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

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**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.

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**Introduction**

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
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.

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).
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.

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.

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.

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.

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.
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.

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.
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.

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

**Figure 15.6** Foam chamber putting out a fire.

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**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.

**Did You Know?**

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

**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.

![Figure 15.8 Mixer](image)

• **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.

![Figure 15.9 Gauge hatch](image)

• **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.

![Figure 15.10 Manway](image)
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.

Vortex breaker—a metal plate, or similar device, placed into the drain line of a cylindrical, cone-shaped, or other type operating unit that 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.

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.
• **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 in a decanter](image)

**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.

![Vessel draw-off boot](image)

**Figure 15.15** Vessel draw-off boot.
A containment system serves several functions:

- **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; also called a **bund wall**, bunding, dike, or firewall.

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.

### 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 Diagram](image)

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

- **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 Diagram](image)

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

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.

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.

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

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

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

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

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

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

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.

![Tank Images]

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.