Chapter 15
Vessels

Objectives

Upon completion of this chapter, you will be able to:

15.1 Describe the purpose or function of vessels (tanks, drums, cylinders, dryers, filters, reactors, and bins/hoppers) in the process industries. (NAPTA Vessels 1) p. 213

15.2 Explain the relationship of pressure to the vessel shape and wall thickness. (NAPTA Vessels 2) p. 214

15.3 Define and provide examples of the following components as they relate to vessels:

desiccant
floating roof
articulated drain
blanketing
spherical tank
foam chamber
sump
mixer/agitator
gauge hatch
manway
heat tracing system (steam or electrical)
vapor recovery system
vortex breaker
baffle
weir
boot
mist eliminator
vane separator (NAPTA Vessels 4) p. 215

15.4 Describe the purpose of dikes, firewalls, and containment walls around vessels. (NAPTA Vessels 3) p. 220

15.5 Identify and describe the various types of reactors and their purpose. (NAPTA Vessels 7) p. 220

15.6 Identify possible hazards associated with vessels, including the following:

improper valve lineup
loss of nitrogen flow
cross contamination
failure of vent system
leaks/spills
chemical reactions (such as corrosion, pH, etc.) (NAPTA Vessels 8) p. 222

15.7 Describe the monitoring and maintenance activities associated with vessel operations. (NAPTA Vessels 5, 6) p. 223

Key Terms

American Society of Mechanical Engineers (ASME)—organization that provides laws of regulation for boilers and pressure vessels, **p. 214.**

Articulated drain—a hinged drain, attached to the roof of an external floating roof tank, that moves up and down as the roof and the fluid levels rise and fall, **p. 215.**

Atmospheric tank—an enclosed vessel that operates at atmospheric pressure; usually cylindrical in shape, equipped with either a fixed or floating roof, and containing nontoxic vapor liquids, **p. 214.**

Baffle—a metal plate, placed inside a tank or other vessel, that is used to alter the flow of chemicals or facilitate mixing, **p. 218.**

Batch reaction—a carefully measured and controlled process in which raw materials (reactants) are added together to create a reaction that makes a single quantity (batch) of the final product, **p. 220.**

Bin/hopper—a vessel that typically holds dry solids, **p. 214.**

Blanketing—the process of putting an inert gas, usually nitrogen, into the vapor space above the liquid in a tank to prevent air leakage into the tank, **p. 215.**

Boot—a section in the lowest area of a process drum where water or other liquid is collected and removed, **p. 219.**

Containment wall—an earthen berm or constructed wall used to protect the environment and people against tank failures, fires, runoff, and spills; also called a *bund wall*, *bunding*, *dike*, or *firewall*, **p. 220.**

Continuous reaction—a chemical process in which raw materials (reactants) are continuously being fed in and products are continuously being formed and removed from the reactor vessel, **p. 220.**

Cylinder—a vessel that can hold extremely volatile or high-pressure materials, **p. 215.**

Desiccant—a specialized substance contained in a dryer that removes hydrates (moisture) from the process stream, **p. 213**

Drum—a specialized type of storage tank or intermediary process vessel, **p. 214.**

Dryer—a vessel containing desiccant and screens across which process streams flow to have moisture (hydrates) removed, **p. 214**

Filter—a device used to remove liquid, gas, or solid particulates from the process stream, **p. 214.**

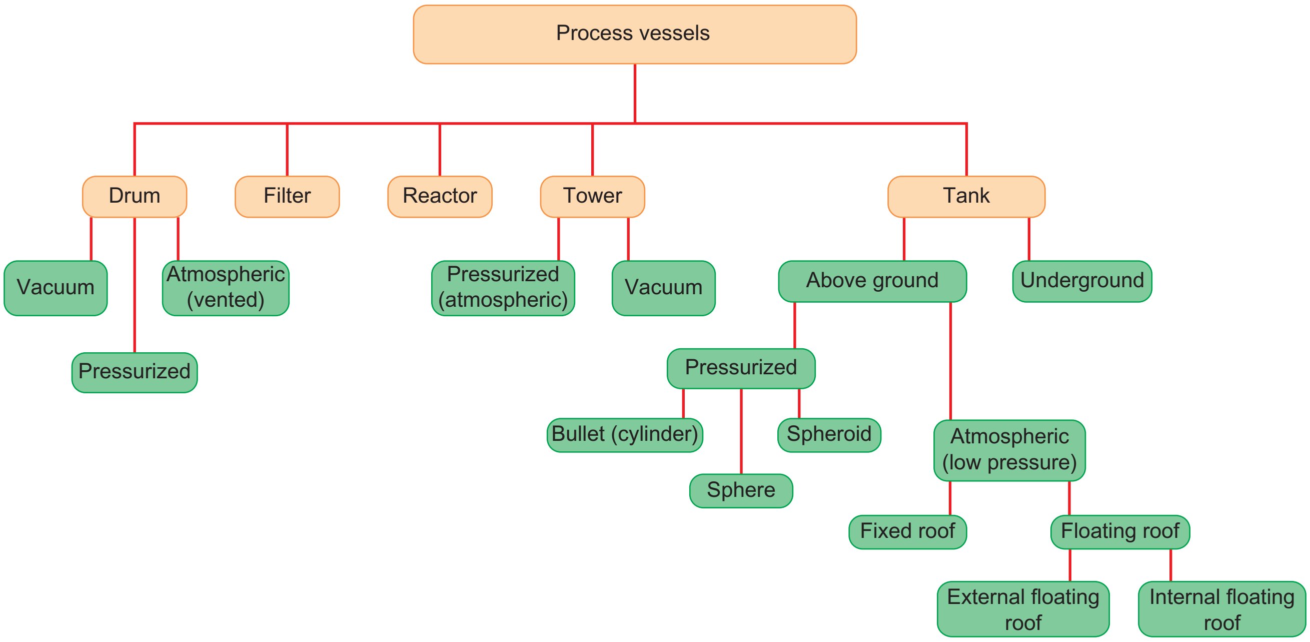
Fixed bed reactor—a reactor vessel in which the catalyst bed is stationary and the reactants are passed over it; in this type of reactor, the catalyst occupies a fixed position and is not designed to leave the reactor, **p. 221.**
Floating roof—a type of vessel covering (steel or plastic), used on storage tanks, that floats upon the surface of the stored liquid and is used to decrease vapor space and reduce potential for evaporation, **p. 215.**
Fluidized bed reactor—a reactor that uses high-velocity fluid to suspend or fluidize solid catalyst particles, **p. 222.**
Foam chamber—a reservoir and piping installed on liquid storage vessels and containing fire-extinguishing chemical foam, **p. 216.**
Gauge hatch—an opening on the roof of a tank that is used to check tank levels and obtain samples of the tank contents, **p. 217.**
Heat tracing—a coil of heated wire or tubing that adheres to or is wrapped around a pipe in order to increase the temperature of the process fluid, reduce fluid viscosity, and facilitate flow, **p. 218.**
Manway—an opening in a vessel that permits entry for inspection and repair, **p. 217.**
Mist eliminator—a device in the top of a tank, composed of mesh, vanes, or fibers, that collects droplets of mist (moisture) from gas to prevent it from leaving the tank and moving forward with the process flow, **p. 220.**
Mixer—a device used to mechanically combine chemicals or other substances; also known as an agitator, **p. 217.**
Pressurized tank—an enclosed vessel in which a greater-than-atmospheric pressure is maintained, **p. 214.**
Reaction furnace—a reactor that combines a firebox with tubing to provide heat for a reaction that occurs inside the tubes, **p. 222.**
Reactor—a vessel in which chemical reactions are initiated and sustained, **p. 220.**
Spherical tank—a type of pressurized storage tank that is used to store volatile or highly pressurized material; also referred to as "round" tanks, **p. 215.**
Stirred tank reactor—a reactor vessel that contains a mixer or agitator to improve mixing of reactants, **p. 221.**
Sump—an area of temporary storage located at the bottom of a tank from which undesirable material is removed, **p. 216.**
Tank—a large container or vessel for holding liquids and/or gases, **p. 213.**
Tubular reactor—a continuously flowed vessel in which reactants are converted in relation to their position within the reactor tubes, not influenced by residence time in the reactor, **p. 222.**
Vane separator—a device, composed of metal vanes, used to separate liquids from gases or solids from liquids, **p. 220.**
Vapor recovery system—the process of recapturing vapors by methods such as chilling or scrubbing; vapors are then purified, and the vapors or products are sent back to the process, sent to storage, or recovered, **p. 218.**
Vessel—a container in which materials are processed, treated, or stored, **p. 212.**
Vortex—the cone formed by a swirling liquid or gas, **p. 218.**
Vortex breaker—a metal plate, or similar device, placed inside a cylindrical, cone-shaped, or other type operating unit, which prevents a vortex from being created as liquid is drawn out of the vessel, **p. 218.**
Weir—a flat or notched dam or barrier to liquid flow that is normally used either for the measurement of fluid flows or to maintain a given depth of fluid as on a tray of a distillation column, in a separator, or other vessel, **p. 219.**

Introduction

Vessel a container in which materials are processed, treated, or stored.

Vessels (Figure 15.1) are a vital part of the operational units in the process industries. A **vessel** is a container in which materials are processed, treated, or stored. Without this type of

Figure 15.1 Types of vessels.



equipment, the process industries would be unable to create and store large amounts of product. Vessels include tanks, towers, reactors, drums, dryers, cylinders, hoppers, bins, and other similar containers that are used to process or store materials. Vessels vary greatly in design (e.g., size and shape) based on the requirements of the process. Factors that affect vessel design include pressure requirements, type of product contained in the vessel (liquid, gas, or solid), temperature requirements, corrosion factors, and volume.

By using tanks to store products in large quantities, companies can maximize both cost effectiveness and efficiency. Drums are used both for process mainstream applications and for auxiliary process applications. Reactors are used to provide the chemical reactions that some processes require to create the end product. Dryers use **desiccants** (specialized substances contained in a dryer that remove hydrates from the process stream). Hydrates (moisture) in a process stream could create a bottleneck in downstream operations. Towers, often the tallest vessels in a plant, are where separation or stripping processes take place. Vessels can operate 24 hours per day, and in all seasons. Many process fluids must maintain a certain temperature to ensure flow ability and stability. For this reason, the vessels that contain these fluids must be protected, particularly in areas of the country that have extremely low temperatures, such as Alaska, and in the winter months in the lower 48 states. Heat tracing, either steam or electrical in design, is placed on strategic areas of the vessel to ensure the contents remain at a constant temperature.

Desiccant a specialized substance contained in a dryer that removes hydrates (moisture) from the process stream

15.1 Purpose of Vessels

Vessels are used to carry out process operations such as distillation, drying, filtration, stripping, and reaction. These operations usually involve many different types of vessels, ranging from large towers to small additive and waste collection drums. Vessels are also used to provide intermediate storage between processing steps. They can provide residence time for reactions to complete or for contents to settle.

A storage **tank** is a common type of vessel, because every process requires containers to hold feed and other materials. Tanks are used for raw materials and additives (process inputs), intermediate (not-yet-finished) products, final products (process outputs), and wastes (recoverable or nonrecoverable off-spec products and by-products).

Tank a large container or vessel for holding liquids and/or gases.

Drum a specialized type of storage tank or intermediary process vessel.

Dryer a vessel containing desiccant and screens across which process streams flow to have moisture (hydrates) removed

Filter a device used to remove liquid, gas, or solid particulates from the process stream.

Bin/hopper a vessel that typically holds dry solids.

A **drum** is used for the collection and separation of material in processes for storage and for the separation of materials before furthering processing. Drums operate either under greater-than-atmospheric pressure or under vacuum pressure.

A **dryer** removes moisture from process streams. Dryers ensure that hydrates do not reach the lower-temperature sections of a process plant, such as distillation, or that hydrates are kept from processes that react with moisture.

A **filter** is used to remove liquid, gas, or solid particulates from the process stream. Filters help prevent damage to downstream equipment.

Bins or **hoppers** typically hold dry solids.

15.2 Types of Tanks

Tanks can reside above or below ground depending on service and location area. In the design and manufacture of tanks, key factors affect wall thickness, materials of construction, and the shape of the tank. These factors are pressure, temperature, and chemical properties. Tanks might be pressurized or operate at atmospheric pressure, depending on contents. Process tank specifications and operation are governed by specification codes from the **ASME** and regulations set by the EPA.

American Society of Mechanical Engineers (ASME) organization that provides laws of regulation for boilers and pressure vessels.

Gasoline (petroleum) storage tanks located at service stations are a good example of underground tanks having problems with corrosion. In the early 1980s, these tanks began to leak, contaminating soil and causing fumes to rise in nearby buildings. As a result, the EPA passed laws in 1988 regulating those tanks. Many are still being removed or replaced.

Atmospheric tank an enclosed vessel that operates at atmospheric pressure; usually cylindrical in shape, equipped with either a fixed or floating roof, and containing nontoxic vapor liquids.

An **atmospheric tank** is an enclosed vessel in which atmospheric pressure is maintained (i.e., these tanks are neither pressurized nor placed under a vacuum; they maintain the same pressure as the air around them). Atmospheric tanks are usually cylindrical (round) in shape and are equipped with fixed or floating roofs, or both. Figure 15.2 shows an example of an atmospheric tank.

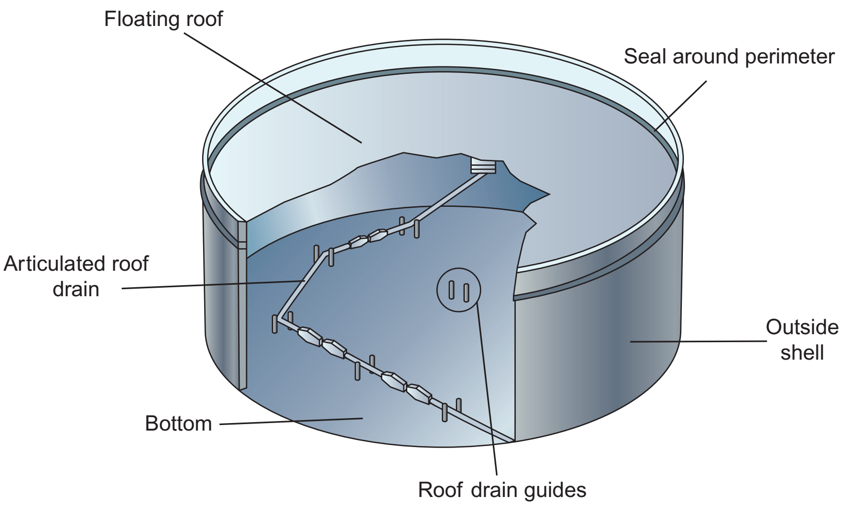
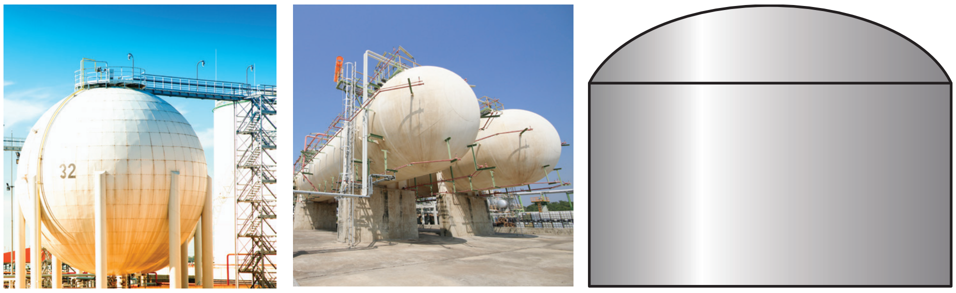


Figure 15.2 Example of a floating roof atmospheric tank.

Atmospheric tanks are usually made of steel plates that are welded together in large sections. Because they do not seal as tightly as pressurized tanks, atmospheric tanks are appropriate only for substances that do not contain toxic vapors or high vapor pressure liquids.

Pressurized tank an enclosed vessel in which a greater-than-atmospheric pressure is maintained.

A **pressurized tank** is an enclosed vessel in which a pressure greater than atmospheric pressure is maintained. Figure 15.3 shows examples of common pressurized tanks.



A. Spherical B. Cylindrical (Bullet) C. Hemispheroid

Figure 15.3 Spherical, cylindrical (bullet), and hemispheroid tanks.

CREDIT: A. Arcady/Fotolia (*sphere*). B. supakitmodn/Fotolia (bullet).

The most common types of pressurized tanks are:

- **Spherical tank**—a type of pressurized storage tank that is used to store volatile or highly pressurized material. Spherical tanks are sometimes referred to as "round" tanks. Their shape allows even distribution of pressure throughout the vessel. Figure 15.4 shows an example of a spherical tank.
- Cylindrical (bullet) tank—used for moderately pressurized contents; rounded ends distribute pressure more evenly than can be done in a nonrounded tank. A **cylinder** is a vessel that can hold extremely volatile or high-pressure materials (such as propane).
- Hemispheroid tank—used for low-pressure substances.

Did You Know?

The spherical tank is commonly called a "Hortonsphere." It was invented by Horace Ebenezer Horton, and the first field tanks were built in Port Arthur, Texas in 1923.

Spherical tank a type of pressurized storage tank that is used to store volatile or highly pressurized material; also referred to as "round" tanks.

Cylinder a vessel that can hold extremely volatile or high-pressure materials.

Figure 15.4 Spherical tank.

CREDIT: muratart/Fotolia.

15.3 Common Components of Vessels

Process technicians will work in various positions on the job site and should be familiar with the many different types of process vessels and their usage.

Tanks are used in many services, including auxiliary processes associated with the main process stream. The nature of the service dictates the type of tank used, its material of fabrication, its size, and regulatory ASME rating. Some of the major components of tanks are:

- **Floating roof**—a steel or plastic roof used on storage tanks; it floats upon the surface of the stored liquid and is used to decrease vapor space and reduce potential for evaporation. Floating roofs can be either internal or external. They use a flexible seal to prevent leakage. Because of their design, floating roofs are not appropriate for pressurized fluids.
- **Articulated drain**—hinged drain, attached to the roof of an external floating roof tank, which removes water from the roof. An articulated drain moves up and down as the roof and the fluid levels rise and fall.
- **Blanketing**—the process of putting an inert gas, usually nitrogen, into the vapor space above the liquid in a tank to prevent air leakage into the tank.

Floating roof a type of vessel covering (steel or plastic), used on storage tanks, that floats upon the surface of the stored liquid and is used to decrease vapor space and reduce potential for evaporation.

Articulated drain a hinged drain, attached to the roof of an external floating roof tank, that moves up and down as the roof and the fluid levels rise and fall.

Blanketing the process of putting an inert gas, usually nitrogen, into the vapor space above the liquid in a tank to prevent air leakage into the tank.

Blanketing a tank reduces the amount of oxygen present and decreases the risk of fire and explosion. Blankets also reduce the risk of tank *implosion* (collapse) by preventing a vacuum from being created as the tank is being emptied. Figure 15.5 shows an example of a tank blanketed with an inert gas.

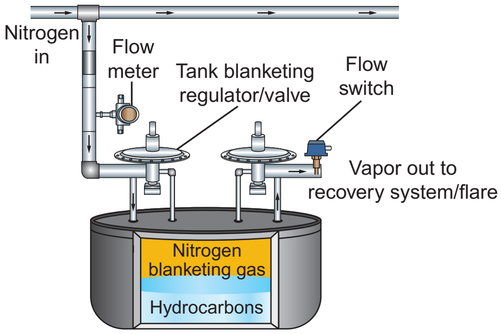
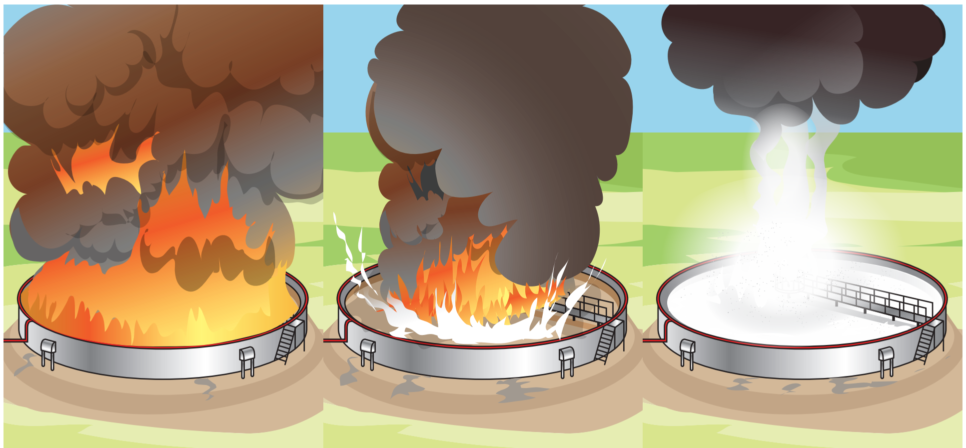


Figure 15.5 Tank blanketed with inert gas.

Foam chamber a reservoir and piping installed on liquid storage vessels and containing fire-extinguishing chemical foam.

- **Foam chamber**—a reservoir and piping installed on liquid storage vessels, which contain chemical foam used to extinguish fires within a tank. Figure 15.6 shows an example of a foam chamber.

Figure 15.6 Foam chamber putting out a fire.



Sump an area of temporary storage located at the bottom of a tank from which undesirable material is removed.

Did You Know?

In some regions of the United States and on oil rigs, sumps are sometimes referred to as "possum bellies."

- **Sump**—an area located at the bottom of a vessel that receives and temporarily stores drainage from the lowest point in that vessel. Figure 15.7 shows an example of a sump.

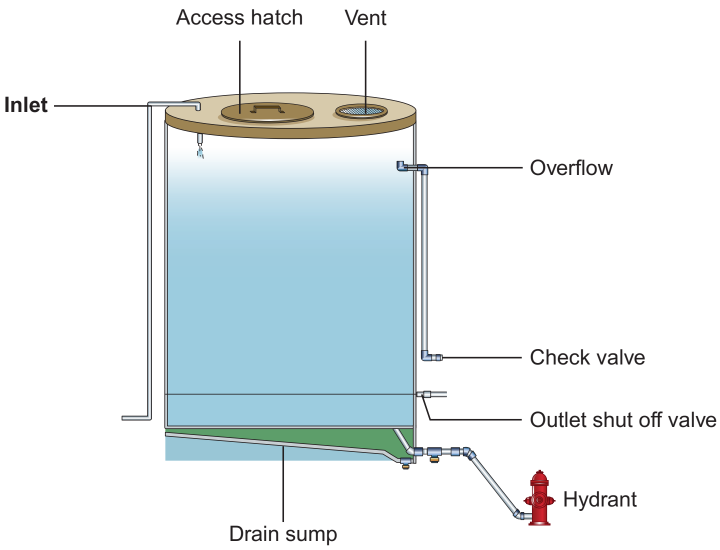


Figure 15.7 Sump.

- **Mixer**—a device used to stir chemicals or other substances; mixers can be mounted vertically or horizontally in a vessel. Mixers can be operated at the tank site using motors located outside the vessel or be started remotely, depending on the type of service. Figure 15.8 shows an example of a mixer.

Mixer a device used to mechanically combine chemicals or other substances; also known as an agitator.

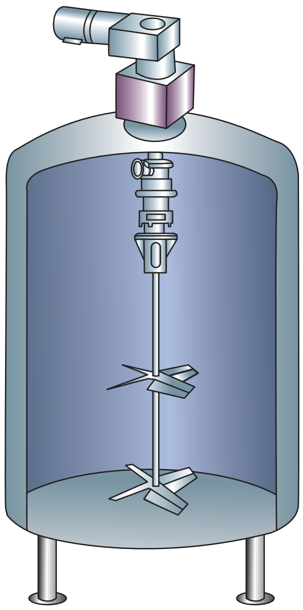


Figure 15.8 Mixer.

- **Gauge hatch**—an opening on the roof of a tank that is used to check tank levels and obtain samples of the tank contents. Figure 15.9 shows an example of a gauge hatch.

Gauge hatch an opening on the roof of a tank that is used to check tank levels and obtain samples of the tank contents.

Figure 15.9 Gauge hatch.

- **Manway**—an opening in a vessel that permits human entry for inspection and maintenance or repair. Most manways are flanged openings located on the roof or side of a tank. Figure 15.10 shows an example of a manway with bolts and nuts removed in preparation for entry.

Manway an opening in a vessel that permits entry for inspection and repair.

A.

B.

Figure 15.10 Manway. **A.** Illustration of manway entry port. **B.** Photo of manway in lower section of the vessel (see arrow).

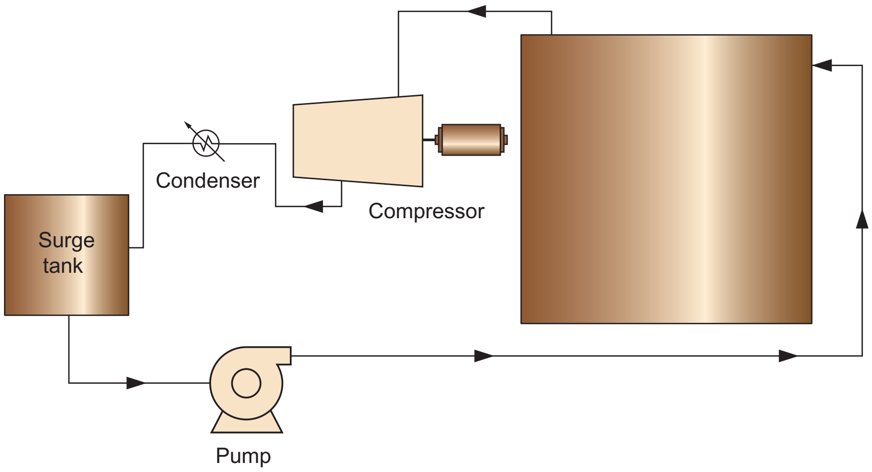
CREDIT: B. wittybear/Fotolia.

Heat tracing a coil of heated wire or tubing that adheres to or is wrapped around a pipe in order to increase the temperature of the process fluid, reduce fluid viscosity, and facilitate flow.

Vapor recovery system the process of recapturing vapors by methods such as chilling or scrubbing. They are then purified, and the vapors or products are sent back to the process, sent to storage, or recovered.

- **Heat tracing**—a coil of heated wire or tubing that adheres to or is wrapped around a pipe in order to maintain or increase the temperature of the process fluid, reduce fluid viscosity, and facilitate flow. Both steam and electrical types of heat tracing are used. Process piping using a heat tracing system is covered with thermal insulation to help maintain its temperature and also to protect personnel from burn injury.
- **Vapor recovery system**—the process of capturing evaporated fluid or vapors in the tank for recycling into the system or for reuse in another area. This method employs processes such as chilling or scrubbing. The recaptured materials are then purified, and the vapors or products are sent back to the process, sent to storage, or recovered. Figure 15.11 shows an example of a vapor recovery system.

Figure 15.11 Vapor recovery system.

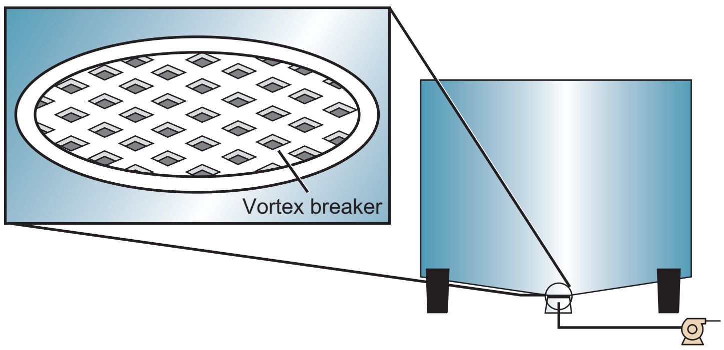


Vortex breaker a metal plate, or similar device, placed inside a cylindrical, cone-shaped, or other type operating unit that prevents a vortex from being created as liquid is drawn out of the vessel.

Vortex the cone formed by a swirling liquid or gas.

- **Vortex breaker**—a metal plate, or similar device, placed into the drain line of a cylindrical or cone-shaped vessel. It prevents a vortex from being created as liquid is drawn out of the tank. A **vortex** is the cone formed by a swirling liquid or gas. Vortex breakers are used to create a more linear flow from the tank and to prevent pump cavitation. Vortex breakers are also used in other vessels that need to maintain a constant flow through the equipment. Figure 15.12 shows an example of a vortex breaker.

Figure 15.12 Vortex breaker.



Baffle a metal plate, placed inside a tank or other vessel, that is used to alter the flow of chemicals or facilitate mixing.

- **Baffle**—a metal plate, placed at strategic positions inside a vessel, that alters the flow of the material in the vessel and can help to facilitate mixing. Figure 15.13 shows an example of a baffle.

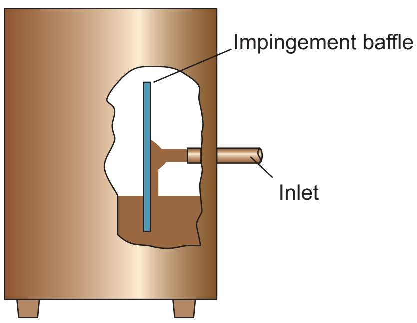


Figure 15.13 Baffle.

• **Weir**—a flat or notched dam or barrier to liquid flow that is normally used either to measure fluid flows or to maintain a given depth of fluid (setting the level). Figure 15.14 shows an example of a vessel (decanter) with a weir. In this example, anything that is above the weir flows over. Oil is lighter than water; it overflows the weir and is removed as the heavier component out the bottom. Because gasoline is also lighter than water, gasoline overflows the weir and is removed as gas out the top. This weir is used to separate three substances (oil, gasoline, and water) in a mixture.

Weir a flat or notched dam or barrier to liquid flow that is normally used either for the measurement of fluid flows or to maintain a given depth of fluid as on a tray of a distillation column, in a separator, or other vessel.

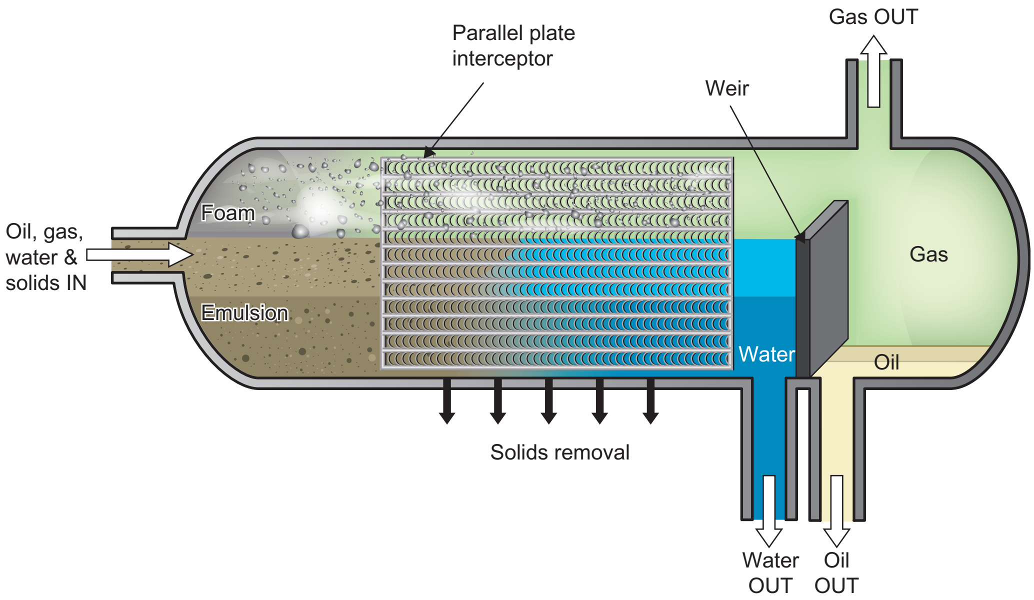


Figure 15.14 Weir in a decanter.

• **Boot**—a section at the bottom of a process vessel where water or other unwanted fluid is collected and removed. This area is located at the lowest section of the vessel. Figure 15.15 shows an example of a boot.

Boot a section in the lowest area of a process drum where water or other liquid is collected and removed.

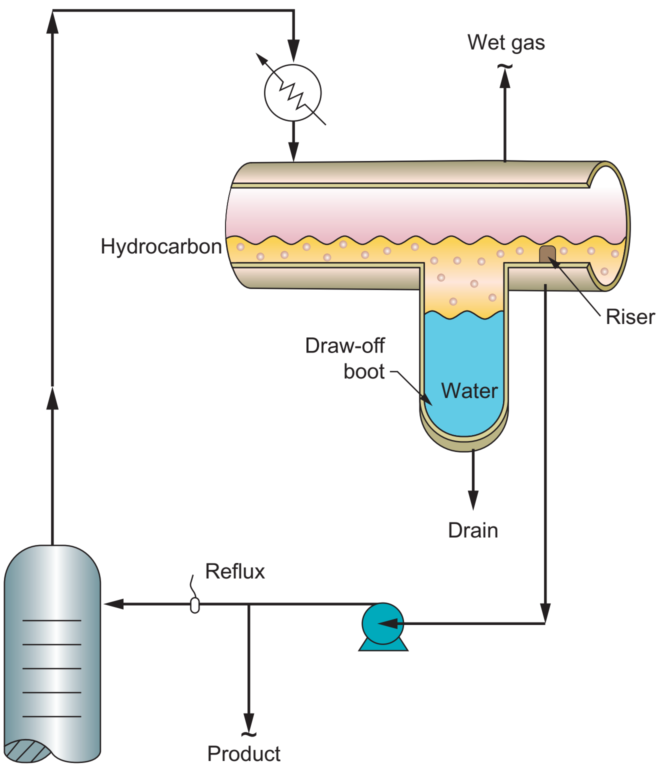


Figure 15.15 Vessel draw-off boot.

Mist eliminator a device in the top of a tank, composed of mesh, vanes, or fibers, that collects droplets of mist (moisture) from gas to prevent it from leaving the tank and moving forward with the process flow.

Vane separator a device, composed of metal vanes, used to separate liquids from gases or solids from liquids.

Containment wall an earthen berm or constructed wall used to protect the environment and people against tank failures, fires, runoff, and spills; also called a *bund wall*, *bunding*, *dike*, or *firewall*.

- **Mist eliminator**—a device placed in the top of a tank, composed of mesh, vanes, or fibers, that collects droplets of mist (moisture) from gas to prevent it from leaving the tank and moving forward with the process flow.
- **Vane separator**—a device, composed of metal vanes, used to separate liquids from gases or solids from liquids.

15.4 Containment Walls, Dikes, and Firewalls

OSHA requires all above-ground tanks to have a containment system built around them for personal and environmental safety in case of leaks, spills, or other accidents. A containment system, usually made from earth or concrete, can take the form of a dike, firewall, or containment wall. A **containment wall**, or dike, is a wall used to protect the environment and people against tank failures, fires, runoff, and spills. It can be earthen, masonry, steel, or concrete. Containment walls must be high enough to hold the entire contents of the largest tank within the enclosed area. Figure 15.16 shows an example of a containment wall. A firewall (also called a *bund*) is an earthen bank or concrete wall built around oil storage tanks to contain the oil in case of a spill or rupture.

Figure 15.16 Containment wall (also called firewall, bunding, bund wall, or dike).

CREDIT: Kat72/Shutterstock.

A containment system serves several functions:

- Contains chemical spills in a small area in order to minimize safety risks and trap contaminants and/or hazardous materials before they can spread to other areas
- Protects the soil, water, and the environment from contaminants
- Protects humans from potential hazards (e.g., chemical release)
- Contains wastewater and contaminated rainwater until it can either be drained into a proper process sewer system line or be vacuumed from the area
- Protects against the spread of fires

With certain types of tanks, in the event of heavy rainfall, technicians must open a valve and drain the liquid from within the containment wall to prevent the tank from floating. This rainfall buildup must be tested to be free of contaminants prior to draining.

Reactor a vessel in which chemical reactions are initiated and sustained.

Batch reaction a carefully measured and controlled process in which raw materials (reactants) are added together to create a reaction that makes a single quantity (batch) of the final product.

Continuous reaction a chemical process in which raw materials (reactants) are continuously being fed in and products are continuously being formed and removed from the reactor vessel.

15.5 Reactors: Purpose and Types

A **reactor** is a vessel in which chemical reactions are initiated and sustained. Within a reactor, raw materials are combined at various flow rates, pressures, and temperatures, and they react to form a product. These reactions can be either batch or continuous. **Batch reactions** are complete loads done start to finish and then removed. **Continuous reactions** are an ongoing process with raw materials entering and product being removed from the reactor.

Reactors come in many shapes and sizes. The most common types of reactors are stirred tank, fixed bed, fluidized bed, tubular, and reaction furnace. The type of catalyst and the properties of the reactants determine which type of reactor will be used.

- A **stirred tank reactor** (Figure 15.17) contains a mixer or agitator mounted to the tank. The shell, or jacket, of this type reactor can be heated or cooled, depending on the process and design.

Stirred tank reactor a reactor vessel that contains a mixer or agitator to improve mixing of reactants.

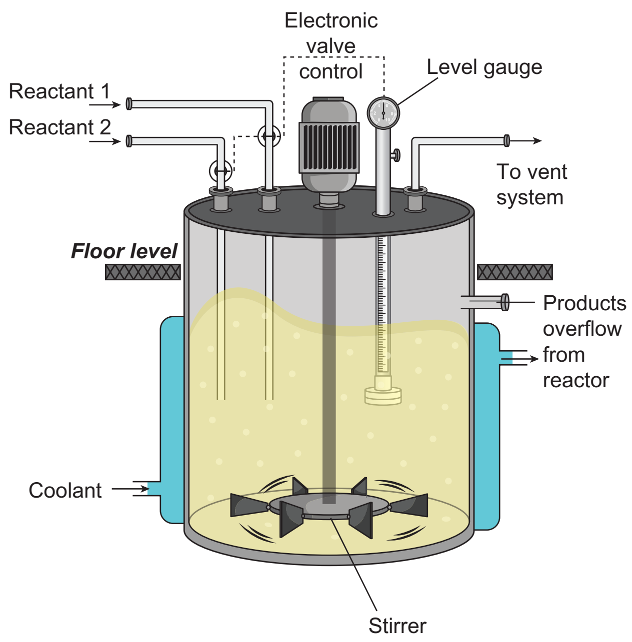


Figure 15.17 Stirred tank reactor.

- A **fixed bed reactor** (Figure 15.18) is a reactor vessel in which the catalyst bed is stationary and the reactants are passed over it. In this type of reactor, the catalyst occupies a fixed position; it is not designed to leave the reactor.

Fixed bed reactor a reactor vessel in which the catalyst bed is stationary and the reactants are passed over it.

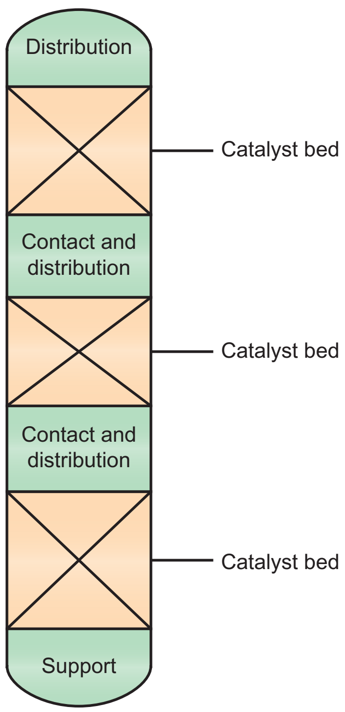
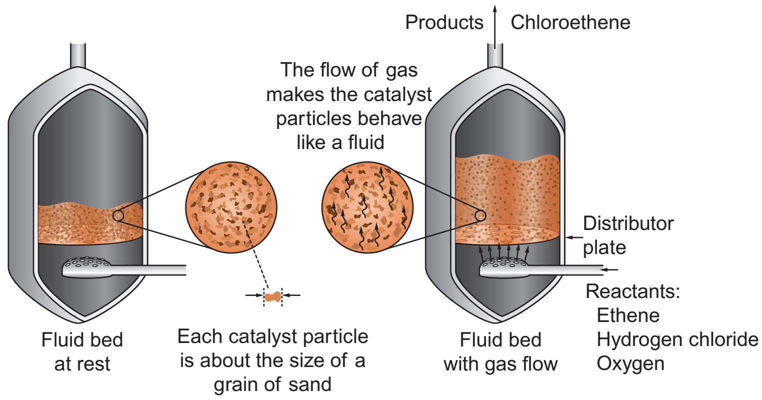


Figure 15.18 Fixed bed reactor.

Fluidized bed reactor a reactor that uses high-velocity fluid to suspend or fluidize solid catalyst particles.

- A **fluidized bed reactor** (Figure 15.19) uses high-velocity fluid to suspend and separate solids. The reactor feed is mixed with the suspended catalyst where the reaction takes place.

Figure 15.19 Fluidized bed reactor.

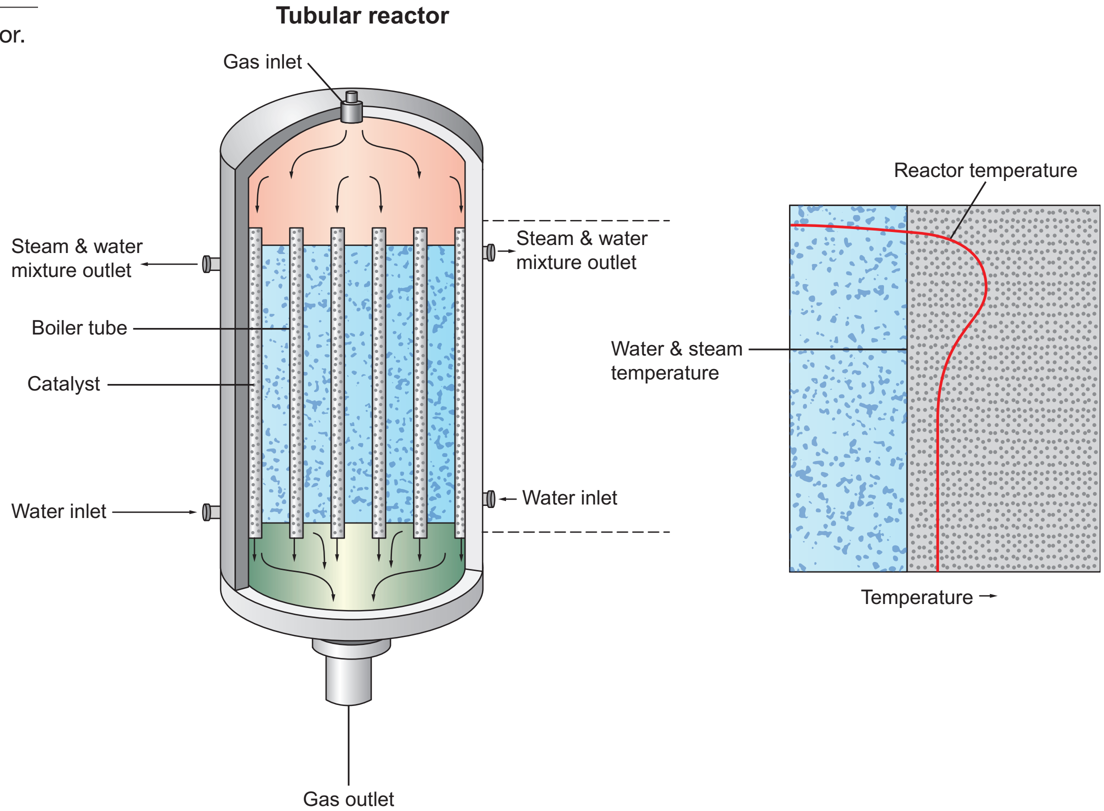


Tubular reactor a continuously flowed vessel in which reactants are converted in relation to their position within the reactor tubes, not influenced by residence time in the reactor.

Reaction furnace a reactor that combines a firebox with tubing to provide heat for a reaction that occurs inside the tubes.

- A **tubular reactor** (Figure 15.20) is a cylindrical heat exchanger used to contain a reaction. Based on process requirements, the design of a tubular reactor can range from a simple jacketed tube to a multipass shell and tube exchanger.
- A **reaction furnace** combines a firebox with tubing to provide heat for a reaction that occurs inside the tubes.

Figure 15.20 Tubular reactor.



15.6 Operational Hazards

Many hazards are associated with vessels. Table 15.1 lists some of those hazards. Process technicians must stay alert to these hazards in order to protect people, the environment, and equipment.

Retraining might be required if safety measures are not upheld.

Table 15.1 Hazards Associated with Improper Operation

Improper Operation	Possible Impacts			
	Individual	Equipment	Production	Environment
Overfilling	Exposure to hazardous chemicals; possible injury	Damage to tank and equipment, especially floating roof tanks	Added cost for cleanup; lost product or raw material	Spill, possible fire, vapor release
Putting wrong or off-spec material in storage tank	Possible action related to accountability if root cause indicates operator error	Contamination of product, could create an undesired reaction between materials	Added cost to remove material, clean tank, and re-run material	Spills when removing material and cleaning tank, or unwanted chemical reactions
Misalignment of blanket system	Possible action related to accountability for actions	Loss of blanket; collapse of tank because of vacuum	Loss of production because of reduced storage	Vapor release
Misalignment of pump systems	Accountability for actions	Damaged pump	Contamination of other tanks	Spill
Pulling a vacuum on a tank while emptying	Accountability for actions	Collapse of tank because of vacuum	Loss of production because of reduced storage	Vapor release
Overpressure	Accountability for actions; exposure to hazardous chemicals; possible personal injury	Rupture of vessel	Loss of production because of reduced storage	Vapor release, fire, or explosion
Improper valve lineup	Retraining if root cause not equipment but operator error	Possible over-pressure or deadhead	Cross contamination or loss of feed stream	
Loss of nitrogen flow	Retraining if root cause not equipment but operator error	Possible vacuum and air entry into tank, possible corrosion	Possible decomposition of material	Possible vapor release
Cross contamination	Retraining in the case of misaligned valves	Possible corrosion or erosion of vessel	Possible out of specification material	
Failure of vent system	Possible personal injury if tank ruptures	Possible rupture of vessel from overpressure	Possible decomposition of material	Possible release to atmosphere or spill to the ground surface
Leaks & spills	Possible personal injury from contact with material	Vessel could have a weak spot causing a leak	Loss of production because of loss of material	Ground or air pollution because of release of material
Chemical reactions	Possible personal injury if exposed to the reaction	Possible corrosion or erosion of the vessel because of unwanted chemical reaction	Loss of production because of contaminated product	Possible environmental contamination if reaction causes a release from the vessel

15.7 Monitoring and Maintenance Activities

When monitoring and maintaining vessels, process technicians must always remember to look, listen, check, and smell for the items listed in Table 15.2.

Failure to perform proper maintenance and monitoring could affect the process and result in harm to people, the environment, and equipment.

Table 15.2 Monitoring and Maintenance Activities for Vessels

Look	Listen	Feel	Smell
■ Monitor level ■ Check firewalls, sumps, and drains ■ Check auxiliary equipment associated with the vessel ■ Check to ensure the drain remains closed ■ Visually inspect for leaks (especially if associated with abnormal odor) ■ Check sewer valves ■ Use level gauges and sight glasses to monitor level ■ Monitor pressure ■ Inspect for corrosion and discoloration ■ During heavy rainfall, open valves as needed to prevent vessels from floating	■ Listen for abnormal noise	■ Inspect for abnormal heat on vessels and piping ■ Check for excessive vibration on pumps/mixers	■ Be aware of abnormal odors that could indicate leakage ■ Use sniffers to detect gas leaks and vapors

Symbols for Vessels and Reactors

In order to accurately locate vessels (e.g., tanks, drums) and reactors on a piping and instrumentation diagram (P&ID), process technicians need to be familiar with the symbols that represent different types of tanks, drums, vessels, and reactors. Figure 15.21 shows examples of vessel symbols.

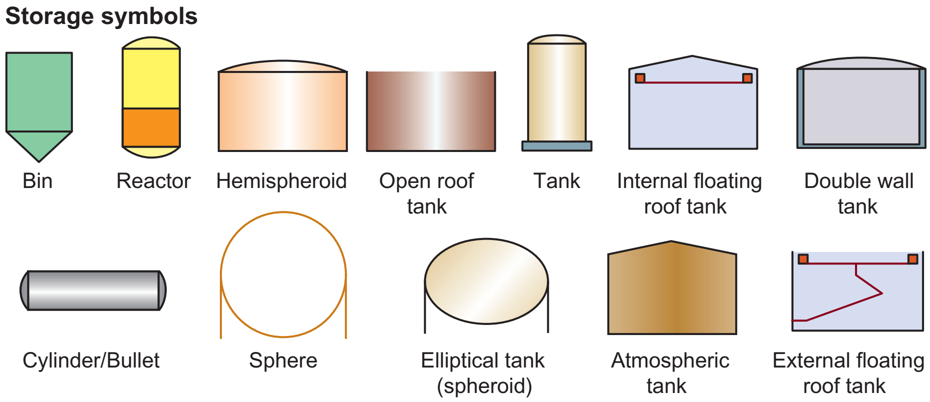


Figure 15.21 Vessel symbols.

Summary

Vessels are integral to the completion of products and services associated with the process unit. Materials are processed, treated, or stored within many different types of vessels. Vessels enable the process industries to create and store large amounts of products for sale and distribution.

Vessels, such as tanks, towers, reactors, drums, dryers, filters, cylinders, hoppers, bins, and other similar containers are used to process or store materials. Vessels vary greatly in design (e.g., size and shape) based on the requirements of the process. Factors that affect vessel design may include pressure requirements, type of product contained in the vessel (liquid, gas, or solid), temperature requirements, corrosion factors, and volume.

Reactors are specialized vessels that are used to contain a controlled chemical reaction, changing raw materials into finished products. Reaction variables include temperature, pressure, time, concentration, surface area, and other factors. Like vessels, reactor designs vary widely based on the chemical reaction that must occur in the process.

The process technician must recognize and understand vessel components, including floating roof, articulated drain, blanketing, foam chamber, sump, mixer, gauge hatch, manway, vapor recovery system, vortex breaker, baffle, weir, boot, mist eliminator, and vane separator.

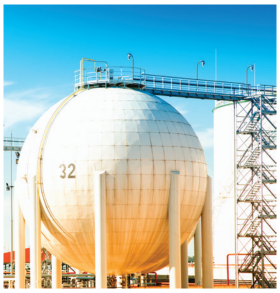
Some vessels have a containment system built around them for personal and environmental safety in case of leaks, spills, or other accidents. A containment system, usually made from earth or concrete, can take the form of a dike, firewall, or containment wall.

Process technicians must always remember to look, listen, feel, and smell when monitoring and maintaining vessels. They also must be aware of the hazards of improper operations of vessels in order to protect people, the environment, and equipment.

Process technicians need to be familiar with the symbols that represent different types of tanks, drums, vessels, and reactors, and be able to accurately locate vessels on a piping and instrumentation diagram (P&ID).

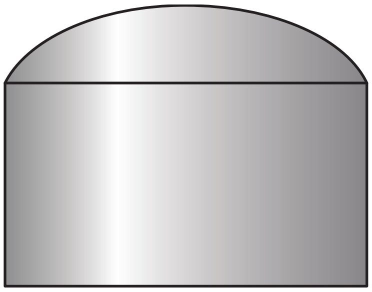
Checking Your Knowledge

1. Define the following terms:
   a. articulated drain
   b. baffle
   c. blanket
   d. boot
   e. containment wall
   f. floating roof
   g. gauge hatch
   h. manway
   i. mist eliminator
   j. mixer
   k. sphere
   l. sump
   m. vane separators
   n. vapor recovery
   o. vortex breaker
   p. weir
2. Which of the following tanks would the most appropriate choice for storing volatile substances under pressure? Provide the label letter and the tank name.



A.


B.


C.

3. *(True or False)* Atmospheric tanks are good for storing substances with toxic vapors.
4. List three purposes for the use of dikes and containment walls.
5. List at least three hazards or impacts associated with improper tank operation.
6. List at least three things a process technician should listen, feel, and smell for during normal monitoring and maintenance.

NOTE: Answers to Checking Your Knowledge questions are in Appendix I.

Student Activities

1. Given a picture of a high pressure storage tank, identify the following components:
   a. blanket
   b. manway
   c. spherical tank
   d. vapor recovery system
   e. vortex breaker
2. Describe the following types of reactors, including design, purpose, and how they work:
   a. stirred tank
   b. fixed bed
   c. fluidized bed
   d. tubular
   e. reaction furnace
3. Given a piping and instrumentation diagram (P&ID), identify vessels found on the unit.