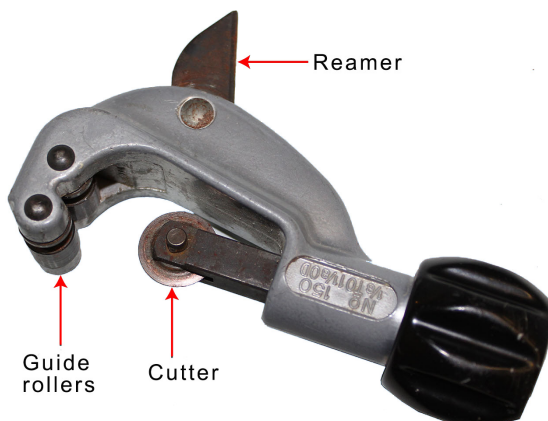


## Pipe Cutting and Threading

When making up a piping system with screwed connections, it is necessary to cut the pipe into the required lengths. Then, thread the ends onto which the fittings will be screwed.

The pipe is supplied from the manufacturer in standard lengths. It may be cut to the required length by means of a **displacement cutter**. The type of cutter usually employed for small piping sizes consists of a cutting wheel and adjustable guiding rollers, as illustrated in Figure 3.

**Figure 3 – Displacement Cutter**



When pipe is cut with a wheel and roller cutter, a burr is left on the inside of the pipe and a shoulder is formed on the outside of the pipe. The external shoulder can be removed by filing. The internal burr is removed with a special tool known as a **pipe reamer**, which is illustrated in Figure 4.

**Figure 4 – Pipe Reamer**

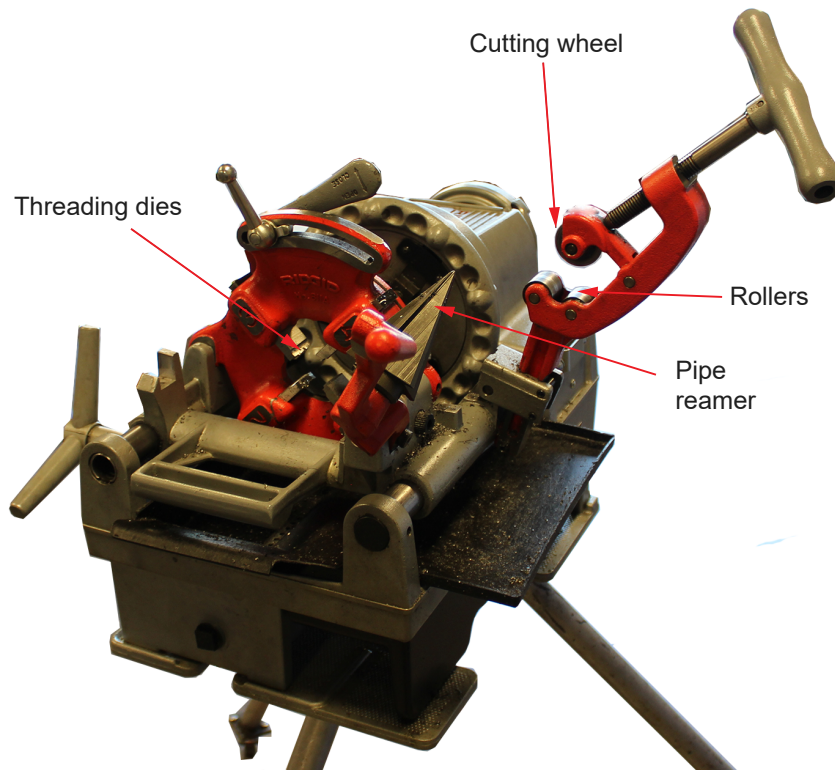


It is extremely important that the internal burr be removed completely. Otherwise, it will tend to catch foreign material passing through the pipe, and forming an obstruction.

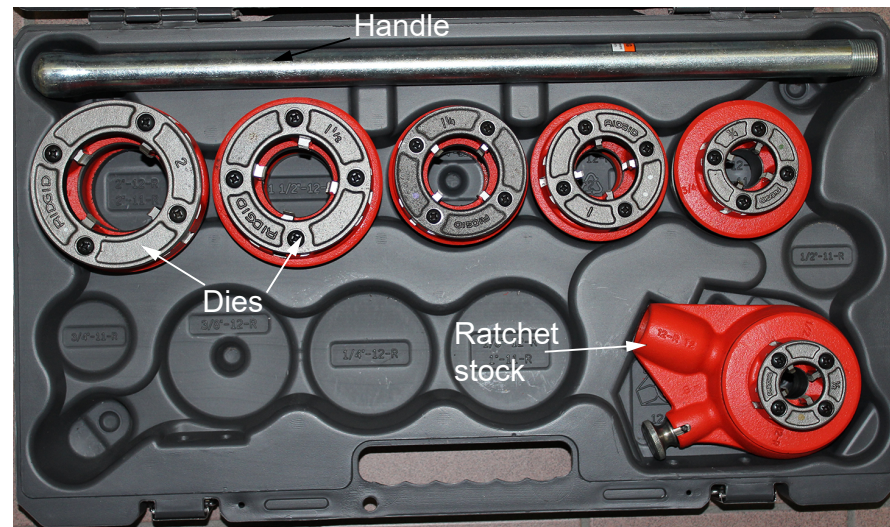
After the pipe has been cut to the proper length, reamed, and the external shoulder removed, the threads are cut onto the pipe ends. Male threads are cut with a set of cutters, known as dies, which are held in a frame, called a stock. These may be moved around the pipe by a hand-driven ratchet lever or by a power driven machine, which turns the pipe while the dies are held stationary. Female threads are cut by a cutter called a **tap**.

A threading machine is shown Figure 5. Ratchet [pipe dies](#) are shown in Figure 6.

**Figure 5 – Power Driven Threading Machine**



**Figure 6 – Ratchet Pipe Dies**



## Flanged Connections

This method uses flanges, which are bolted together face to face, usually with a gasket between the two faces. The advantage of [flanged connections](#) over welded connections is that they permit disassembly. Flanged connections are also more convenient to assemble and disassemble than screwed connections.



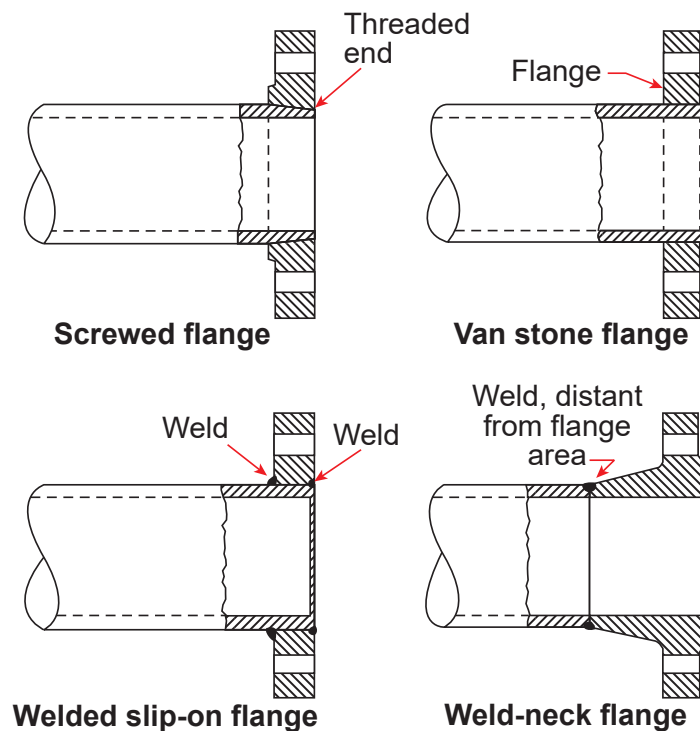
There are three general types of pipe flanges used. They are classified according to how they attach to the pipe. These types of flanges are illustrated in Figure 7.

- Screwed
- Welded
- Loose or lapped Van Stone flange

Note that two types of welded flanges are shown: the slip-on weld and the weld-neck. In the weld-neck type, the hub of the flange is **butt welded** to the pipe, whereas the slip-on flange is attached by two fillet welds.

**Van Stone flanges** are used in piping systems constructed from stainless steel or other costly materials. In the Van Stone type, the flange fits loosely on the pipe. The pipe end is lapped over and faced off as shown in Figure 7. The pipe to be connected is similarly lapped and has a loose companion flange. A gasket is used between the two lapped faces of the pipes.

**Figure 7 – Pipe Flange Types**



To prevent leakage at flanged connections, the flange faces, which butt together, need to be absolutely flat and smooth. While it is theoretically possible to grind the faces to this condition, it is a time consuming and expensive proposition. Therefore, gaskets are usually used between flange faces. Gaskets are made of a soft material. When the flanged connection is tightened, the gasket will fill any small depressions in the flange faces, and prevent leakage.

Gaskets are made in three general designs.

1. The **full-face gasket** covers the entire face of the flange and has holes provided for the flange bolts. This is primarily a low-pressure type of gasket. It is used for joining cast iron and steel flanges.
2. The **flat ring gasket** covers only the flange face, between the flange's bolt holes.
3. The **ring joint gasket** is an oval ring, which fits in grooves that are machined in ring joint flanges. Ring joint gaskets are generally used for high pressure and special services.

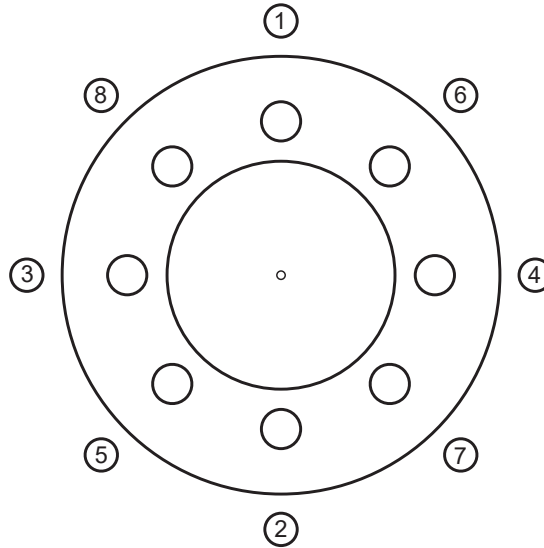




When assembling a flanged joint, it is important that the flange and gasket surfaces be clean and free from any foreign particles. The flanges must be carefully aligned so that the flange faces fit together properly. The bolt threads should be lubricated and the nuts screwed on by hand as far as possible.

When pulling up with a wrench, the bolts should not be tightened in rotation, but the cross over method should be used. With this method, opposite bolts around the flange are tightened gradually and evenly. A suitable sequence for bolt tightening is shown in Figure 8.

**Figure 8 – Bolt Tightening Sequence**



### Welded Connections

In this method, the pipe lengths are either welded directly to one another or to any valves or fittings that may be required. The use of these welded joints for piping has several advantages over screwed or flanged connections:

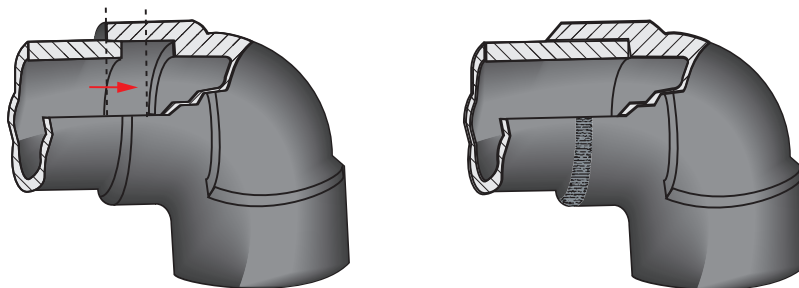
1. The possibility of leakage is eliminated, due to the absence of screwed or flanged joints.
2. The weight of the piping system is reduced due to the elimination of heavy flanges and fittings.
3. The cost of material and the need for maintenance are reduced due to the absence of flanges and fittings.
4. The piping looks neater and is easier to insulate because there are no bulky flanges and fittings.
5. Welded joints give more flexibility to the piping design as the pipes may be joined at practically any angle to each other.

The main disadvantage of using welded joints for piping is that a skilled welder must be obtained whenever a connection is to be made.



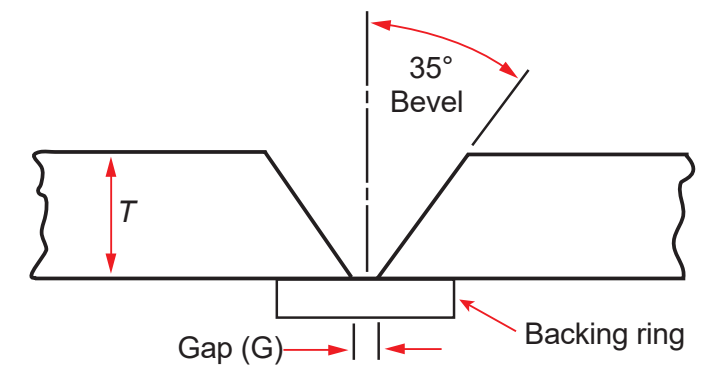
When piping of DN 50 (2 in. NPS) and smaller is welded, it is usually **socket welded**. The couplings, valves, and other fittings have a recessed portion into which the pipe fits. The weld is made around the socket edge. This method is illustrated in Figure 9.

**Figure 9 – Socket Welding Elbows**



For larger sizes of pipe, the pipe ends are either butt-welded together, or butt-welded to valves or fittings. When this method is used, the edges of the pipes or fittings are beveled to form a groove for depositing the weld metal. Backing or back up rings, which fit inside the pipe at the weld, may be used for lining up the pipe, and to prevent weld metal from protruding inside the pipe. This method is shown in Figure 10.

**Figure 10 – Butt Weld Groove with Backing Ring**



## IDENTIFICATION OF FITTINGS

Valves, fittings, flanges, and unions must be clearly marked or identified. This helps to ensure that they are of the proper strength and material for the particular service for which they are used.

**ALL FITTINGS NOT PROPERLY OR CLEARLY IDENTIFIED SHOULD BE REJECTED.**

All markings must be legible. They must indicate the following minimum requirements.

1. The manufacturer's name or trademark.
2. Service designation, such as pressure-temperature rating for which the fitting is designated.
3. ASTM (American Society for Testing and Materials) number and Grade number.

The above markings are listed according to the degree of importance. However, for cast and ductile iron fittings, (2) and (3) will be in the reverse order, since the material identification is more important than the service designation.



**Table 2 – Service Symbols**

Symbol	Reference
A	Air
G	Gaseous
L	Liquid
O	Oil
S	Steam
W	Water

**Table 3 – Material Markings Symbols or Identification System**

Material Marking	Abbreviated Symbol or Identification System
Malleable Iron	MI
Cast Iron	Not required for gray cast iron
Ductile (Nodular) Cast Iron	Ductile or DI
Carbon Steel	Steel or ASTM Specification No. and Grade
Alloy Steel	Grade Identification Symbol and Steel ASTM No.



## OBJECTIVE 3

*Describe methods and devices used to allow for pipe expansion and support.*

## PIPING EXPANSION

As piping is heated, it will expand in length. Unless this is allowed for in the design of a piping system, it will cause additional stress in the piping. The following are methods used to provide for expansion in pipelines.

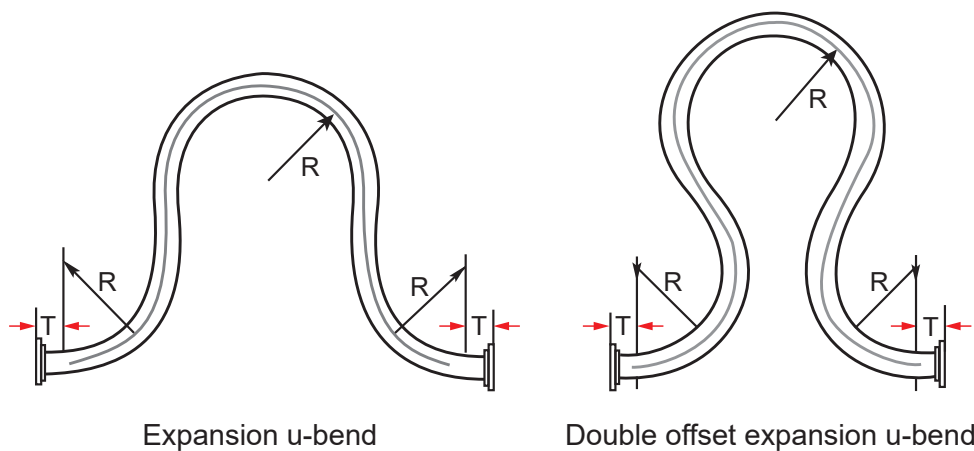
- [Expansion bends](#)
- [Expansion joint](#)

### Expansion Bends

Expansion bends make use of pipe fabricated with special bends. The increase in the length of pipe due to expansion is taken up by the flexing or springing of these bends. Figure 11 illustrates some typical shapes of expansion bends.

The use of expansion bends is usually preferred for high-pressure work, as there is no maintenance involved and there is little likelihood of leaks developing. However, expansion bends require more room than expansion joints.

**Figure 11 – Expansion Bends**



### Expansion Joints

Two types of expansion joints in general use are the:

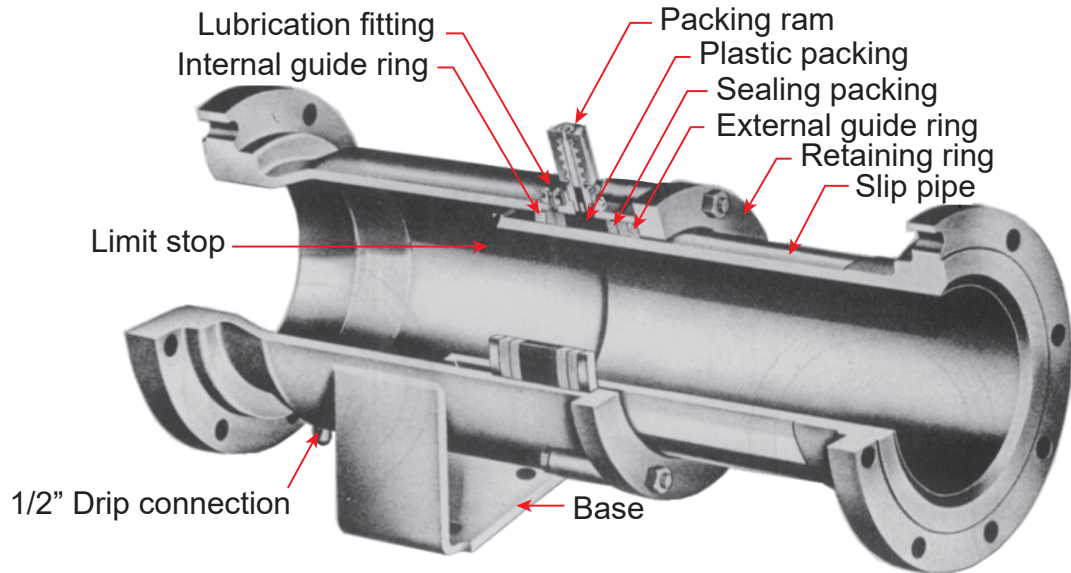
- Slip
- Corrugated

## Slip Expansion Joint

This type, which is illustrated in Figure 12, features a slip pipe with a flange bolted to an adjoining pipe. The slip pipe fits into the main body of the joint, which is fastened to the end of the other adjoining pipe.

When the pipe line expands, the slip pipe moves within the joint body. To prevent leakage between the slip pipe and the joint body, semi-plastic packing is used around the outside of the slip pipe. The slip pipe moves within the packing. Additional plastic packing may be added while the joint is in service by means of a packing ram. Grease fittings are used to provide lubrication.

**Figure 12 – Slip Expansion Joint**



(a)



(b)

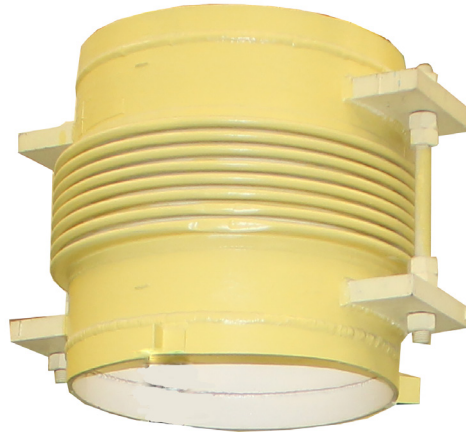


## Corrugated Expansion Joint

A corrugated expansion joint consists of a flexible corrugated section, which is able to absorb a certain amount of endwise movement of the pipe.

The bellows type corrugated expansion joint, shown in Figure 13, is suitable for pressures up to 2000 kPa.

**Figure 13 – Bellows Type Corrugated Expansion Joint**



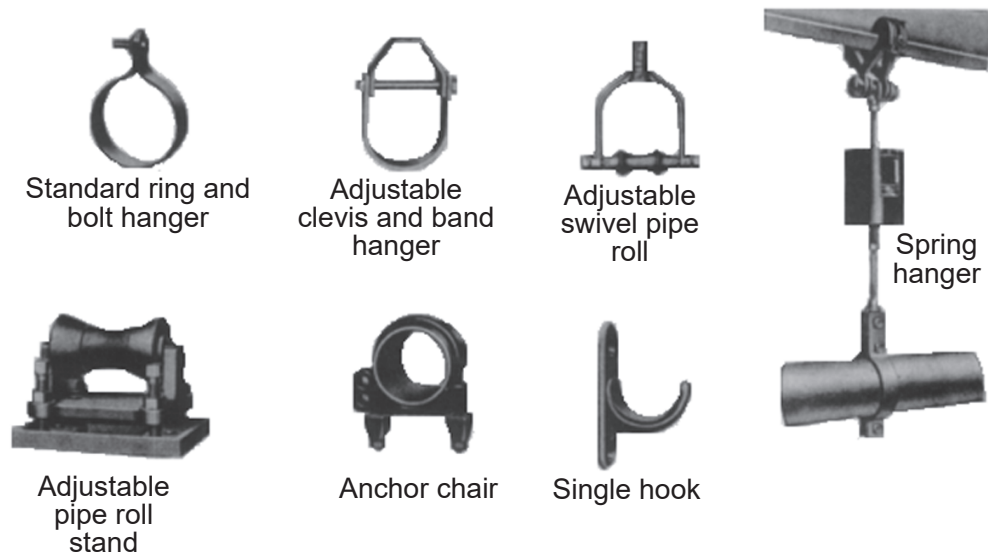
## Piping Supports

Piping must be supported to prevent its weight from being carried by the equipment to which it is attached. The supports must prevent excessive sagging of the pipe and, at the same time, must allow free movement of the pipe due to expansion or contraction. The supporting arrangement must be designed to carry the weight of the pipe, valves, fittings, and insulation plus the weight of the fluid contained within the pipe.

A steam pipe is typically anchored to a fixed surface at one end, using a pipe anchor, and allowed to expand its entire length toward an expansion joint.

Figure 14 illustrates various types of pipe supports and hangers.

**Figure 14 – Pipe Supports and Hangers**



*(Courtesy of Crane Limited)*

A pipe hanger or support at 3 metre intervals is used as a general guideline for ordinary installations. Hangers and supports should be placed close to valves and other heavy piping components.



## OBJECTIVE 4

*Explain the methods used to promote good drainage of steam pipes, including the installation and maintenance of steam traps, to reduce the effects of water hammer.*

## PIPING DRAINAGE

In the case of steam piping, it is necessary to constantly drain condensate from the lines. If this is not done, the condensate will be carried along with the steam, causing **water hammer** and possible rupture of pipes or fittings. In addition, the admission of moisture-carrying steam to turbines or engines is most undesirable. The following devices are used to remove condensate and moisture from steam lines.

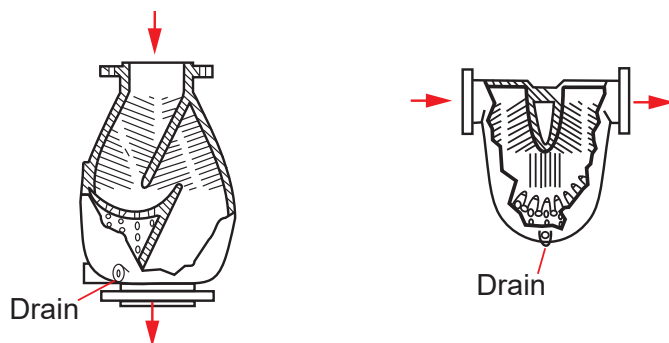
- [Steam separators](#)
- [Steam traps](#)

### Steam Separators

Steam separators (sometimes called steam purifiers) installed in the steam line, will remove moisture droplets and other suspended impurities from the steam. The separator either causes the steam to suddenly change its direction of flow, or it imparts a whirling motion to the steam. Both of these cause the moisture and other particles to drop out of the steam.

The separators (Figure 15) use baffles to cause the steam flow to suddenly change direction. The moisture particles removed collect at the bottom and pass out through a drain opening.

**Figure 15 – Baffle Type Steam Separators**





## Steam Traps

The purpose of the steam trap is to discharge the condensed water from steam lines, separators and other equipment, without allowing steam to escape. Most traps are also designed to discharge air from the lines or equipment.

Steam traps should be installed where condensate accumulates. Condensate must be drained as rapidly as it accumulates, to prevent water hammer. The condensate must be recovered for heating, hot water needs, or for return to boilers. Steam traps are a “must” for steam piping, separators, and all steam heated or steam operated equipment.

There are numerous trap designs, which can be classified into three types, according to their principles of operation.

- [Mechanical Trap](#)
- [Thermostatic Trap](#)
- [Thermodynamic Trap](#)

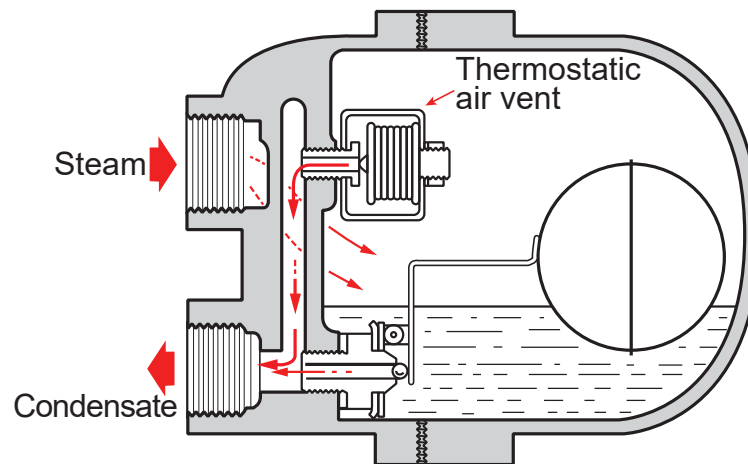
### Mechanical Traps

In the mechanical trap design, either a ball or bucket float is used. It opens and closes the trap outlet valve, depending upon whether condensate is present within the trap body.

The ball float trap (Figure 16) has a hollow float. As the condensate enters, the float rises and opens the outlet valve. Then, as the condensate is discharged, the float sinks and closes the outlet valve.

This trap also features a bellows controlled air vent located near the top of the trap. If steam surrounds the bellows, the bellows expands and closes the vent outlet. However, if air (which is cooler than steam) surrounds the bellows, the bellows contracts and opens the vent, allowing air to escape.

**Figure 16 – Float Trap with Thermostatic Air Vent**

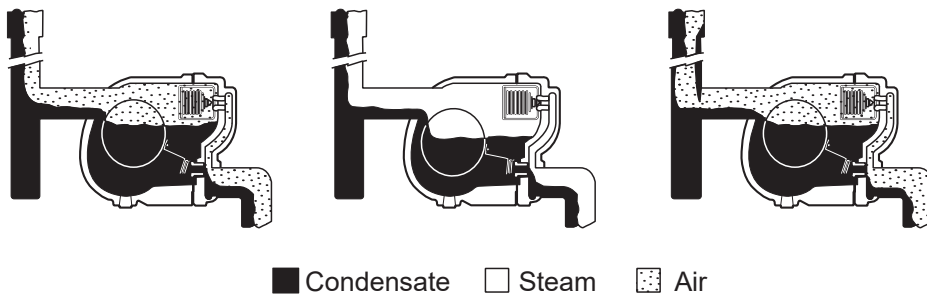


*(Courtesy of Spirax Sarco Limited)*



Figure 17 illustrates the operation of a similar type of float trap.

**Figure 17 – Float Trap Operation**



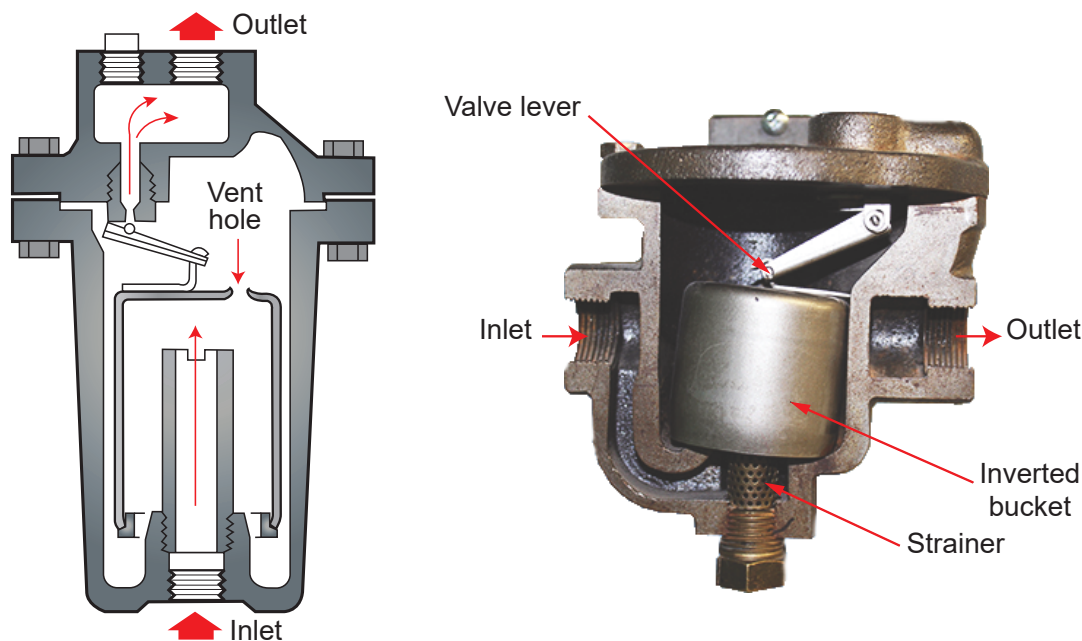
(Courtesy of Armstrong International, Inc.)

The float trap works equally well whether the condensate load is light or heavy. Its operation is not affected by changes in steam pressure. It does not become air-locked upon start-up when there is a large amount of air present, as it will discharge this air immediately and automatically.

However, the ball float trap has the disadvantage of being vulnerable to damage from water hammer. In addition, this type of trap is not suited for outdoor use. The condensate may freeze in cold weather, which will damage the float.

Another common mechanical trap is the inverted bucket trap, also called an inverted open float trap. Two styles are shown in Figure 18.

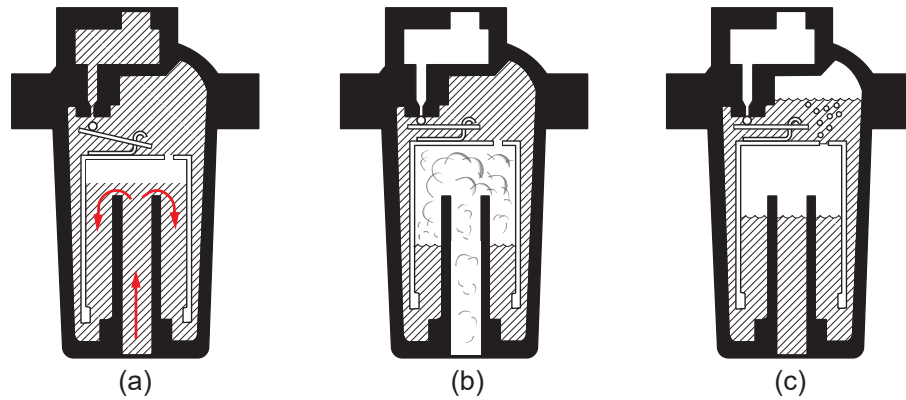
**Figure 18 – Inverted Bucket Trap**



The operating principle is the same for both styles. The bucket initially hangs down and holds the discharge valve open. Condensate enters the trap and flows under the bottom edge of the bucket to fill the trap body. Then the condensate flows through the open discharge valve at the outlet.

Any steam that enters the trap will collect at the top of the inverted bucket giving it buoyancy and causing it to rise, thus closing the discharge valve. Air and CO<sub>2</sub> gas also collect at the top of the inverted bucket and pass through the vent at the top of the bucket to the upper part of the trap body. Air and CO<sub>2</sub> are then expelled from the steam trap along with the discharging condensate. Figure 19 illustrates the operation of an inverted bucket steam trap.

**Figure 19 – Operation of an Inverted Bucket Steam Trap**



(Courtesy of Spirax Sarco Limited)

### Thermostatic Traps

The operation of thermostatic traps depends upon the difference in temperature between steam and condensate. These traps are commonly used on radiators in steam heating systems, hence they are also known as radiator traps. Figure 20 shows the construction of a bellows type (radiator) steam trap.

As the steam in the radiator gives up its heat to the room, it condenses to water. This water must be removed from the radiator as fast as it is formed. The radiator trap is a device that allows the condensed steam or water to be discharged from the radiator, but prevents any steam from discharging.

Essentially, the trap consists of a corrugated bellows or flat hollow disc, with a valve-shaped plunger attached to it. The bellows contains a volatile fluid, which boils by the heat from the steam that surrounds the bellows.

**Figure 20 – Thermostatic Steam Trap**

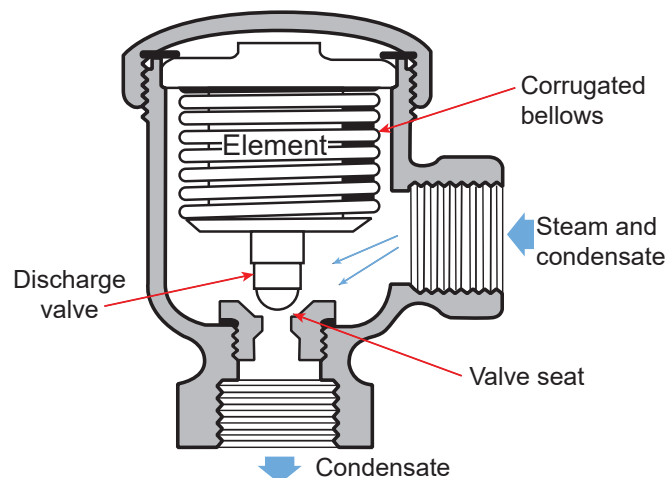
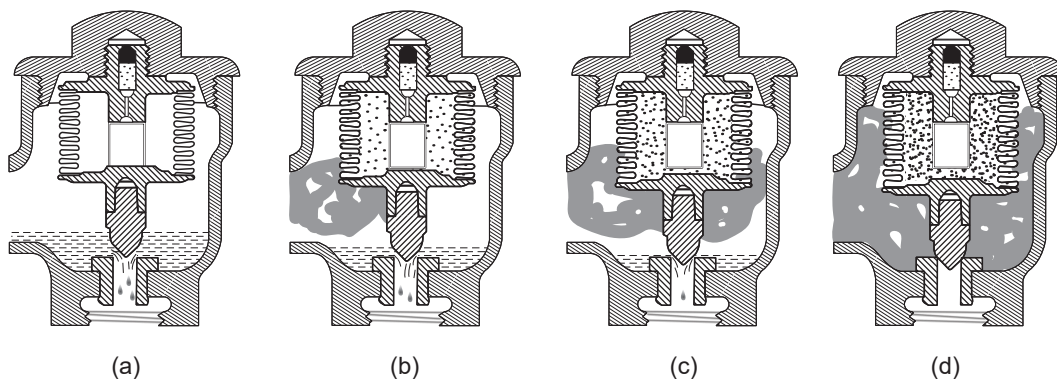




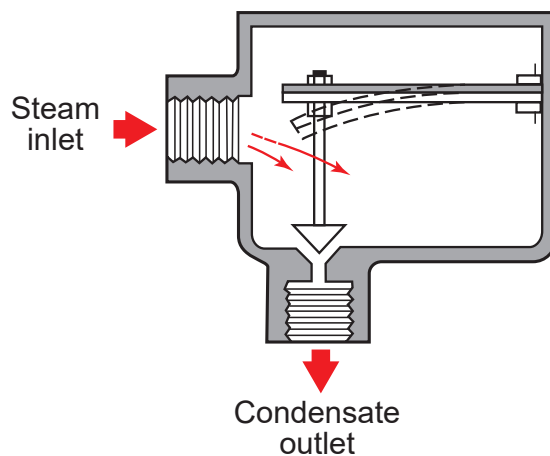
Figure 21 illustrates the operation sequence of a bellows type trap. In Figure 21(a), only condensate is being discharged from the heating unit. The trap is wide open, so condensate flows freely. As steam enters the trap, Figure 21(b), pressure within the bellows increases and causes it to expand. In Figure 21(c), most of the condensate is drained from the heating unit. When steam completely surrounds the bellows, as in Figure 21(d), the pressure inside the bellows forces the plunger to seat securely onto the discharge port.

**Figure 21 – Operation of a Radiator Trap**



Another type of thermostatic trap is the bimetal steam trap shown in Figure 22. This design consists of bimetal strips (dissimilar metals welded together), which deflect when heated. As condensate fills the trap, its temperature decreases. In response, the bimetal strip straightens, opening the valve and allowing condensate to flow through the trap. However, when the trap fills with steam, the bimetal strip heats up and deflects downward to fully close the valve, keeping steam from passing to the condensate line.

**Figure 22 – Bimetal Steam Trap in the Open Position**

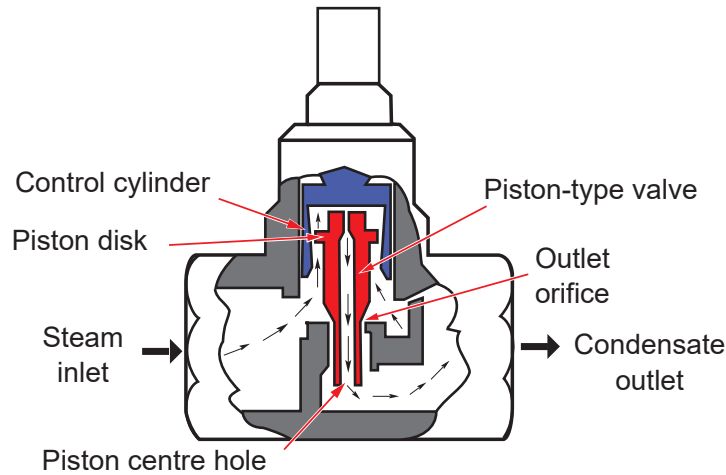


(Courtesy of Spirax Sarco Limited)

## Thermodynamic Traps

This type of trap employs the difference between the heat energy in the steam and condensate to control its operation. One design of thermodynamic trap is the impulse trap, shown in Figure 23.

**Figure 23 – Impulse Trap**



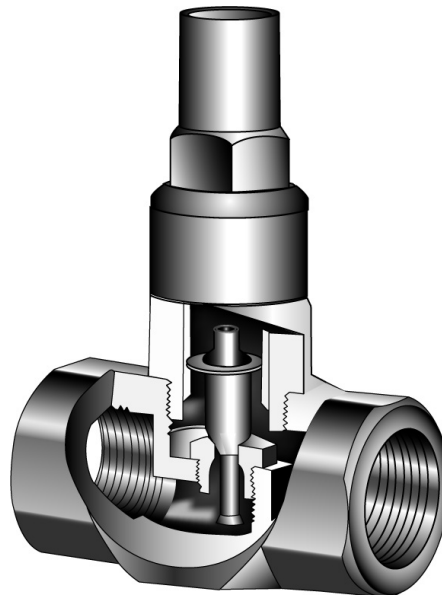
This design consists of a piston type valve working within a control cylinder. When cool condensate enters the trap, the pressure of the condensate, acting upon the piston disk, will lift the valve to the open position. This allows the condensate to escape through the outlet orifice.

However, a portion of the condensate, instead of escaping through the outlet orifice, passes up past the piston disk into the upper part of the control cylinder. Then the condensate goes down through a small hole drilled through the centre of the piston valve to the outlet.

If the condensate entering the trap is at its saturation temperature, the condensate entering the upper section of the control cylinder flashes into steam. This is because the control cylinder is at lower pressure (outlet pressure). The large volume of steam resulting will plug or choke the small hole through the centre of the valve. The pressure will build up above the piston disk, and force the valve into the shut position.

Figure 24 is a cutaway view of the impulse trap.

**Figure 24 – Impulse Trap Cutaway View**

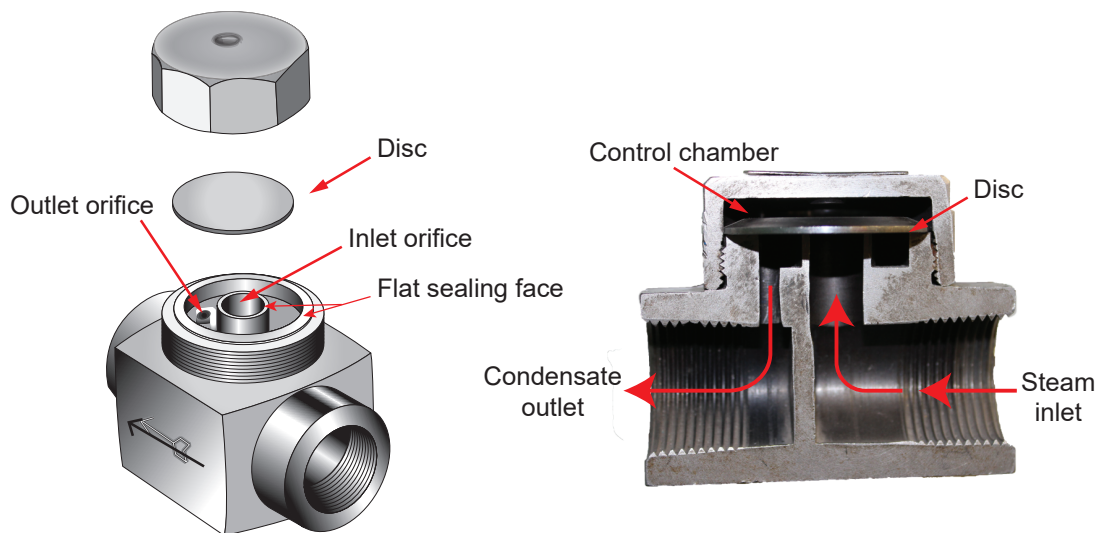




Another design of thermodynamic trap is the disc type (Figure 25).

In this type, the condensate entering the trap raises the disc and flows under it to the discharge. When steam enters the trap, the steam expands and travels at high velocity across the underside of the disc. Some of the steam also passes up to the small space above the disc. The steam, passing at high velocity under the disc, causes a pressure reduction in that area. The steam above the disc, being at higher pressure, forces the disc down, and closes off the outlet of the trap.

**Figure 25 – Disc Trap**



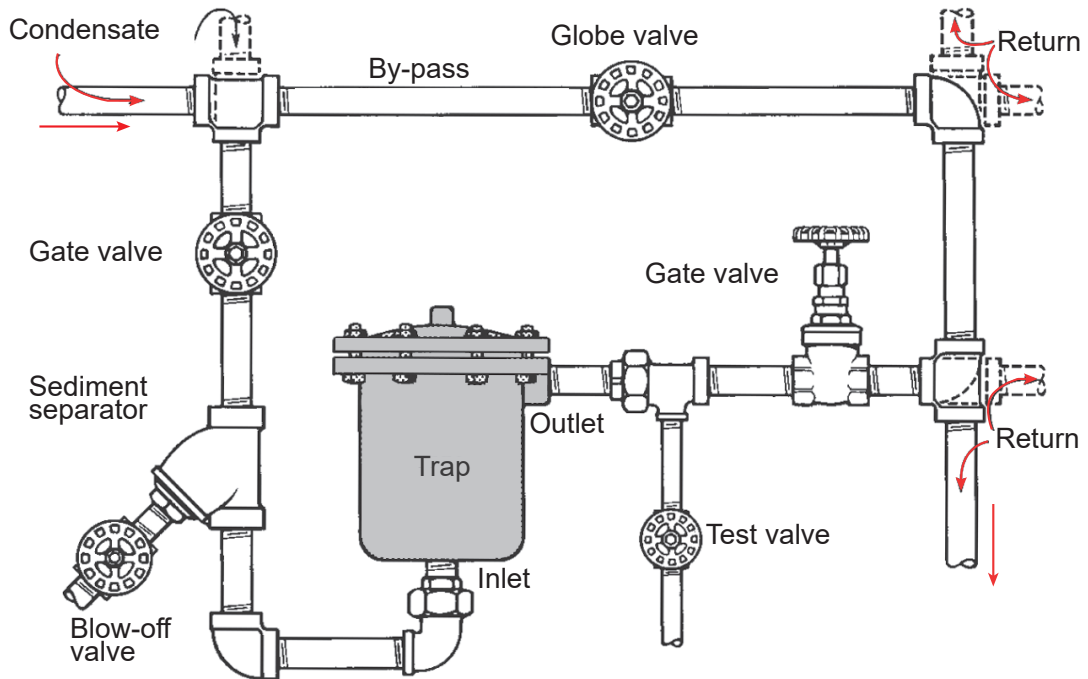
## Trap Installation

New piping systems must be blown clear of all foreign matter before trap installation. The trap is installed below the lowest point in the system, with the line leading to the trap pitched downward to assure good drainage. A sediment separator is always installed just ahead of the trap to prevent the entry of foreign matter. Inlet and outlet gate valves permit isolating the trap for inspection and cleaning. Unions are provided so the trap may be removed for repair or replacement. A bypass line with a globe valve makes it possible to rid the system of condensate by hand throttling while the trap is out of service.

Figure 26 shows the piping arrangement. To put the trap into operation:

1. Close the valve in the outlet line.
2. Open the inlet valve, and allow condensate to fill the trap.
3. When the trap is filled, open the outlet valve.

**Figure 26 – Typical Piping Arrangement for Inverted Open Float Steam Trap**



(Courtesy of Crane Limited)

## Trap Inspection and Servicing

Frequency of inspection depends on the condition of the line. To isolate the trap for inspection, close the inlet and outlet gate valves and open the sediment blowoff or the test valve to relieve the pressure. Lockout and tagout procedures must be followed. Inspection or repairs can be made while the trap is in the line, or the trap can be removed from the line easily by loosening the unions.

On a regular basis, the sediment separator should be blown clean, by using the blow-off valve. The proper operation of the trap can be determined by opening the test valve and closing the outlet gate valve.

### CAUTION

The test valve will discharge high temperature condensate and steam! **DO NOT** open the test valve unless suitable safe work procedures are followed and correct personal protective equipment is used.

A correctly functioning thermodynamic or inverted bucket trap will intermittently discharge condensate, with some flash steam evident. Float-style traps will have a steady discharge of condensate with some flash steam. If the trap discharges only steam, or if the trap does not discharge anything at all, the trap is defective and needs repair or replacement.



## WATER HAMMER

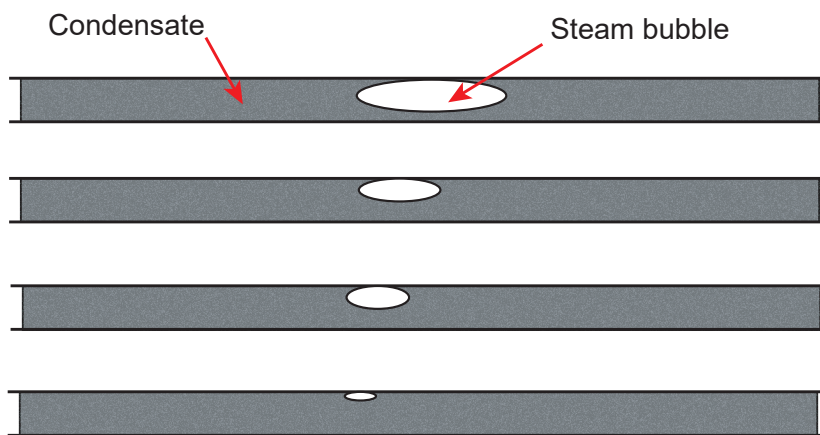
Water hammer is the term used to describe a series of loud, violent shocks, produced within the piping of a steam system. These shocks have the potential to severely damage piping and fittings.

One situation that produces water hammer is when a motor driven centrifugal pump suddenly stops, due to a power interruption or other pump “trip.” When this happens, the water in the pump discharge line will stop and reverse direction. Subsequent rapid closing of the check valve at the pump will cause water hammer.

A more dangerous form of water hammer occurs due to the interaction of condensate and steam inside a pipe. When steam is introduced into a cold pipe, or when flow in a steam pipe is very slow and normal cooling occurs, the steam reverts to water, and forms condensate. If the condensate can be removed from the pipe as fast as it forms, there should be no water hammer. However, drains are not always located everywhere condensate collects.

Tests have been conducted in transparent piping. Observations indicate that water hammer occurs when a bubble of steam has become enclosed by cooler condensate. Steam in the bubble transfers heat to the surrounding water and then reverts to condensate. This rapid condensation leaves a low pressure void and condensate rushes in to fill the void. In other words, the steam bubble implodes. The result is that the inrushing water from one side of the bubble is met by inrushing water from the opposite side of the bubble. This causes a bang, or shock wave, generated by a collision of the masses. Figure 27 illustrates the progressive collapse of a steam bubble.

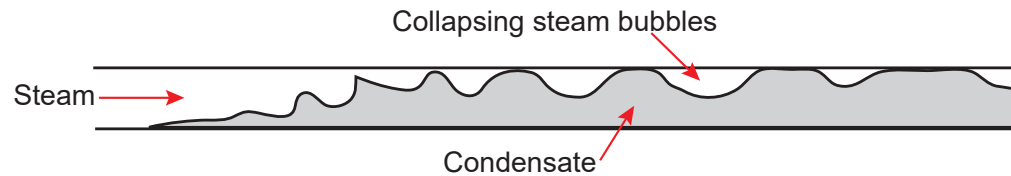
**Figure 27 – Collapsing Steam Bubble**



*(Courtesy of Crane Limited)*

Water hammer may also be produced if steam is admitted too quickly into a pipe containing water or condensate. When this happens, steam forms a pocket that blocks the flow of condensate. Contact with the condensate causes the steam to condense, forming a vacuum in the place from the pocket of steam used to be. Condensate rushes to fill this vacuum. Once the vacuum is filled, rushing condensate is forced backwards and against the walls of the pipe. This forceful movement of condensate causes shockwaves that are heard as water hammer. These shockwaves are forceful enough to rupture piping or fittings.

Higher steam pressures applied to the system serve to increase the pressure differential. This drives the water into the collapsing void with greater ferocity. Shattered pipe fittings, broken mains, or damaged equipment are visible evidence of the violent results of uncontrolled water hammer.

**Figure 28 – Steam Overruns Condensate**


(Courtesy of Crane Limited)

In Figure 28, steam entering from the left overruns the cold condensate. The steam will displace any air above the condensate. That way, if a bubble collapses, no air remains in the collapsing bubble to cushion the impact. As the velocity of the steam increases, it causes ripples to form on top of the water.

These ripples come in contact with the top of the pipe and form multiple steam pockets. This produces multiple shock waves. In small piping, such as in a steam heating radiator, repeated banging is common. When the thermostat calls for steam to be admitted to the radiator, intense banging may begin. As steam progresses through the radiator, residual condensate is warmed and the banging becomes less violent.

### Case Study

These are excerpts of an incident shared by a Power Engineer on shift, in a large high-pressure steam plant, who witnessed the devastating effects of water hammer.

*“There was an explosion at the plant. The body of a six-inch non-return valve was blown apart under 1000 kPa steam pressure. The final report says it was water hammer. No one was injured, but the insulation from a large part of the steam line was sprayed everywhere and was found to be 90% asbestos. The cleanup is expected to take about three months and another month of work before the plant is operational again.”*

*“The inspector condemned the boilers plus the main header until all affected piping has had non-destructive tests. The explosion instantly filled the boiler room with steam so thick you couldn’t see more than eight inches in front of you. The condensing steam was falling so thick that it was like a heavy thunderstorm, complete with thunder from the ruined valve and lightning from the popping lights and transformers.”*

**Therefore, it must be stressed that before admitting steam to any piping system, all water or condensate must be removed from all parts of the system.** Traps which are fitted to main lines, branch lines, and separators for drainage purposes, must have bypass lines around them. Trap bypasses may also be opened at any time to ensure positive drainage (Figure 26).



## OBJECTIVE 5

*Explain the requirements, materials, and methods for insulating pipe.*

### PIPING INSULATION

Most power plant piping systems are used to convey substances that are at temperatures much higher than that of the surrounding air. Examples include the main steam and feedwater piping.

To reduce the amount of heat lost to the surrounding air from the hot substance, the piping is covered with insulation. The insulation not only retains the heat in the hot lines, but also prevents the temperature inside the power plant building from becoming uncomfortably high. In addition, insulation of hot pipe lines will prevent injury to personnel due to contact with the bare surfaces of the pipe.

Pipes carrying substances at a lower temperature than that of the surrounding air (e.g. refrigeration and cryogenic systems) should be insulated to prevent them from sweating. This will also prevent any consequent dripping and corrosion.

A material that is suitable for use as insulation should have the following characteristics:

- High insulating value
- Long life
- Vermin proof
- Non-corrosive
- Ability to retain its shape and insulating value when wet
- Ease of application and installation

An insulating material may be defined as one that transmits heat poorly. Substances with a large number of microscopic air pockets within the material make the most efficient insulators. The extremely small air spaces restrict the formation of convection currents. Air is a poor conductor of heat, but a very good transmitter of heat through convection.

### Piping Insulation Materials

Some of the more common materials used for pipe insulation are:

- Calcium silicate
- Glass fibre
- Mineral fibre
- Expanded silica
- Elastomeric
- Foamed plastic
- Refractory fibre
- Insulating cement
- Magnesia (85%)
- Reflective metal insulation

### Calcium Silicate

Calcium silicate is a granular insulation made of lime and silica, reinforced with organic and inorganic fibres, and molded into rigid forms. Service temperature range is 38°C to 650°C. Its flexibility is good. Calcium silicate is water absorbent, but it can be dried out without deterioration. The material is non-combustible and is used primarily on hot piping and surfaces.

### Glass Fibre

Glass fibre is glass that has been processed into fibres. It is then formed into pipe covering sections, which are suitable for temperatures up to 454°C. It is non-combustible, but is water absorbent.

### Mineral Fibre (Rock and Slag Wool)

Rock and/or slag fibres are bonded together with a heat resistant binder to produce mineral fibre or wool available in loose blanket, board, pipe insulation, and molded shapes. Its useful upper temperature limit approaches 1040°C. The material has a practically neutral pH, is non-combustible, and has good sound control qualities.

### Expanded Silica or Perlite

Perlite is made from an inert siliceous volcanic rock, combined with water. Heating, which causes the water to vaporize and its volume to expand, expands the rock. This creates a cellular structure of minute air cells surrounded by vitrified product. Added binders resist moisture penetration and inorganic fibres reinforce the structure. The material has low shrinkage and high resistance to corrosion. Perlite is non-combustible and operates in the intermediate and high temperature ranges. The product is available in rigid pre-formed shapes and blocks.

### Elastomeric

Foamed resins, combined with elastomers, produce a flexible cellular material. It is available in pre-formed shapes and sheets. Elastomeric insulations possess good cutting characteristics and low water and vapour permeability. The upper temperature limit is 125°C. Elastomeric insulation is cost efficient for low temperature applications with no jacketing required. Resiliency is high. Consideration should be made for the fire retardant ability of the material.

### Foamed Plastic

Insulation produced from foaming plastic resins creates predominately closed-cellular rigid materials. Foamed plastics are lightweight with excellent moisture resistance and cutting characteristics. The chemical content varies with each manufacturer. It is available in pre-formed shapes and boards. Foamed plastics are generally used in the low and lower intermediate service temperature range, 150°C to 183°C. Consideration should be made for the fire retardant property of the material.

### Refractory Fibre

Refractory fibre insulations are mineral or ceramic fibres, including alumina and silica, bound with extremely high temperature binders. The material is manufactured in blanket or rigid form. Thermal shock resistance is high. Temperature limits reach 1650°C. The material is non-combustible.

### Insulating Cement

Insulating and finishing cements are a mixture of various insulating fibres and binders. They are combined with water and cement to form a soft plastic mass for application on irregular surfaces. Insulation values are moderate. Cements may be applied to high temperature surfaces. Temperature limits reach 1038°C. Finishing cements, or one-coat cements, are used in the lower intermediate range and as a finish to other insulation applications.



## Magnesia (85%)

This material is composed mainly of magnesium carbonate. It is available in molded form for pipe covering. It is also supplied in powdered form to be mixed with water to make an insulating cement, which is used to cover pipe fittings. Magnesia pipe covering is suitable for service up to 320°C.

## Reflective Metal Insulation

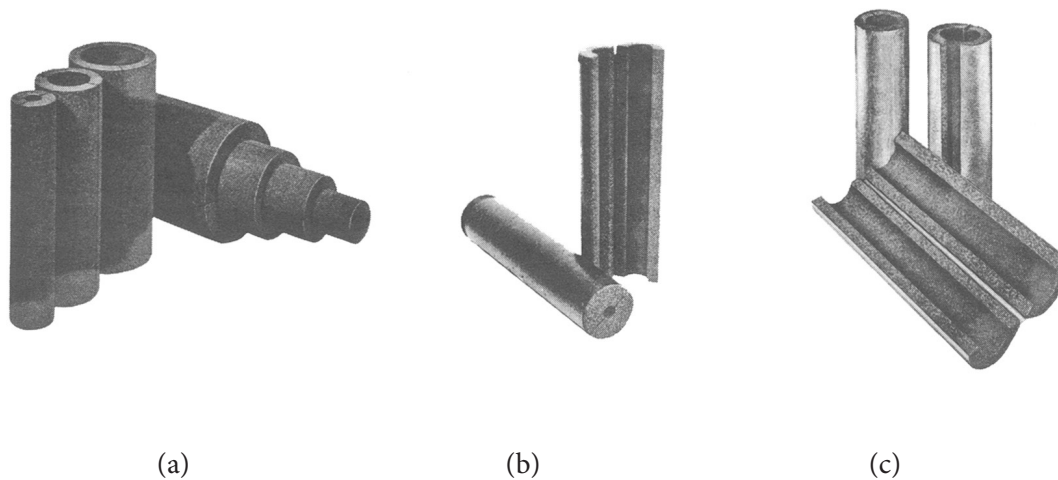
This is a fairly new type of insulation. It is constructed of metal reflective sheets of stainless steel, spaced and baffled to form isolated air chambers around the piping. The highly polished reflective sheets reflect the heat and prevent loss due to radiation; yet, they absorb little heat by conduction. This is used for temperatures above 1040°C.

## Pipe Insulation Types

Piping insulation is normally fabricated in half-cylindrical sections to fit over the pipe. It is held together by metal wire or bands, and then covered with canvas, sheet metal, aluminum or galvanized steel.

Shown in Figure 29 are some typical examples of pipe insulating sections. Figure 29(a) shows small diameter pipe insulation. It is split along its length and opens up to fit over the pipe. Figures 29(b) and 29(c) show the half-cylindrical sections of insulation for various larger size pipes.

**Figure 29 – Molded Pipe Insulation**

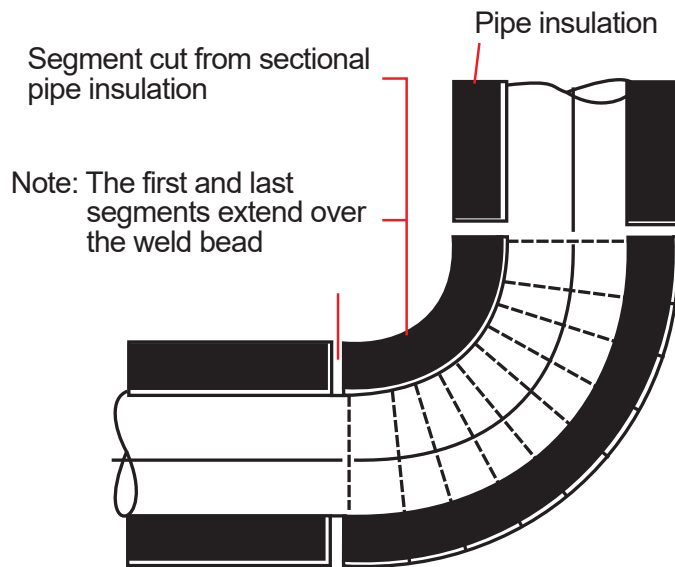


Figures 30 and 31 illustrate the molded form used for piping and pipe fittings.

**Figure 30 – Insulated Piping Systems**



**Figure 31 – Pipe Elbow Insulation**





## CHAPTER SUMMARY

This chapter covered the different types of piping materials. Steel is the most commonly used material; however, it may not be the best choice for a given situation. This is why it is important to understand the benefits of each material type. The different standards used for commercial pipe sizes, the importance of knowing whether the inside or outside diameter is specified, and how the thickness of pipe impacts the inner diameter was also discussed.

The three different methods used to connect piping - threaded and screwed, welding, and flanges - were covered. Screwed fittings included various forms of elbows, bushings, unions, and reducers. Each type of fitting serves a specific purpose; for this reason, it is important to understand the difference between the fittings.

When using flanged connections, gaskets are needed to prevent leaks. A Power Engineer must be able to specify the correct gasket for the correct job, whether low or high pressure. Lastly, welded connections were covered. While welded connections have many advantages, they require skilled tradespersons to assemble sections of pipe correctly.

Just as bridges have expansion joints to minimize increased stress on warm sunny days, expansion joints are required for steam pipes as well. Two types were discussed: the slip joint and the corrugated expansion joint.

When steam condenses within piping, a dangerous phenomenon can occur. This is called water hammer. Water hammer is the term used to describe violent load shocks produced within steam pipes. In order to prevent this, plants must continuously drain condensate from steam lines using steam separators and steam traps.

Steam pipes have to be insulated in order to protect personnel, create a comfortable working environment, and minimize heat losses. Insulation comes in many different forms. The end of the chapter discusses the different types of pipe insulations and the temperatures they can sustain.





## Introduction to Energy Plant Valves

### LEARNING OUTCOME

*When you complete this chapter you should be able to:*

*Discuss the design and uses of the valve designs most commonly used in industry and on boilers.*

### LEARNING OBJECTIVES

*Here is what you should be able to do when you complete each objective:*

1. *Describe standard valve designs.*
2. *Describe design and operation of specialized boiler valves.*
3. *Describe a typical steam pressure reducing station, and the design and operation of steam system pressure-reducing valves.*
4. *Discuss valve details, including materials of construction and identification markings.*
5. *Describe typical valve maintenance requirements.*





## CHAPTER INTRODUCTION

Various types of valves are required in piping systems to regulate fluid flow.

Valves can be manually operated and/or have an actuator to control the valve opening. The actuator may be operated pneumatically, hydraulically, or electrically. Valves represent a considerable percentage of the overall system costs; therefore, they must be carefully selected. Consideration must be given to the following details.

- Working pressure and temperature
- Type of fluid (corrosive or erosive)
- Flow rate
- Valve characteristics desired (percentage valve travel to flow rate)
- Valve being used for isolation purposes only (wide open or closed)
- Cost of installation and maintenance
- Pressure drop across the valve

Valves are an essential element of any power plant. They are used for many different reasons such as safety isolation, changing fluid flow speed and direction, and reducing pressure.

This chapter will begin by summarizing the seven basic valve designs. It will discuss each valve design's components, benefits, and uses. Boilers require certain specialized valves, due to their high temperature and pressure operating conditions. These too will be discussed.

Examples of different piping arrangements from the steam header to the boiler will be given. The different types and operation of pressure reducing valves are included.

This chapter also covers how to identify and select valves. A valve's service rating (material, pressure, temperature and application) are critical safety points that must be addressed when ordering new valves or replacing existing ones. Lastly, the chapter discusses ways that valves may leak, and the best way to maintain and repair them.

## OBJECTIVE 1

*Describe standard valve designs.*

---

### VALVE DESIGNS

---

There are several standard [valve](#) designs, including:

- [Gate](#)
- [Ball](#)
- [Globe](#)
- [Plug](#)
- [Needle](#)
- [Check](#)
- [Butterfly](#)

#### Gate Valve

The gate valves illustrated in Figure 1 and 2 have a gate-like disc, which is actuated by a threaded stem and a handwheel. The stem can also be called a spindle. Turning the handwheel moves the disc up and down at right angle to the flow path. In the closed position, the disc seals between two seats to shut off the flow.



Figure 1 shows a gate valve with a rising stem. In this design, the stem is attached to the gate. The top portion of the stem has screw-like threads, which mesh with threads in the valve wheel. As the valve wheel turns, the stem and disc rise up or down, but the wheel does not. The advantage of this design is that an operator can see at a distance whether the valve is open, by observing the position of the stem.

Figure 2 shows a gate valve with a non-rising stem. In this design, the stem has threads on the bottom half, which mesh with threads inside the disc. When the valve wheel turns, the disc moves up or down on the stem. The handwheel, however, does not move up or down. Non rising stem valves are used where there is little room between the valve handle and a fixed surface, such as a beam.



Gate valves are suitable as stop or isolation valves, where conditions require either full flow or no flow. Their advantage is that, when fully opened, the resistance to flow is low with a minimum of pressure drop, since the fluid flows in a straight line.

However, gate valves are not suitable for flow throttling purposes. Erosion forces associated with high velocity flow due to a partially opened gate valve can cause excessive wear to the valve disc and seats, a condition called [wire drawing](#).



Figure 1 – Gate Valve (Rising Stem)

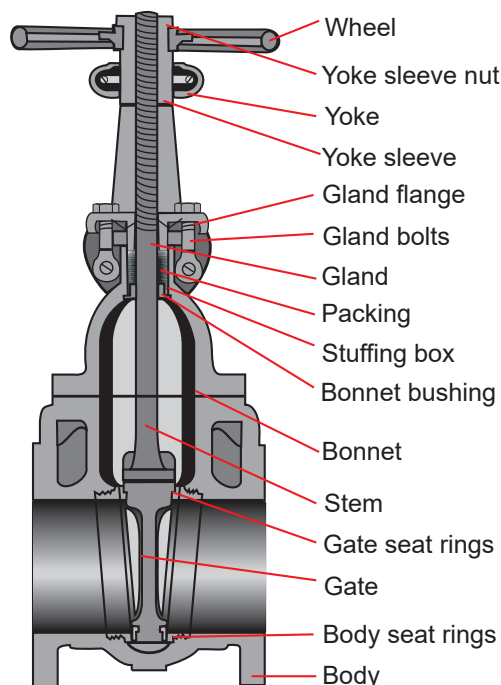
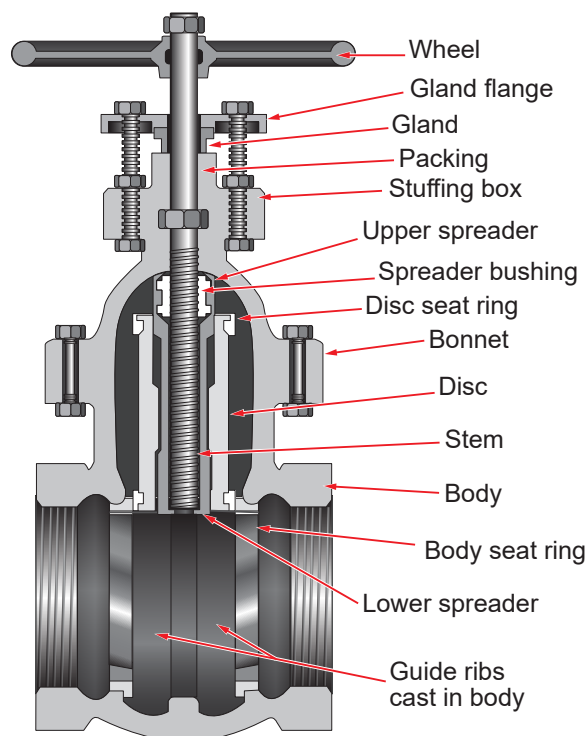


Figure 2 – Gate Valve (Non-Rising Stem)



## Globe Valve

The globe valve, as shown in Figure 3, is constructed in such a way that fluid flow passing through it must change direction twice. The circular disc and the seat are parallel to the main flow path. The disc is moved toward, or away from, the seat by means of a threaded stem. When the disc is raised off the seat, the valve is open. Then, the flow enters below the disc, passes up through the seat, and goes to the outlet.

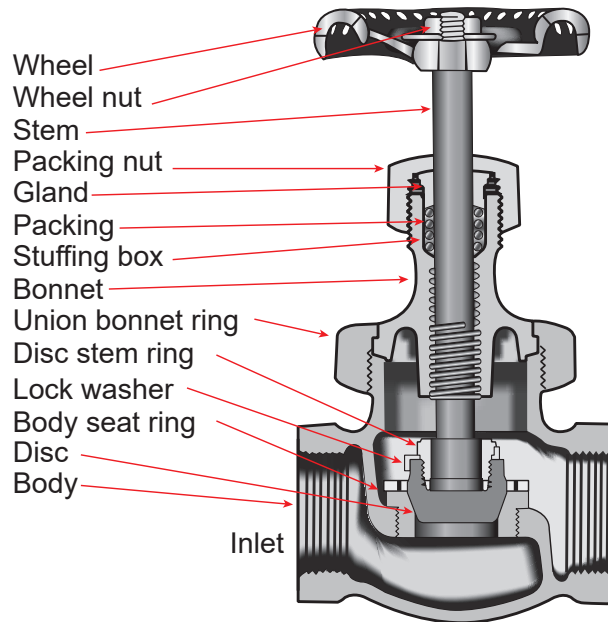
The design in Figure 3 has the valve wheel attached to the top of the stem. The disc is attached to the bottom of the stem. Internal threads in the valve body mesh with threads on the valve stem. As the valve wheel turns, the stem, valve wheel, and disc all move up or down.

The globe valve is ideal for throttling or regulating flow with a minimum of wire drawing and seat erosion. A disadvantage of the globe valve is that, due to the change in flow direction, it offers more resistance to flow than the gate valve does. As well, it is not possible to “see through” an open globe valve, to inspect or clean interconnecting piping.

An unbalanced, single disc globe valve is shown in Figure 3. It is seldom used in sizes larger than 305 mm, because it is difficult to open and close against high fluid pressure.



**Figure 3 – Globe Valve**

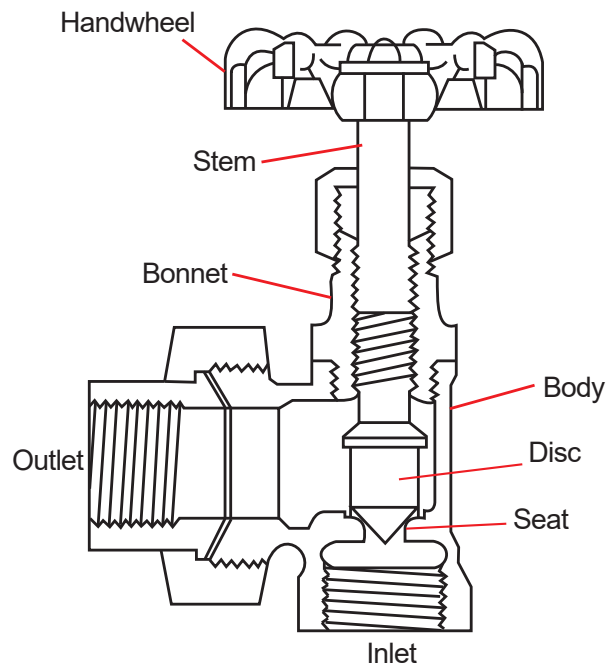


### Needle Valve

Needle valves are designed to allow precise flow control. Their name is derived from the sharp pointed disc and matching seat. They are extensively used for controlling continuous blowoff or chemical feed. The stem threads are finer than usual so that considerable movement of the hand wheel is required to increase or decrease the valve position.

Usually, these valves have a reduced seat diameter in relation to the pipe size (Figure 4).

**Figure 4 – Needle Valve**





## Butterfly Valve

The butterfly valve is often used as a final control element in air or large water piping systems. It comes in sizes from 25 to 3800 mm in diameter. It is designed for pressures up to 13 800 kPa and temperatures up to 1100°C.

Butterfly valves are often lined with a resilient material so the rotating disc seats tightly when closed. These valves provide a bubble tight seal with low operating torque. They operate by the wing-like action of the disc. When open, the disc and handle are parallel to the flow. The flat disc rotates through 90° from the wide open to the fully closed position.

Butterfly valves have two body styles: lug body (or double ported) and wafer.

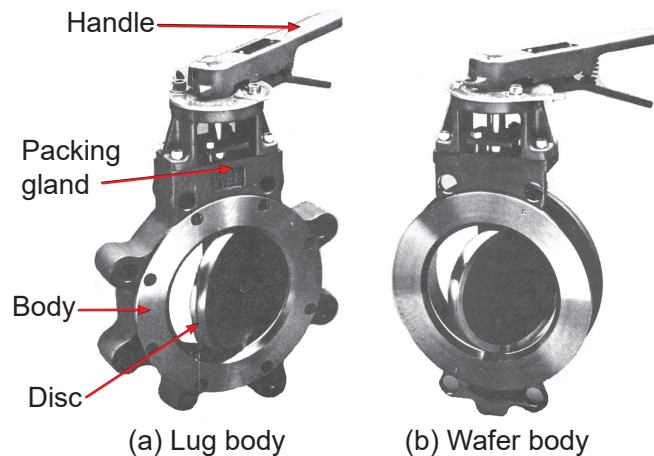
Referring to Figure 5(a), the double-ported type has a flanged body. The body is usually a solid ring type mounted between pipe flanges. The disc is generally cast in one piece. Correct alignment of this valve is required to prevent binding of the disc. The pressure drop across the valve (throttling or closed position) determines the thickness of the disc.

The wafer body type, shown in Figure 5(b), does not have flanges. It is installed by sliding it between two flanges in the piping. It has a sealing surface which matches up with the sealing surfaces of the piping flanges. The wafer valve often has a moulded-in seat for extra life and a better seal.

Both styles of valves are installed with appropriate temperature and pressure rated gaskets, to prevent leakage at the flanges.

The valves, shown in Figure 5, are fitted with handles for manual operation. A power actuator is required to position the disc for bigger sizes because large pressure differentials can exist across the disc.

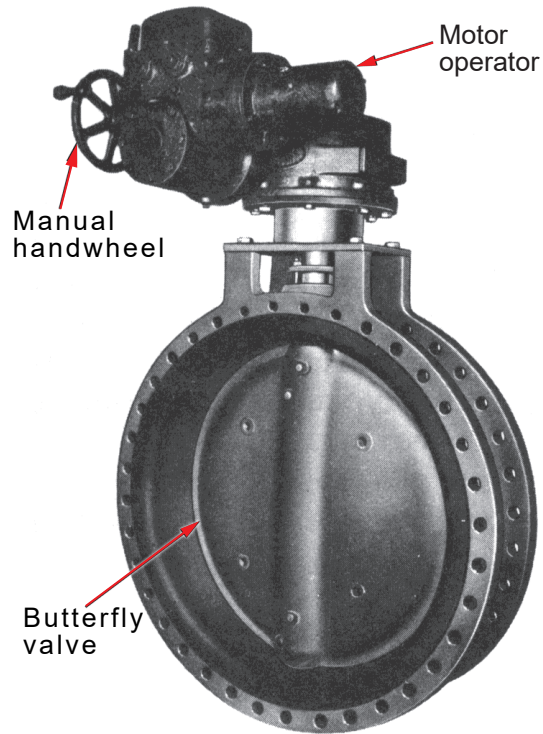
**Figure 5 – Butterfly Valves**



(Courtesy of DeZurik)

The valve shown in Figure 6 can be operated manually or electrically.

**Figure 6 – Power Operated Butterfly Valve**



*(Courtesy of Rockwell Manufacturing)*

Butterfly valves are used in:

- Thermal and hydroelectric power stations
- Oil and gas processing industries
- Oil and gas transmission
- Water and sewage plants

They have the following advantages:

- Relatively light weight
- Ease of operation
- Self-cleaning
- Small pressure drop across the valve when it is fully open.

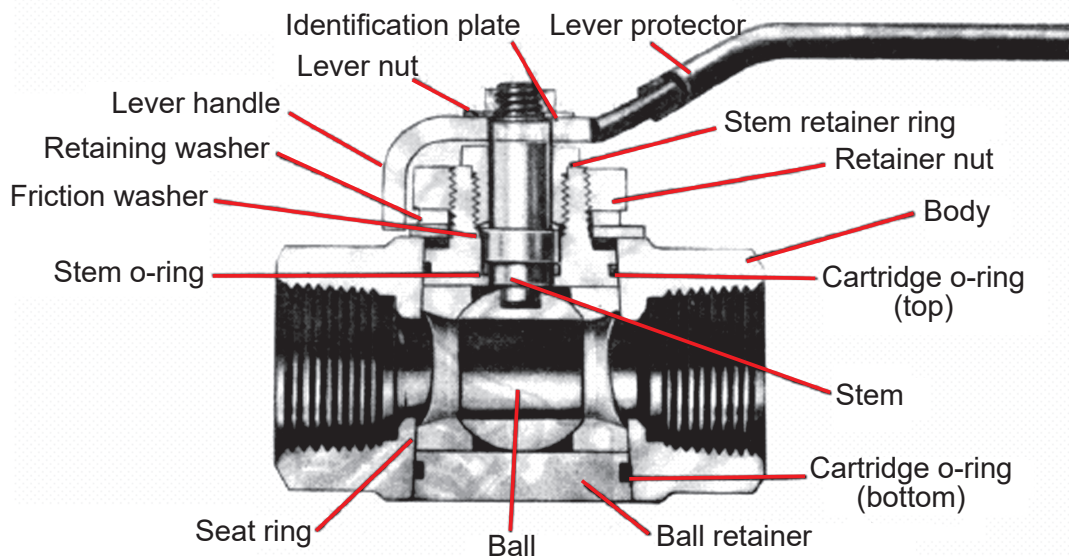


## Ball Valve

The ball valve, illustrated in Figure 7, contains a spherical plug with a passage bored through it which controls the fluid flow through the valve body. The basic type of ball valve requires a quarter turn to move from fully open to the fully closed position. When open, the handle is parallel to the flow of liquid. The valve can be operated by means of a lever handle or a powered actuator.



**Figure 7 – Ball Valve**



The spherical plug not only allows precise control of the flow through the valve, but also gives a tight shutoff when in the closed position. These valves are designed so that internal lubrication is not required and the torque to rotate the ball is negligible.

Ball valves can be manufactured in sizes from 3 to 1000 mm, for pressures up to 69 000 kPa with service temperatures from  $-185^{\circ}\text{C}$  to  $550^{\circ}\text{C}$ .

Ball valves are suitable for handling slurries and fluids with a high solid content. For this reason, ball valves have found wide applications in the paper industry, chemical plants, and sewage treatment plants.

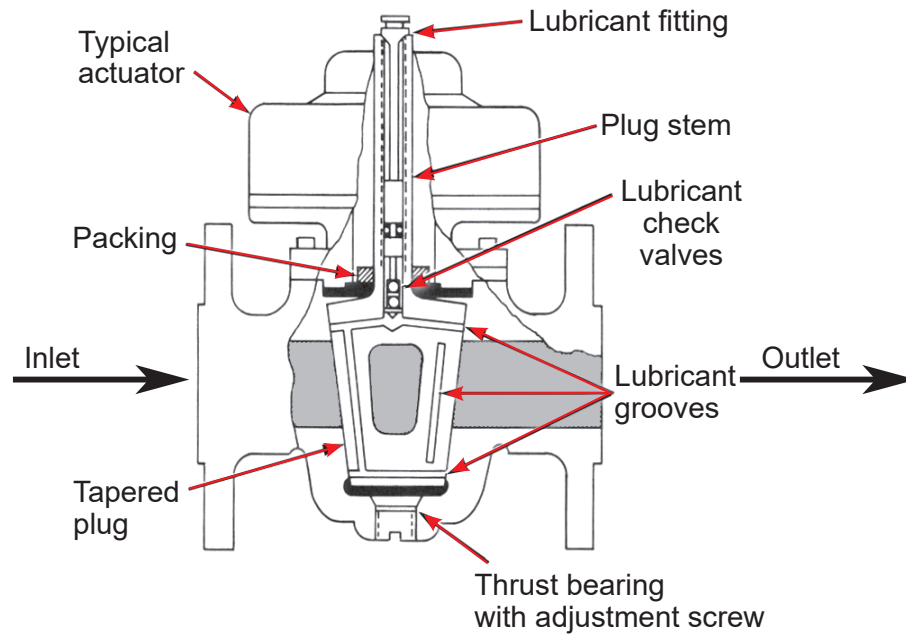
## Plug Valve

The plug valve is a quarter turn valve, as are butterfly and ball valves. The plug valve consists of a tapered or straight cylinder containing a hole inserted into the cavity of the valve body. The hole in the plug lines up with the axis and opening in the valve body. The valve illustrated in Figure 10 has a tapered plug secured in the valve body by the valve cover. A packing box is recessed in this cover, with packing held in place by the gland. This prevents leakage along the valve stem.

The tapered plug has a tendency to jam in the tapered seat and can cause scoring if forced to turn. Most plug valves are lubricated to eliminate this problem. The lubricant is supplied through the center of the stem and is distributed through channels to the seating surfaces. Other valves are equipped with a flexible, smooth liner which eliminates the need for lubrication. The pressure drop across this valve, when it is in the wide open position, is very low. This valve is also self-cleaning.

Plug valves are used as quick opening valves in:

- Gas supply lines
- Low-pressure steam lines
- Water treatment plants
- Pulp and paper and chemical industries

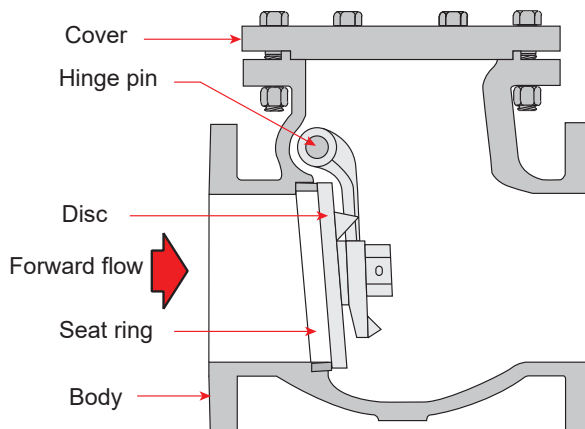
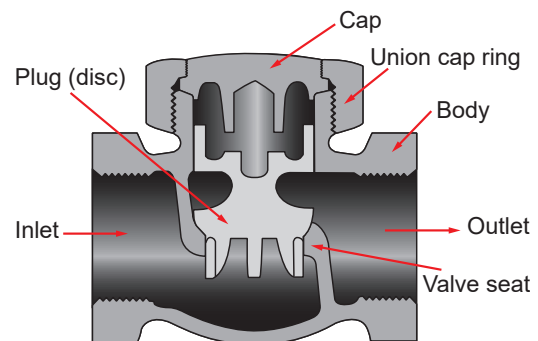
**Figure 8 – Plug Valve**


(Courtesy of Flowserve)



## Check Valve

The check valve prevents reversal of flow in piping. The flow of fluid keeps the check valve open, whereas gravity or reversal of flow causes the valve to close. The two basic types of check valves are the swing check (Figure 9) and the lift check (Figure 10).

**Figure 9 – Swing Check Valve**

**Figure 10 – Lift Check Valve**


The swing check valve (Figure 9) has a flap or disc, which hangs down in the flow path. The inside diameter of the disc is the same diameter as the pipe bore. With flow in the forward direction, the pressure of the fluid forces the disc to swing upwards on a hinge, allowing flow through the valve.

A flow reversal causes the disc to shut against the seat, stopping the fluid. In the absence of flow, the weight of the flap causes the valve to close.



With abrupt reversals in flow, the disc can slam against the valve seat. This can cause significant wear of the seat and can generate water hammer in the pipe system. Fitting a damping mechanism to the disc and using metal seats to limit the amount of seat wear will help to overcome this problem.

The flow through the lift check valve undergoes two changes in direction as it passes through the valve. The disc moves upward to allow the fluid to pass through and moves downward to close if the flow tries to reverse. In larger check valves of this design, a dashpot (a dampening cylinder) is often used to cushion the action of the disc. Lift check valves provide considerably more resistance to flow than swing checks, but create less water hammer when closing.

Lift check valves (Figure 10) are similar in configuration to globe valves, except that the disc operates automatically with a reversal of flow. A cone-shaped plug rests on a seat that is typically made of metal. The disc and seat separate the inlet and outlet ports. In some valves, the plug may be held on its seat by a spring. When the flow into the valve is in the forward direction, the fluid pressure lifts the plug off its seat and opens the valve. With a reversal in flow, the plug returns to its seat and is held in place by the downstream pressure.

If a metal seat is used, the lift check valve is only suitable for applications where a small amount of leakage under reverse flow conditions is acceptable. Since the design of a lift check valve generally limits its use to water applications, it is used to prevent reverse flow of condensate in steam traps.

The main advantage of the lift check valve is its simplicity. Since the plug is the only moving part, the valve is robust and requires minimal maintenance. Also, the use of a metal seat limits the amount of seat wear. The valve is designed only for installation in horizontal pipelines.

## OBJECTIVE 2

*Describe design and operation of specialized boiler valves.*

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### BOILER VALVE TYPES

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ASME Code, B31.1 122.1.7A states that each boiler discharge outlet (except safety valve or safety relief valve connections) shall be fitted with a stop valve located at an accessible point in the steam delivery line. The stop valve must be as near to the boiler nozzle as is convenient and practicable.

B31.1 also recommends using stop valves of the outside-screw-and-yoke type with rising spindle. The advantage of this type is that the operator can see, even from a distance, whether the valve is open or closed. Also, since the threaded part of the spindle is outside the valve body, it is not exposed to the corrosive action of steam or water, and the threads can be easily lubricated.

The stop valve (gate valve) in Figure 1 features an outside-screw-and-yoke with rising spindle. The handwheel is carried on the yoke and does not rise with the spindle.

The stop valve (globe valve) in Figure 3 has a rising spindle with internal threads. In this case, the handwheel is attached directly to the spindle and rises with it.

### Non-Return Stop Valve

The **non-return stop valve**, also referred to as a “stop-and-check” valve, is a special type of globe valve. This style of valve is installed at the boiler outlet in cases where the boiler outlet discharges into a common header with other boilers.

Figure 11 is a simple illustration of the internals and operating principle of the non-return valve (NRV). It acts as a stop valve when the hand wheel is in the closed position. When closed, the valve stem pushes down on the disc forcing it against the seat. However, the valve stem is not directly attached to the disc.

When the hand wheel is raised to the full open position (or partially open position), it cannot lift the disc off the seat. Opening the hand wheel merely gives the disc assembly the freedom to move upward if the inlet steam pressure increases above the outlet steam pressure.

If the steam pressure below the disc is greater than the steam pressure above the disc, the disc will rise and allow steam to flow out of the boiler. However, if the pressure above the disc becomes greater than the pressure below the disc, the disc will be forced down onto the seat, thus closing the valve in the same manner as a check valve. This prevents a reversal of steam back to the boiler.

The action of the non-return valve is important in three situations.

1. When the boiler is being started and brought on line with other boilers, the disc will remain closed until the boiler pressure exceeds the pressure in the common steam header. This prevents the higher steam header pressure from flowing back into the boiler.
2. If the boiler trips during normal operation, the pressure in the boiler will quickly drop below the pressure in the common header. The non-return valve will close, again preventing flow reversal into the boiler.
3. If a boiler tube were to rupture, the pressure in the boiler would drop and the non return valve would automatically close, thus preventing the other boilers from feeding steam into the damaged boiler.

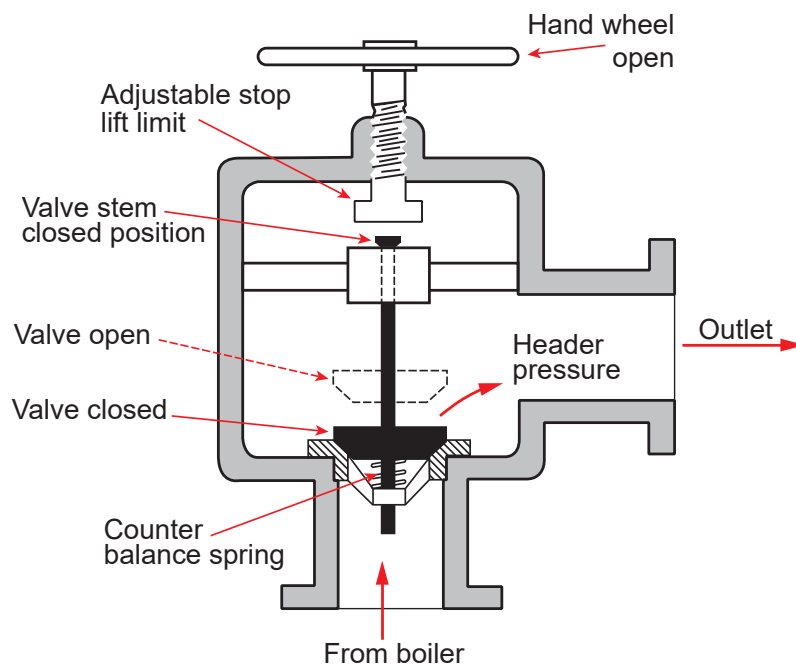
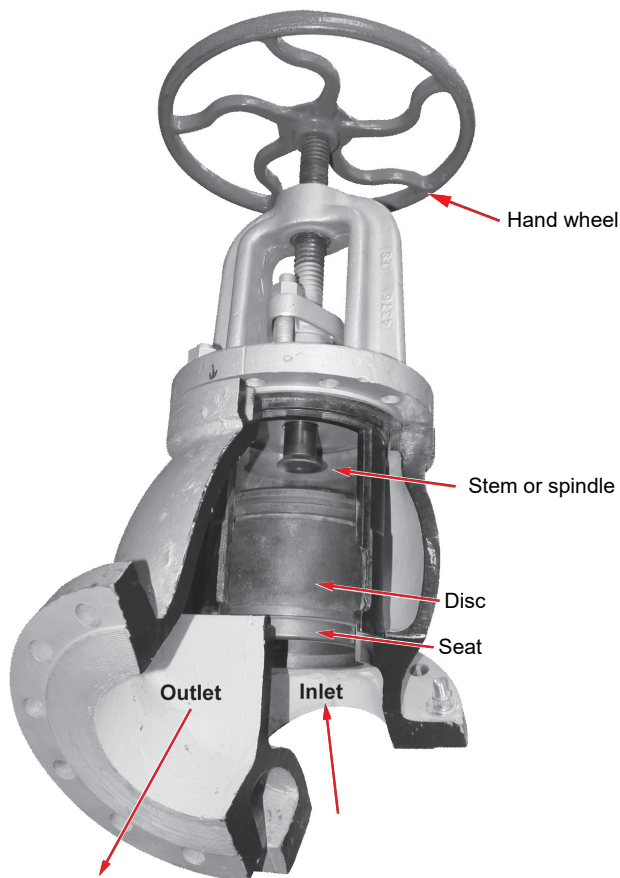

**Figure 11 – Simplified Non-Return Stop Valve**


Figure 12 shows a cutaway of a non-return stop valve with an outside-screw-and-yoke. In this design, the disc is part of a piston, which is not connected to the spindle, but is free to rise and fall.

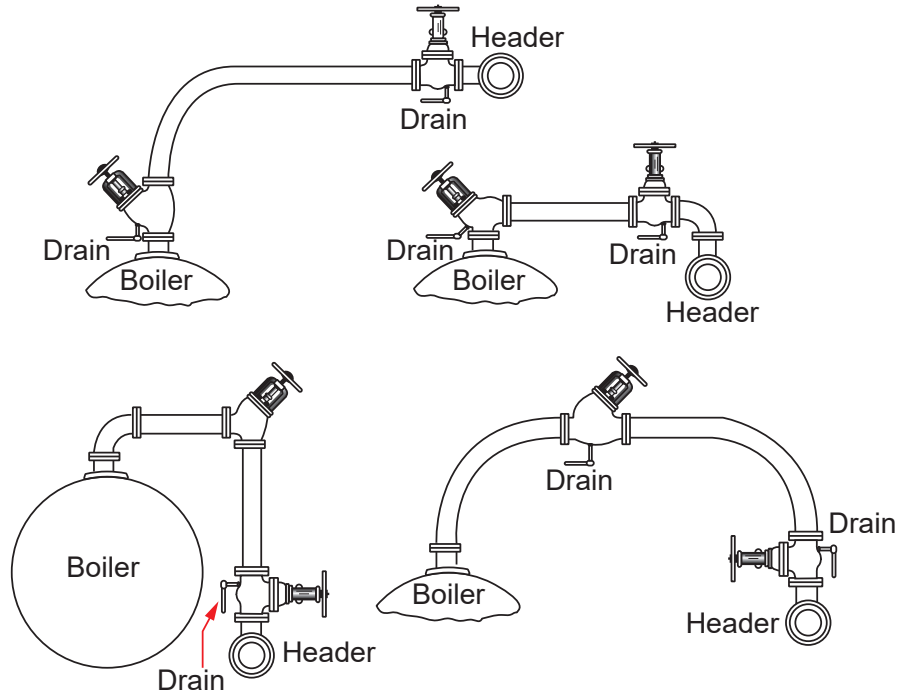
**Figure 12 – Piston-type Non-Return Stop Valve**


Various arrangements of piping from boiler to header are illustrated in Figure 13. Each arrangement features a non-return valve closest to the boiler and a stop valve at the header. Drains are provided in each case to drain the piping between the two valves.

These piping arrangements meet the requirements of ASME B31.1 122.1.7 (A.3), which states:

*“When two or more boilers are connected to a common header, or when a single boiler is connected to a header having another steam source, the connection from each boiler having a manhole opening shall be fitted with two stop valves having an ample free-blow drain between them.”*

**Figure 13 – Non-Return Stop Valves and Header Valve Arrangements**





### OBJECTIVE 3

*Describe a typical steam pressure reducing station, and the design and operation of steam system pressure-reducing valves.*

## PRESSURE REDUCING STATION

The purpose of a **pressure reducing station (PRS)** is to receive a process fluid (such as steam) at a higher pressure and reduce it to a controlled lower pressure for use in a downstream, lower pressure system, or equipment. There are various designs of pressure reducing stations, but the design described here involves the use of a **pressure reducing valve (PRV)**, also called a pressure regulator.

Figure 14 shows the components of a typical station, in this case with steam as the process fluid. The heart of the station is the pressure regulator. A sensing line feeds the lower (controlled) pressure to the regulator, which then adjusts its position to control that pressure.

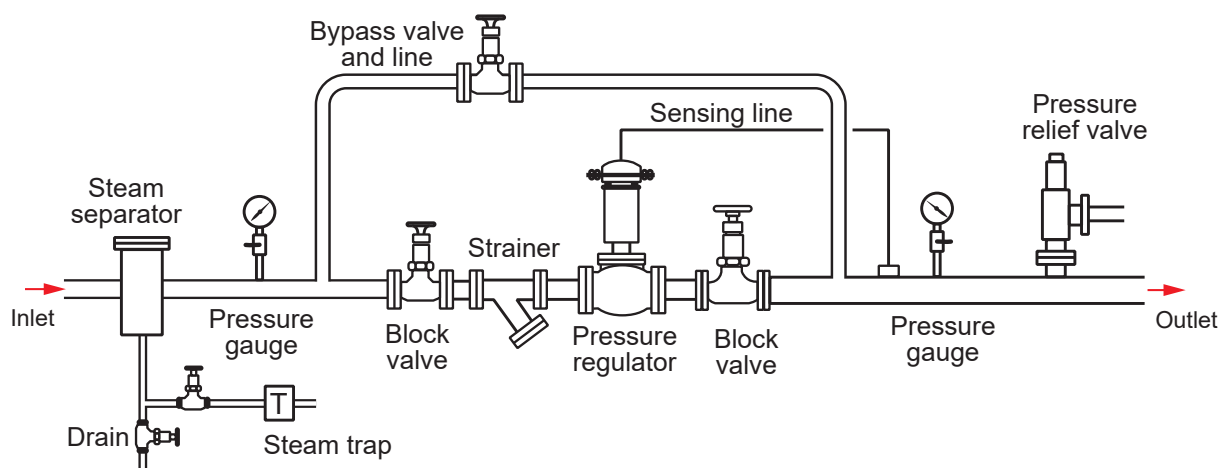
A strainer upstream of the regulator prevents foreign particles from entering the regulator. Gate valves are installed as block valves on either side of the regulator and strainer, to permit isolation for maintenance. A bypass line and globe valve are used to manually provide downstream pressure control when the regulator or strainer is being maintained.

Pressure gauges are installed on the low and high pressure sides of the station, allowing the operator to monitor the regulator operation. A pressure relief valve is required on the low-pressure side to protect the system if the regulator fails, and during bypass operation.

For a steam system, it is common to have a steam separator, with a steam trap, to remove free water before the regulator. This is not usually required for other liquid-free fluids.

Other process fluid systems that typically use pressure regulators include water, natural gas, and compressed air.

**Figure 14 – Steam Pressure Reducing Station**



## PRESSURE REDUCING VALVES

There are several different designs of pressure reducing valves. Two of the most common designs and their operating principles are described here. Both use a compressed spring and a diaphragm. These PRVs are the:

1. Spring operated reducing valve with internal diaphragm.
2. Spring-operated reducing valve with external diaphragm.

### Spring-Operated Reducing Valve with Internal Diaphragm

This valve (Figure 15) has two main sections: the valve housing, and the bonnet. A flexible diaphragm separates these sections.

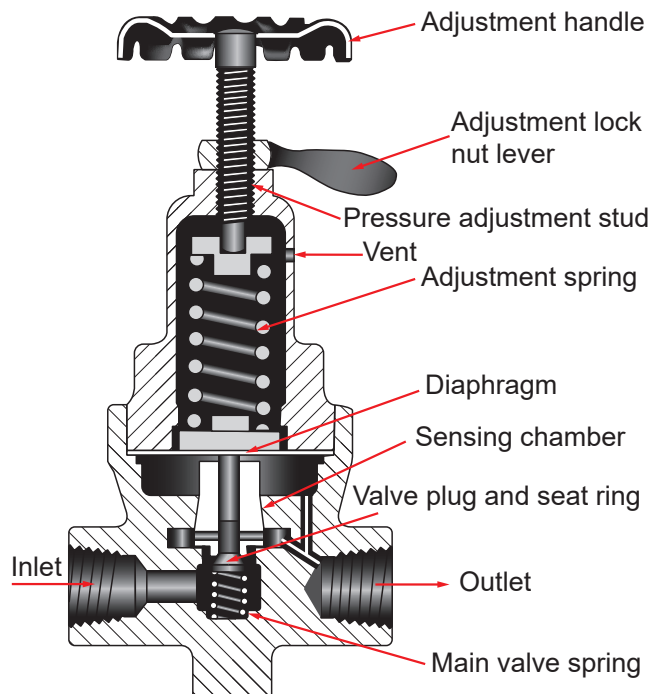
The bonnet is open to the atmosphere. A compression spring acts downward on the diaphragm, forcing the valve to open. The space below the diaphragm is connected to the low-pressure side of the valve. The fluid (liquid or gas) exerts an upward force against the diaphragm, counteracting the force of the spring. At a set outlet pressure, these two forces are balanced, holding the valve open a certain distance and allowing a proportional flow through the valve.

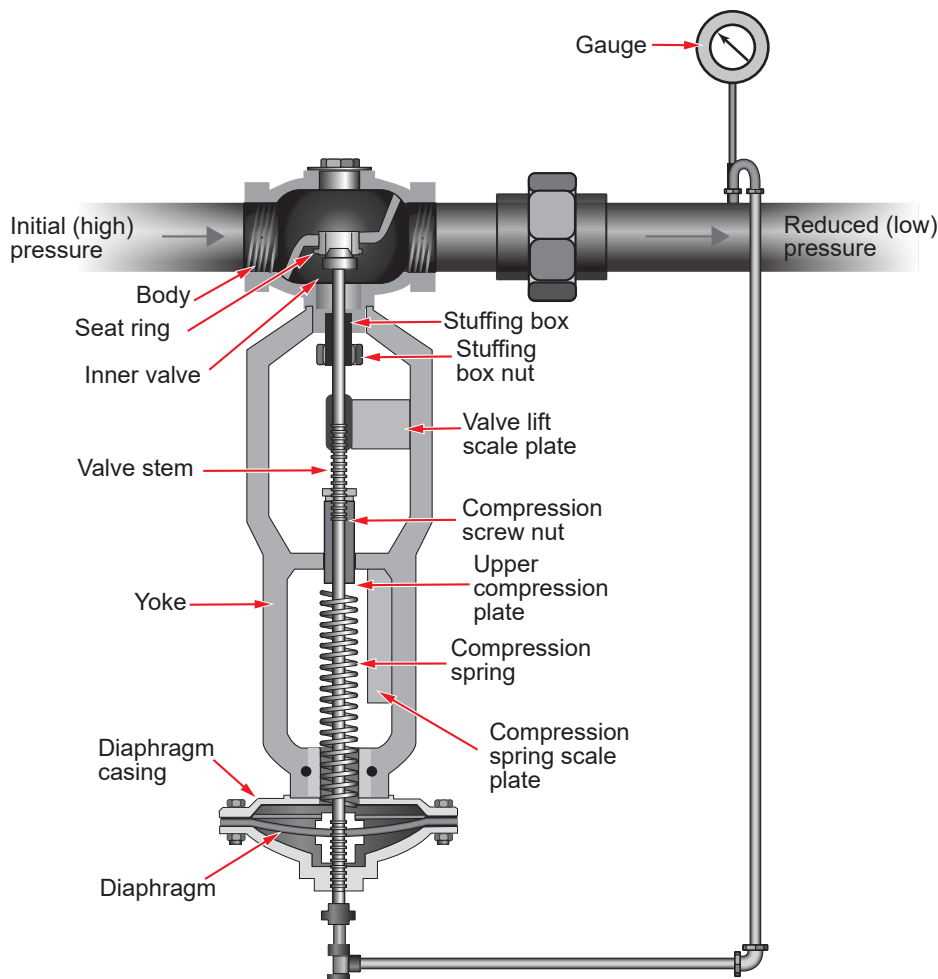
When the demand for fluid increases, the pressure on the outlet side drops slightly, resulting in a reduced upward force on the diaphragm. The spring force moves the diaphragm downward, which forces the valve to open more. More fluid is allowed to pass through and the outlet pressure is restored. The opposite sequence occurs when the demand for fluid decreases.

The outlet pressure can be adjusted by changing the compression of the spring, by using an adjusting screw accessible through the top of the bonnet (or, as in Figure 15, with an adjusting handle). Turning the screw downward increases the spring compression and raises the outlet pressure. Turning the screw upward reduces the outlet pressure. The adjusting screw is secured by a locknut after the final adjustment has been made.

The valve disc can either be directly connected to the diaphragm or, as is illustrated in Figure 15, separated from the diaphragm. In this case, a small spring plus the pressure of the fluid on the high-pressure side of the valve force the valve to follow the upward movement of the diaphragm.

**Figure 15 – Spring-Operated PRV (Internal Diaphragm)**




**Figure 16 – Spring-Operated PRV (External Diaphragm)**


### Spring-Operated Reducing Valve (External Diaphragm)

The reducing valve, illustrated in Figure 16, operates on the same principle as a valve with an internal diaphragm. However, it differs in basic design in that the diaphragm and spring are mounted outside the valve housing on a yoke.

The diaphragm operates the valve through an extended valve stem. A control line connects one side of the diaphragm casing to the low-pressure side of the valve.

With this arrangement, the diaphragm is not affected by the temperature of the fluid, which can overheat and damage the diaphragm. The fluid in the control line and diaphragm casing become the same temperature as the surrounding air.

When used in steam lines, the line and casing fill with condensate. On initial startup or after servicing, these lines must be filled with distilled water, to protect the diaphragm.

All reducing valves should be installed with isolating valves on either side, and with a by-pass valve and line so that the valve can be removed for repairs without interrupting the fluid supply. They should also be equipped with a pressure gauge and safety valve on the low-pressure side. This equipment ensures the safe and continuous operation of the system.

Since the isolating valves are either wide open or fully closed (not subjected to throttling), gate valves are preferred since they offer minimum resistance to flow. The by-pass valve, which throttles the flow when the reducing valve is out of service for maintenance or repair, should be a globe valve.

## OBJECTIVE 4

*Discuss valve details, including materials of construction and identification markings.*

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## VALVE DETAILS

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### Materials of Construction

To select the materials of construction for valve bodies, designers need to consider the pressure, temperature, and type of fluid in the application. For example:

- a) Cast iron is used for applications with low-pressure and temperature.
- b) Bronze is used for moderate pressures and temperatures up to 280°C.
- c) Carbon steel is used for services up to 425°C.
- d) Alloy steel is used for high-pressure applications and temperatures up to 650°C.
- e) Special alloy steels are used for temperatures in excess of 650°C.

**Valve trim** consisting of the disc, seat ring, valve stem, and guide bushings, are manufactured from bronze, mild steel, alloy or stainless steel.

Valve packing, depending on the service, is made of combinations of:

- Teflon
- Teflon coated high strength yarns and vegetable fibres
- Graphite
- Metallic reinforcement used for corrosive surfaces

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## IDENTIFICATION OF VALVES

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It is extremely important that the proper type of valve be used for a particular service. Accidents have frequently occurred when a valve made of the wrong material has been installed in a pipe line.

Therefore, all valves must be properly identified as to the material of construction, and service conditions for which they are designed. All valves not properly or clearly identified should be rejected.

All markings shall be legible and must indicate at least the following:

- a) Manufacturer's name or trademark
- b) Service designation, i.e., pressure-temperature for which the fitting is designated
- c) Material designation, i.e., steel or cast iron, ASTM Number, etc.



Figure 17 shows acceptable valve markings. The manufacturer's name is "Crane." The valve body meets "ASME B16.34 Valves Flanged, Threaded, and Welding End" Standard Specification A105: Carbon Steel Forgings for Piping Applications. The valve is an ASME B16.34 Standard "Class 800" valve, rated for 1975 psi (13.6 MPa) at 100°F (38°C). The nameplate also indicates the materials of the stem, disc, and seat.

**Figure 17 – Typical Valve Identification Markings**



## OBJECTIVE 5

*Describe typical valve maintenance requirements.*

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## VALVE MAINTENANCE

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### Valve Leaks

Visually inspect all valves frequently, and repair small leaks immediately. A valve leak is often remedied easily and quickly. Failure to stop a leak early may result in damage to the bonnet and flange surfaces, which may then require costly and time-consuming repairs. Valve leaks usually occur in the:

- Stem
- Bonnet
- Flange

### Stem Leaks

Stem leaks can normally be fixed by slightly tightening the packing nut or gland. Always tighten up bolted glands evenly; otherwise, the gland will bind the valve stem.

If insufficient packing is left to stop leakage, renew the packing. The procedure for renewal of packing in stuffing boxes of valve stems is similar to that of pump shafts. The only difference is that the valve stem packing may be tightened enough to stop all leakage since no constant flow of liquid is required for lubrication. Never tighten the packing more than necessary to stop leakage since over tightening causes extra friction resulting in wear and added effort in opening and closing the valve.

Wear on stem packing is mainly due to the rising and turning motion of the valve stem. New packing contains sufficient lubricant to reduce the friction to a minimum. Older packing may have exhausted its lubricant. A few drops of oil applied occasionally to the valve stem will reduce friction and extend the life of the packing.



### Bonnet and Flange Leaks

These leaks can be caused by insufficient tightening of the bolts or by bolts loosening under service strain. Try tightening the bolts first to stop the leak, but do not overstress them. If tightening the joint does not stop the leak, the gasket should be replaced as soon as possible.

Neglecting to stop flange leaks will result in wire drawing on the faces of the flanges. Wire drawing is the forming of deep grooves, running from the center of the flange to the outside, caused by the scouring action of the escaping fluid.

### Valve Lubrication

Lubricating the external thread of the valve stem will cut down friction, wear, and effort in operating the valve. Valves equipped with a grease nipple should receive a shot of grease periodically, to supply the threaded bushing in the top part of the yoke with lubricant.



## Internal Inspection

Most valves are designed to permit internal inspection without having to remove the valve body from the line. Periodic inspection of the valve disc and seat is the best form of preventive maintenance. The complete bonnet and disc assembly can be removed for cleaning and inspection. The seating surfaces in the body should be checked at the same time.

If inspection of the valve disc (or the wedge) and the seat shows damage, such as grooving and wire-drawing, the seating surfaces should be refaced.

Globe valves equipped with a **composition disc** should have the disc replaced as soon as a seat leak is discovered. It is a simple procedure and early replacement will prevent damage to the seat.

The following procedures can be used for globe valves to repair damaged valve discs and seats.

1. Slightly damaged surfaces can be refaced by grinding the valve disc in on the valve seat in combination with a grinding compound.
2. If damage is more extensive, the seat should be refaced with a reseating tool. The valve disc should be refaced either by carefully filing down the damaged seating surface, or by taking a slight cut of material off using a lathe or grinding machine. Then the disc and seat should be ground in together to obtain matching seating surfaces.
3. When the valve is equipped with a renewable seat, and the disc and seat are extensively damaged, it is cheaper and less time consuming to replace both disc and seat rather than to repair them.

The seating surfaces of gate valves are much harder to reface than those of globe valves. Special equipment is required to do a satisfactory job.

## CHAPTER SUMMARY

This chapter covered the necessity of valves in a power plant. First, it summarized the seven different types of valve designs:

- Gate
- Globe
- Needle
- Butterfly
- Ball
- Plug
- Check valves

Given that boilers operate under extreme conditions, they require specialized boiler valves to ensure the safety of both personnel and equipment. Non-return stop valves were discussed as an example. They are required to prevent steam from flowing back into boilers when their pressure is lower than the steam header pressure.

The material used to produce a valve depends on the condition in which the valve will be used. While bronze may be fine for moderate pressures and for lower temperatures, steel alloys are used for high-pressure and temperature conditions.

Finally, this chapter discussed the importance of identifying valves by their manufacturer, their service designation, and their material designation. As well, valve maintenance was covered. Stem leaks and bonnet leaks were discussed, and inspections methods were introduced.



## UNIT SUMMARY

This brings us to the end of Unit 7, Energy Plant Piping. The following is a short summary of each chapter, and will serve as a reminder of the material covered in this unit.

**Chapter 1:** This chapter focused on the importance of piping and piping accessories. This included material selection, thermal insulation, supports, piping connections, and expansion joints. As well, water hammer - which results in violent shock due to rapid condensation of steam within steam pipes - was discussed.

**Chapter 2:** Valves were introduced in this chapter. Again, the importance of material choice was discussed. Notice that material choice is a recurring theme, as it is essential to choose the right equipment for the job. Seven different valve designs were reviewed, including their advantages and disadvantages. Boilers require specialized valves, such as non-return valves. It is vital for operators to know what these specialized valves do and why they are important. Operators also need to know how to maintain valves and how to identify when valves are not operating as they should.

A self-assessment tool is available on MyPower LMS. Login using the unique user ID and password found on the inside front cover of Unit 1.

















4th Class Edition 3.5 • Part A

# UNIT A-7

## ***KNOWLEDGE EXERCISES AND UNIT GLOSSARY***

<b>Chapter 1</b>	<b>Introduction to Energy Plant Piping Systems</b>	<b>U7-9</b>
<b>Chapter 2</b>	<b>Introduction to Energy Plant Valves</b>	<b>U7-11</b>
<b>Unit A-7</b>	<b>Unit Glossary</b>	<b>U7-13</b>







## Chapter 1 (Cont.)

### Objective 3

5. Identify the advantages and disadvantages of using expansion bends over expansion joints.

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### Objective 4

6. Describe the operating principle of an inverted bucket steam trap.

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### Objective 5

7. List the characteristics to be considered when selecting desirable insulation materials.

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## KNOWLEDGE EXERCISES – CHAPTER 2

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Instructor: \_\_\_\_\_ Course: \_\_\_\_\_

### Objective 1

1. List the standard valve designs.

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### Objective 2

2. Describe the situations where the back flow prevention action of a non-return valve is important.

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### Objective 3

3. State the purpose of a pressure reducing station.

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## Chapter 2 (Cont.)

4. Sketch and describe the principle of operation of a pressure reducing station.

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### Objective 4

5. List the required identification markings on a valve.

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### Objective 5

6. Explain how to stop a leak coming from a valve stem.

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## UNIT A-7 GLOSSARY

Term	Definition
<b>Ball valve</b>	A quarter-turn valve, the handle of which rotates a ball having a central hole that allows fluids to pass through with little impairment.
<b>Bushing</b>	A pipe fitting with both male and female threads, used for connecting lengths of pipe having different diameters. The female threads may be concentric or eccentric to permit liquid drainage.
<b>Butt welded fitting</b>	A welded pipe fitting where the fitting is connected to the pipe using a butt weld.
<b>Butterfly valve</b>	A quarter turn valve that uses a circular disc to control the flow of fluid through a pipe.
<b>Cap</b>	A pipe fitting with internal threads, used to close off the open end of a pipe.
<b>Check valve</b>	A valve that automatically prevents reversal of fluid flow in a piping system.
<b>Composition disc</b>	A valve disc made of a non-metallic material such as Teflon or rubber, to promote tight shut-off.
<b>Concentric reducer</b>	A reducer fitting used to connect pipes of different diameters so that the centre lines of both pipes are aligned.
<b>Coupling</b>	A pipe fitting used to mechanically connect two straight lengths of pipe.
<b>Cross fitting</b>	A pipe fitting used to mechanically connect four pipes at 90 degrees to one another. These fittings are often installed to permit access to piping systems for inspection and cleaning.
<b>Diamètre nominal (DN)</b>	The European and International size designation for pipe. DN indicates approximate outside diameter in millimetres.
<b>Displacement cutter</b>	A device with a cutting wheel and guide rollers used to cut steel or non-ferrous pipe or tubing, in sizes up to 12 inch NPS.
<b>DN</b>	See <i>diametre nominal</i> (DN).
<b>Eccentric reducer</b>	A reducer fitting used to connect pipes of different diameters so that one edge of both pipes is aligned. Eccentric reducers permit fluids, such as steam condensate, to drain from a pipe unimpeded.
<b>Elbow</b>	A pipe fitting used to make angle turns in piping. Common angles are 90 and 45.
<b>Expansion bend</b>	A U-shaped bend in a pipe that accommodates changes in piping system length caused by thermal expansion or contraction.
<b>Expansion joint</b>	A device installed in a piping system that accommodates axial, angular, or lateral displacement of pipe, caused by changes in temperature.
<b>Flanged connection</b>	A pipe connection using two flat plates which are bolted together face to face, usually with a gasket between the two faces.
<b>Flat ring gasket</b>	A gasket that covers only the face of a flange.
<b>Full-face gasket</b>	A gasket that covers the entire face of a flange. This type of gasket has holes to allow flange bolts to pass through.
<b>Gate valve</b>	A valve with a sliding plate that, when completely open, provides minimal flow restriction, and when completely closed provides tight shut-off. Gate valves are not designed for throttling or controlling flow.
<b>Globe valve</b>	A valve with a movable plug and a stationary seat. Used to control fluid flow.
<b>Mechanical trap</b>	A steam trap that operates on the difference between the specific gravities of condensate and steam.



Term	Definition
<b>Needle valve</b>	A globe valve with a small-diameter port and a needle-shaped plug, designed to permit precise flow regulation.
<b>Nipple</b>	A short threaded piece of pipe for making connections between valves and other piping fittings.
<b>Nominal pipe size (NPS)</b>	"An approximate indication of pipe diameter. • Up to and including DN 300 (NPS 12), the number represents the nominal outside diameter of the pipe. • For DN 350 (NPS 14) and larger pipe, the number represents the actual outside diameter of the pipe."
<b>Non-return stop valve</b>	A type of globe valve with a plug that moves independently of the valve spindle when the valve is in the open position, permitting it to act as a check valve if fluid reversal occurs. This valve is commonly used on boiler main steam outlets.
<b>NPS</b>	See <i>nominal pipe size</i> (NPS).
<b>Pipe die</b>	A cutting tool used to create male threads on a pipe.
<b>Pipe reamer</b>	A tool used to remove the internal burr left by a displacement cutter.
<b>Pipe tap</b>	A cutting tool used to cut female threads for pipe fittings.
<b>Plug fitting</b>	A pipe fitting with external threads, used to close off an unused opening in a pipe fitting.
<b>Plug valve</b>	A lubricated quarter-turn valve containing a tapered conical flow element, that when rotated regulates the flow of fluid through the valve. These valves are common in natural gas service.
<b>Pressure reducing station (PRS)</b>	A piping system comprised of a number of components, that receives a high pressure process fluid (such as steam) and lowers the pressure so that the process fluid is suitable for use with downstream equipment. The main components include a pressure reducing valve (PRV), pressure gauges, isolating valves, a bypass valve, a strainer, unions, a sensing line downstream of the PRV, and a safety valve. In steam service, the piping is equipped with steam traps.
<b>Pressure reducing valve (PRV)</b>	A device that lowers the pressure of a process fluid to a desired downstream pressure setpoint, regardless of fluctuations in upstream pressure or flow conditions.
<b>PRS</b>	See <i>pressure reducing station</i> (PRS).
<b>PRV</b>	See <i>pressure reducing valve</i> (PRV).
<b>Reducer fitting</b>	A device used to connect pipes of different diameters
<b>Return bend</b>	A pipe fitting used for reversing direction of a pipe run by 180 degrees.
<b>Ring joint gasket</b>	A gasket that fits in a grooved flange face.
<b>Schedule number</b>	A number that represents pipe wall thickness.
<b>Socket welded fitting</b>	A fitting, such as a valve, fitting or flange, that has a recess to permit insertion of a pipe prior to it being welded into place.
<b>Steam separator</b>	A device installed in a steam line to remove moisture droplets and other suspended impurities from the steam, by forcing the steam to change direction.
<b>Steam trap</b>	An automatic valve that drains condensate from a steam-containing enclosure while remaining tight to live steam, or if necessary, allowing steam to flow at a controlled or adjusted rate. Most steam traps will also pass non-condensable gases while remaining tight to live steam. ANSI/FCI 69-1-1989



Term	Definition
<b>Tee</b>	Pipe fitting used for making a branch line connection at 90°. Reducing tees may have different sized openings for reducing the size of the pipes for the inlet, branch or outlet of the tee.
<b>Thermodynamic trap</b>	A steam trap that operates based on the difference between the heat energy of the steam and that of the condensate.
<b>Thermostatic trap</b>	A steam trap that operates based on the difference between the temperature of the steam and that of the condensate.
<b>Union</b>	A pipe fitting with two female threaded ends and a threaded connector nut in the middle. Used to allow easy assembly and disassembly of piping connections.
<b>Valve</b>	A device for regulating the flow of gases, liquids, and slurries through piping systems, or for isolating sections of piping systems.
<b>Valve trim</b>	The parts of a valve that contact the fluid in a piping system. Trim usually consists of the valve seat, valve disc or gate, valve stem, and guide bushings.
<b>Van stone flange</b>	A flange that fits loosely on the end of a pipe, so that sections of pipe can be more easily aligned during assembly.
<b>Water hammer</b>	Loud, violent shocks produced within a piping system. Typically caused by hydraulic shock, thermal shock, flow shock or differential shock.
<b>Wire drawing</b>	Damage to the surface of a valve seat, gate, or plug, caused by long-term throttling of process fluid, that prevents shut valves from completely stopping fluid flow. Wire drawing has the appearance of "cuts" on the valve trim surfaces.
<b>Y-bend fitting</b>	Pipe fittings used for making branch line connections at 45°.













