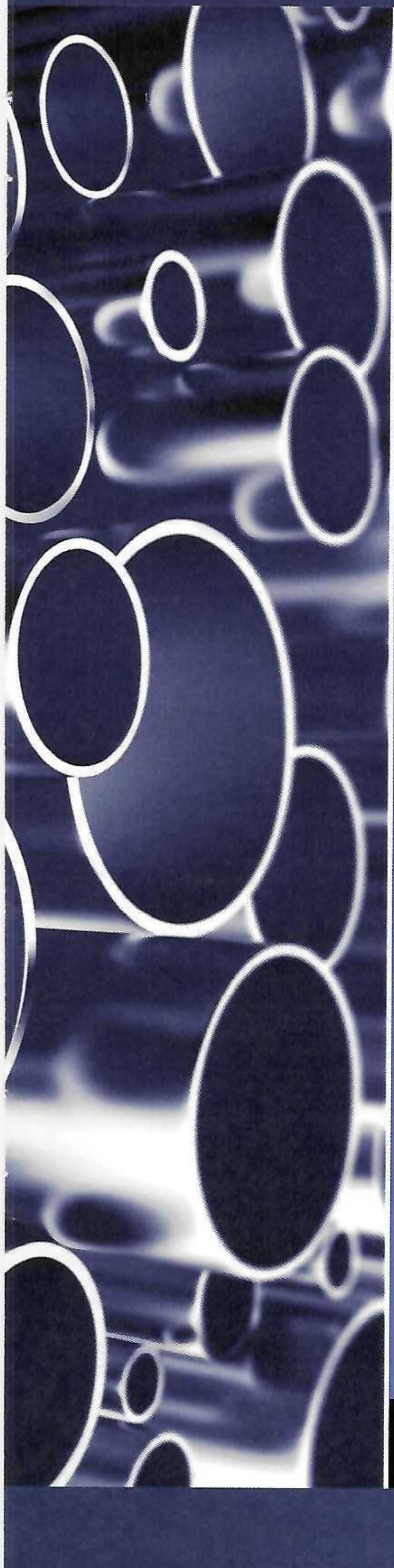
Introduction to Drain, Waste, and Vent (DWV) Systems



Overview

To design, install, and maintain drain, waste, and vent (DWV) systems, plumbers must be familiar with the factors that affect them. Sanitary drainage systems include the piping system inside the building, the drainpipe buried outside the building, and the public sewer. Knowing how drains, fittings, vents, and pipe move waste out of a building enables plumbers to prevent system malfunctions.

Module 02111

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02111 V4.5

02111
Introduction to DWV Systems

Objectives

Successful completion of this module prepares trainees to:

1. Identify the major components of a DWV system and describe their functions.
   a. Identify and describe the components of DWV systems.
   b. Explain the requirements for sizing of drains and vents.
2. Describe the types, purpose, and construction of traps.
   a. Identify the types of traps.
   b. Identify the parts of traps.
   c. Describe the ways traps can lose their seal.
3. Describe the types of fittings used in DWV systems.
   a. Describe the materials used in making DWV fittings.
   b. Identify the types of DWV fittings and their requirements.
4. Describe the construction of various DWV systems.
   a. Explain the importance of grade.
   b. Describe the construction of sewer and waste treatment facilities.
   c. Identify the health concerns associated with DWV systems.
   d. Explain how plumbing codes affect the construction of DWV systems.

Performance Task

Under the supervision of your instructor, you should be able to do the following:

1. Sketch an isometric drawing of a simple DWV system and label its components.

Trade Terms

Adapters
Back pressure
Branch interval
Building sewer
Capillary action
Cleanout
Double ¼ bends
Double trapping
Drain, waste, and vent (DWV) system
Drainage fittings
Elevation
Evaporation
Fall
Fixture drains
Grade
Graywater
Heel inlets
Hydraulic gradient
Interceptors
Inverted wyes
Long sweep ¼ bends
P-trap
Pipe scale
Runs
S-traps
Sanitary combination
Sanitary fittings
Sanitary increasers
Sanitary upright wyes
Sanitary wyes
Short sweep ¼ bends
Side inlets
Siphonage
Sludge
Spigot
Stack
Test tees
Velocity
Vent branch
Vent ells
Vent tees
Weir

Industry Recognized Credentials

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CODE NOTE

Codes vary among jurisdictions. Because of the variations in code, consult the applicable code whenever regulations are in question. Referring to an incorrect set of codes can cause as much trouble as failing to reference codes altogether. Obtain, review, and familiarize yourself with your local adopted code. Safety codes are developed by the US Occupational Safety and Health Administration (OSHA).

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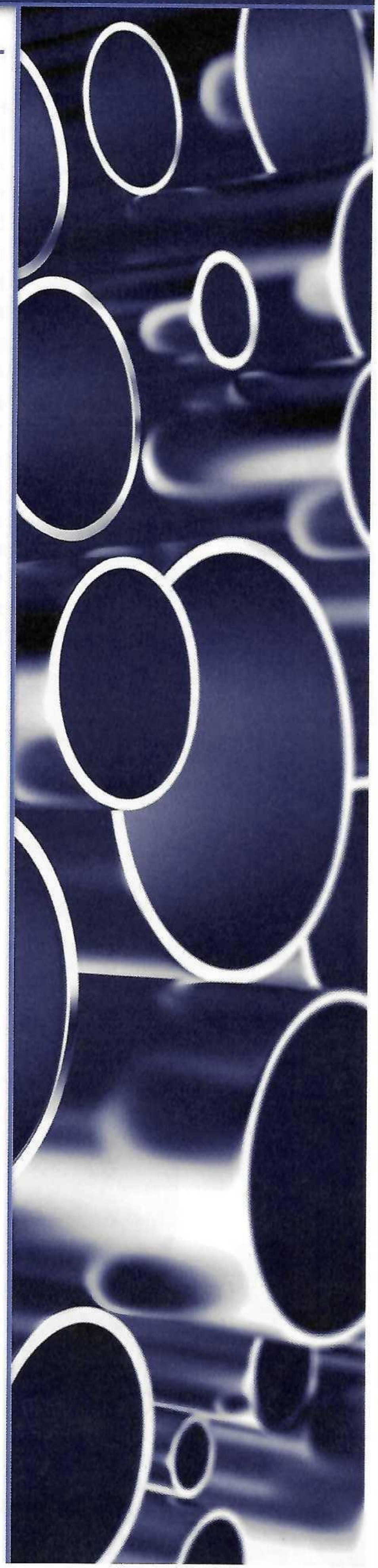

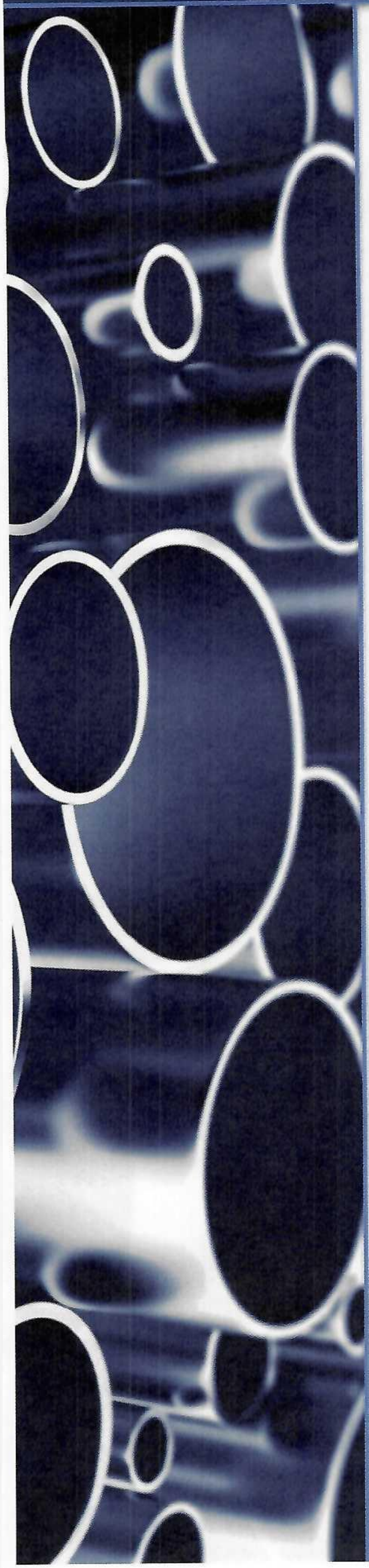

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SECTION ONE

1.0.0 DRAIN, WASTE, AND VENT SYSTEM OVERVIEW

Objective

Identify the major components of a DWV system and describe their functions.

a. Identify and describe the components of DWV systems.
b. Explain the requirements for sizing of drains and vents.

Trade Terms

Adapters: Fittings that join pipes of different sizes or materials, such as copper and galvanized pipe or cast-iron and plastic pipe.

Building sewer: The part of the drainage system that extends from the end of the building drain and conveys its discharge to a public sewer, private sewer, individual sewage-disposal system, or other point of disposal.

Drain, waste, and vent (DWV) system: Refers to the combined sanitary drainage and venting systems. This term is technically equivalent to soil-waste-vent (SWV).

Fixture drains: The drains from traps of fixtures to the junction of those drains with any other drain pipe.

Graywater: Wastewater generated from domestic processes other than human-waste disposal. These include laundry, dishwashing, and bathing. Graywater comprises 50 to 80 percent of residential wastewater.

Plumbers need to understand how drainage systems work and know the flow of waste products from a building, to the treatment facilities, and back into the ecosystem (streams, rivers, and lakes). This cycle begins at the fixture drains that connect to the drain, waste, and vent (DWV) system. Waste, either liquid or in solution with solids, enters the DWV system from the fixture drains and flows into the building's sanitary pipe system. The pipe system is designed to remove this waste safely from the building's interior.

Sanitary drainage systems can be divided into three main parts (see *Figure 1*):

- The pipes inside the building, usually referred to as the DWV system
- The drainpipe buried outside the building, which is called the building sewer
- The public sewer, which carries the building wastes to the treatment plant and eventually back to the ecosystem

Certain installations may include a graywater system in addition to the DWV system. This piping collects used water from sinks, showers, and laundry facilities. Because it captures and reuses water that would otherwise be wasted, a graywater system is considered a green application. Graywater is mainly used to flush toilets or provide irrigation for landscapes. Most jurisdictions do not allow graywater irrigation of edible plants and some restrict the use to subsurface irrigation. Graywater systems must be carefully designed to meet local plumbing codes as well as health department requirements.

1.1.0 DWV System Components

Plumbers may design, install, and maintain the DWV systems inside buildings and the building sewers buried outside on the property. Usually, the municipality is responsible for installing and maintaining the public sewers, lift stations, and treatment plants.

1.1.1 Building DWV Systems

The DWV system inside a building is a circuit of piping designed to remove the wastes from plumbing fixtures and drains safely, reliably, and efficiently. There are many names for each type of pipe and fitting in this network. *Figure 2* illustrates the major components of a DWV system, including the following:

- Building drain
- Soil stack
- Stack vent
- Individual vents
- Fixture branches
- Fixture drain or trap arm
- Traps
- Bends or elbows
- Tees
- Wyes
- Couplings, reducers, and adapters

In some applications a graywater system may be added to the DWV system. These systems can redirect graywater for certain uses without treatment if allowed by local codes.

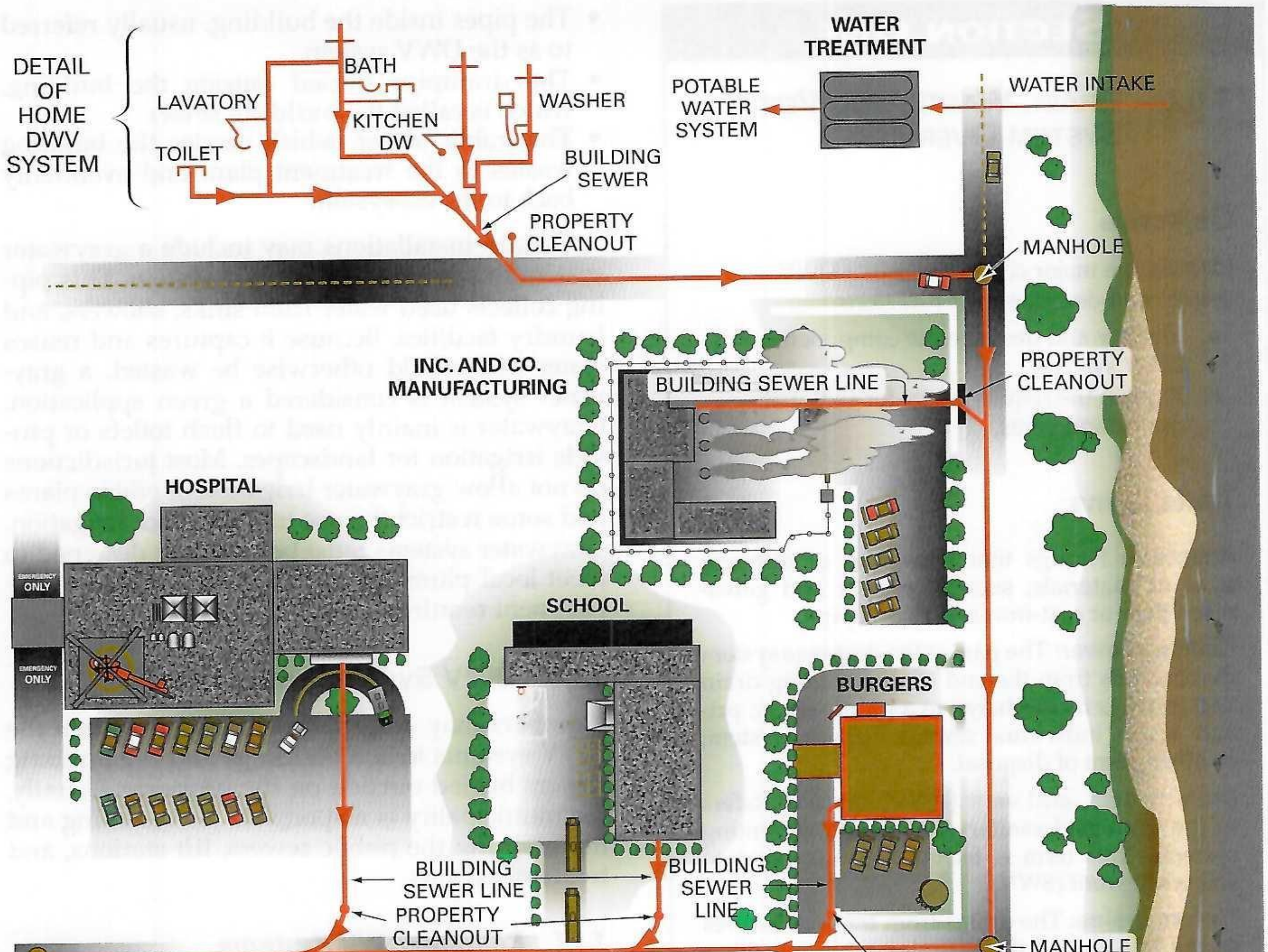


Figure 1 Overview of a typical community sewer system.

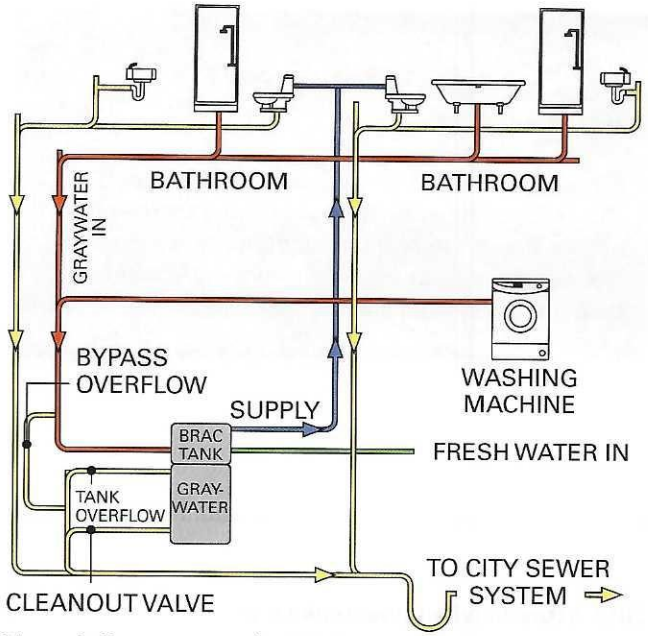


Figure 2 Components of a DWV system and graywater system.

Figure 3 Fixture drains.

1.1.2 Fixture Drains

Fixture drains connect fixtures to the building's DWV piping system. Many fixtures have drains that strain the wastewater before it enters the drainage piping. Examples of fixture drains include a basket strainer for a kitchen sink, PO (pop-up) plugs for lavatories, and other strainers for bidets and showers (*Figure 3*).

1.2.0 Sizing Drains and Vents

Drainage systems fall into two major categories: storm water drains and building drains. In addition, graywater systems may be used in many areas to address environmental issues. These systems are increasingly being used in commercial or industrial applications to meet LEED (Leadership in Energy and Environmental Design) requirements. Storm water drains collect storm water from roofs and pavement. The water is either held for on-site disposal or is discharged at a certain rate into a storm sewer system. The sizing of storm drainage systems is based on expected rainfall. Building drainage systems must be appropriately sized based on the expected water use in the building. Plumbers must understand the mechanics of fluid flow through pipe to properly size drains and vents.

GOING GREEN

Graywater Systems

The plumbing industry is increasingly adopting green practices. It recognizes the benefits of recycling and reusing limited resources. However, adopting new practices comes with some challenges. Consider the use of graywater for landscape irrigation. Everyone agrees that it is a good idea, but local jurisdictions tend to differ in their acceptance of these systems. For example, some jurisdictions still define graywater as sewage. As a result, they won't permit using graywater for landscape irrigation. Other jurisdictions may discourage its use with expensive and complex approval requirements. Communities and governments must weigh the benefits of graywater use against potential health risks, additional regulation, and additional costs. As communities develop experience with graywater systems, restrictions and codes will likely change. This situation means plumbers should be paying close attention to code changes that apply in their work area. It also means being aware of other authorities such as the local health department, which also may impose rules for graywater reuse. Complicated? Yes. But many believe that the use of graywater systems will continue to grow in response to environmental concerns.

Vents are used in plumbing systems to balance pressure in the piping network. This balance of pressure is necessary to prevent the fixture traps from losing their seals. For the vents to function properly, plumbers must size the vents correctly according to how many fixtures are connected, the number of drainage fixture units (how much water discharges into the drain per minute), and the length of the vent pipe. If inadequately-sized vents are installed, the plumbing system does not work properly. You will learn how to size drainage and venting systems as you advance through the plumbing curriculum.

Did You Know?

"PO"

PO originally stood for plug opening. This term comes from the early type of lavatory fixtures that used a stopper to seal off the drain. Now, lavatory drains with pop-up assemblies are more common than the older chain and stopper types.

Additional Resources

"Design of Sewer System." Civil Engineers PK. Updated 2017. **https://civilengineerspk.com/**

2015 International Plumbing Code Commentary (Includes IPSDC), 2014. International Code Council (ICC).

Plumbing Venting: Decoding Chapter 9 of the IPC, Bob Scott. 2014. Procodeclasses.

1.0.0 Section Review

1. Systems that can capture water that is not heavily contaminated and redirect it for certain uses without treatment if allowed by local codes are called _____.
   a. hard water
   b. ground water
   c. graywater
   d. blackwater
2. What is the main factor when engineers set the sizes of stormwater drain piping in building plans?
   a. The size of the building
   b. The expected rainfall
   c. The frequency of major storms
   d. The capacity of the water treatment plant

Section Two

2.0.0 DWV Traps

Objective

Describe the types, purpose, and construction of traps.

a. Identify the types of traps.
b. Identify the parts of traps.
c. Describe the ways traps can lose their seal.

Trade Terms

Back pressure: A condition which may occur in the DWV system whereby a higher pressure than atmospheric pressure is created in the drain/vent piping, causing a reversal of the normal flow through drain piping and traps. Also referred to as backpressure backflow.

Capillary action: The tendency of water to be drawn into porous or fibrous material against gravity above the level of the water source.

Cleanout: An access point to connected parts of the drainage system for the removal of blockages.

Double trapping: A situation in which one trap is attached to another, creating negative pressure that stops the intended flow of drainage.

Evaporation: The natural change from liquid to vapor of water at a temperature below its boiling point.

Fall: The amount of slope given to horizontal runs of pipe expressed as a height in inches per foot of run.

Hydraulic gradient: The level of the surface of water flowing in a partially-full pipe by gravity alone.

Interceptors: Devices designed and installed so as to separate and retain deleterious, hazardous, or undesirable matter from normal waste, while permitting normal sewage or liquid wastes to discharge into the drainage system by gravity.

P-trap: A trap constructed in the shape of the letter P with the loop facing downward, which provides a water seal in a waste or soil pipe, used mostly at sinks and lavatories.

Siphonage: Loss of water in a trap seal started by unequal pressure inside and outside DWV piping. The water initially flows in the direction of the lower pressure. Sustained siphonage, even in the absence of pressure differences, results from the cohesive property of water.

Stack: A general term for certain vertical DWV pipes, including offsets of soil, waste, vent, or inside conductor piping. This does not include vertical fixture and vent branches that do not extend through the roof or that pass through not more than two stories before being reconnected to the vent stack or stack vent.

S-traps: Traps with long downstream legs, which tend to promote siphonage. S-traps are no longer permitted by code for new installations but are still found in older buildings.

Weir: When referring to plumbing, a ledge or lip in a fixture that controls the level of water inside the fixture. The word comes from Old English, meaning dam.

Traps and vents protect the safety of homes and other buildings. The water seal in a trap protects people from airborne pathogens (germs), foul odors, and potentially explosive sewer gases.

Traps are important components of the DWV piping system and is a fitting or device that provides a liquid seal of 2" to 4". This seal prevents sewer gases from leaking back into the building but should not affect the flow of sewage or wastewater through the drain. As will be explained later in this module, vents protect trap seals.

Modern codes require every plumbing fixture to have a trap that protects the fixture and users from the sanitary drain system. Some fixtures, such as water closets and many urinals, have integral or built-in traps.

A fixture trap is a vital part of any DWV system. To function properly, a fixture trap must flush completely, be self-cleaning, have a smooth interior waterway, and be accessible for cleanout. The depth of the seal and the amount of water normally held in the trap are important factors in trap design. The fixture trap, which creates a water seal, requires a vent system to protect it from **siphonage**, **back pressure**, wind, and aspiration. Back pressure is often referred to as backpressure backflow.

2.1.0 Types of Traps

The **P-trap** is the most commonly used trap. P-traps can be one-piece or two-piece with a union nut. P-traps can also have a **cleanout**. Several styles of P-traps are shown in *Figure 4*. P-traps designed to be attached directly to fixtures are usually 1¼" to 1½" for sinks and lavatories, 1½" to 2" for tubs and showers, and 2" to 4" for floor drains.

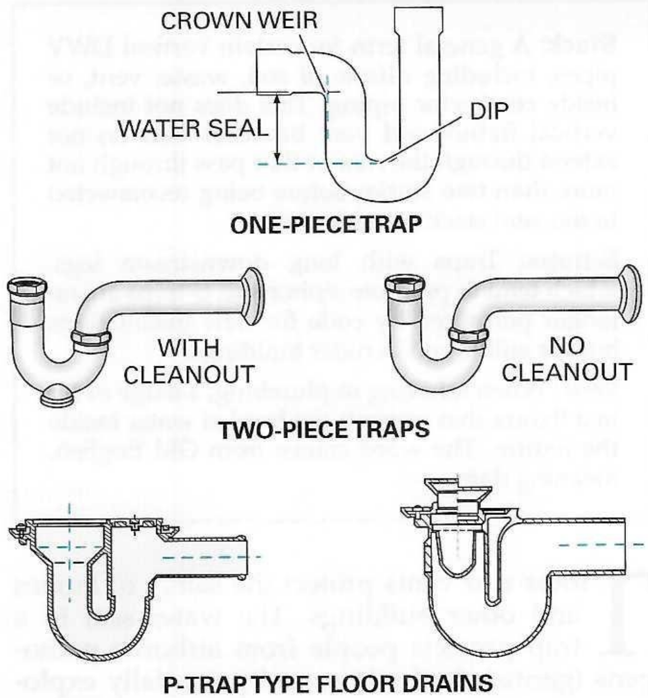


Figure 4 P-traps.

P-traps can be made of brass, brass with chrome plating, plastic, copper, cast iron, malleable iron, or glass. Floor drains may be designed with P-traps.

Interceptors prevent hazardous or undesirable materials from entering building drainage systems, public or private sewers, and sewage treatment plants or processes. Hazardous or undesirable materials include hair, lint, fats, oils, grease, flammable liquids, sand, solids, acid or alkaline waste, and chemicals. Interceptors are available for specific applications. Hair interceptors, for example, may be installed in beauty salons, barbershops, hospitals, or pet grooming shops. Grease interceptors (*Figure 5*) may be installed in restaurants, commercial kitchens, or auto repair shops. Although they differ in design, all interceptors operate on similar principles. Wastewater flows through a chamber where harmful materials are separated before the wastewater flows out again.

For example, in interceptors designed to capture solid wastes such as grease, wastewater flows into a chamber through screens. Because the solids are heavier than the wastewater, gravity causes them to fall to the bottom of the chamber, where they are retained until the chamber is cleaned out. On the other hand, greases and oils are less dense than water and float. These substances become trapped in a chamber at the top of the fixture.

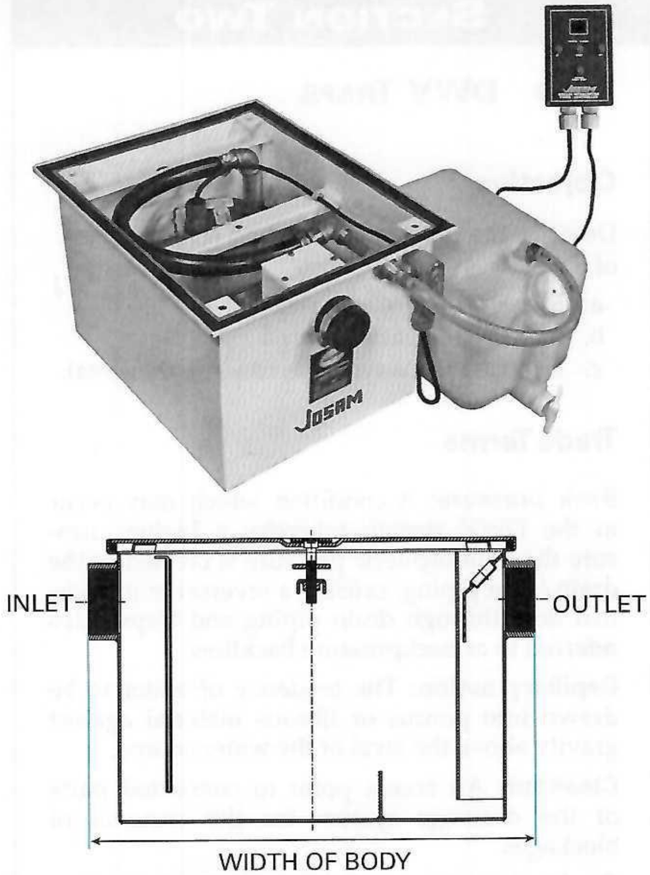


Figure 5 Grease interceptor.

Current plumbing codes prohibit the use of **S-traps** (*Figure 6*). P-traps are more efficient and effective. The long downstream leg of the S-trap tends to promote siphonage. Plumbers could make the trap more effective by increasing the depth of the seal, but this led to other problems. With greater depth, there was a greater chance that solids would stay in the trap. Fungus growth was also a problem in traps that were too deep. Two types of S-traps were used: the full S-trap and the ¾ S-trap. Many older homes still have S-traps. Plumbing supply stores stock these traps for repairs but not for installation in new construction.

> **NOTE**
> Nonsiphon traps are available with deeper trap seals. These are used where the plumbing system is subjected to abnormal changes in pressure or to a lot of evaporation.

Water closets (toilets) have integral traps as part of their design. Water closets (*Figure 7*) should never be attached to another trap. This is called **double trapping** and creates a pressure that will stop the flow of drainage.

Figure 6 S-trap.

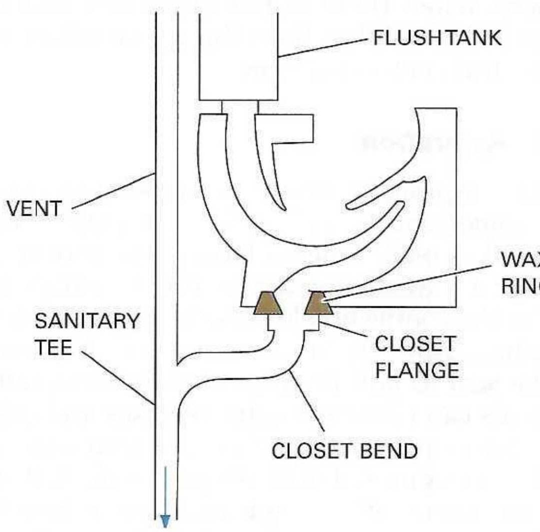


Figure 7 Integral or built-in trap.

2.2.0 Parts of Traps

The following are the basic parts of a trap (*Figure 8*):

- *Inlet*—Where water enters from the fixture
- *Top dip*—The inside curve of the pipe under the inlet
- *Bottom dip*—The bottom of the lowest curve of the pipe beneath the inlet
- *Crown* weir (sometimes called the *trap weir*)—The crown weir is the highest point in the seal of the trap. Crown weirs and trap weirs are often referred to simply as *weirs*.
- *Fixture drain* (also called the *trap arm*)—The point where wastewater leaves the trap and goes into the drainage piping.

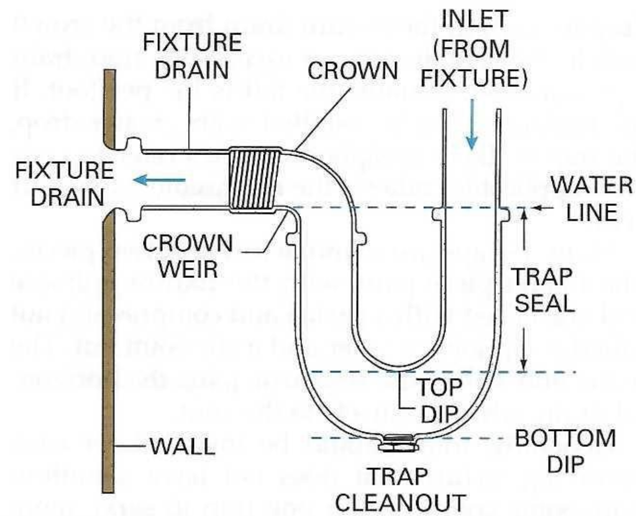


Figure 8 Parts of a trap.

2.3.0 Trap Installation Considerations

The proper operation of DWV traps can't be over emphasized. Plumbers need to know the principles of trap installation and operation, and the conditions that can reduce or negate their function.

2.3.1 Installation Requirements

Although applicable code governs specific installation requirements, such as dimensions and locations of traps, there are some typical trap installation requirements (*Figure 9*).

Generally, the vertical distance from the fixture outlet to the crown weir may not exceed 24". The second critical dimension is the horizontal distance from the crown weir to the trap vent. This distance varies depending on the diameter of the trap. The third important dimension is the total

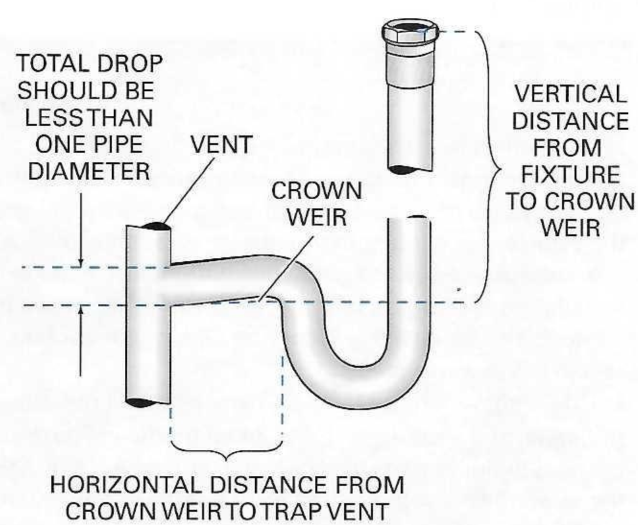


Figure 9 Critical dimensions of a trap vent.

drop (or fall) in the fixture drain from the crown weir to the vent. It may not exceed one trap drain pipe diameter. Usually, the fall is ¼″ per foot. If the horizontal leg is installed with greater drop, the trap is likely to siphon. Always refer to your local applicable code for the requirements in your area.

Many P-traps are manufactured in two pieces. The J-bend piece joins with the fixture tailpiece and is secured with a gasket and compression nut called a slip-joint washer and a slip-joint nut. The outlet end, called the trap arm, joins the horizontal drain, which connects to the vent.

Generally, traps should be installed for each plumbing fixture that does not have a built-in trap. Some codes permit one trap to serve more than one fixture. For example, three lavatories that are 30″ or less apart may be connected to one trap. Sinks containing two or three compartments also may be connected to one trap.

2.3.2 Loss of Trap Seal

When a trap functions properly, waste from the fixture flows into and through the trap (*Figure 10*). The trap is refilled with the last of the wastewater to leave the fixture. This water provides the necessary liquid seal. For the trap to function this way, the pressure on both sides of the trap must remain nearly equal. Water tends to flow in a level line, called the hydraulic gradient. The crown weir must always be installed lower than the top of where the fixture drain enters the vent line.

Properly designing and installing the DWV system can prevent siphonage and back pressure. There are multiple ways a trap may lose its seal, including:

- siphonage
- aspiration
- momentum
- oscillation (wind effect)
- back pressure
- evaporation
- capillary action
- cracks

2.3.3 Siphonage

If the trap is not properly vented, it is likely to siphon. Siphonage occurs when there is negative pressure inside the DWV piping. The pressure difference pushes the water that is normally held in the trap into the DWV piping system. Generally, siphonage occurs when the DWV piping is improperly vented or the vent is blocked (*Figure 11*). As the waste leaves the trap, an area of reduced pressure is created in the drainage piping. Because of the difference in pressure, the water is forced from the trap by the higher atmospheric pressure and destroys the trap seal. Siphonage happens when there is too much fall and the crown weir is higher than the top of where the fixture drain enters the vent.

2.3.4 Aspiration

The term aspiration means the drawing in, out, or up of something, usually a fluid. In piping, aspiration takes place when a large volume of water flows past a waste line connecting to a trap. The flow by the connection lowers the pressure in the waste line, drawing the water from the trap, causing the seal to fail. Because of aspiration, failed trap seals can allow the entry of gases and odors from the vent system. When the trap seal has failed or is saturated with the gas or odor, it will emit the same, often unpleasant, odor into the building.

Did You Know?

In the earliest home plumbing fixtures (in the 1850s), the main safeguards against odors and sewer gases were handmade traps that the plumber installed in the drains of individual fixtures. These traps often lost their water seals because of siphonage and back pressure and became ineffective. Efforts to prevent seal loss failed, because the principle of venting fixture drains was not known at the time.

In the early 1900s, the problems with fixture traps led health officials to require a secondary safeguard: the installation of building traps on each sanitary or combined building sewer. Without this additional safeguard, rats were able to travel freely from one building to another. Building traps became the second line of defense against rats in the sewer systems.

This requirement was a big advance at the time. However, since the development of modern collection, drainage, and venting systems, most model codes don't require building traps. In fact, many codes actually prohibit building traps. The only exceptions are in areas where sewer gases are extremely corrosive or where the sewer gases contain high explosive gas content, creating a risk of explosions in the public sewer system that might, for instance, blow off manhole covers and cause considerable damage.

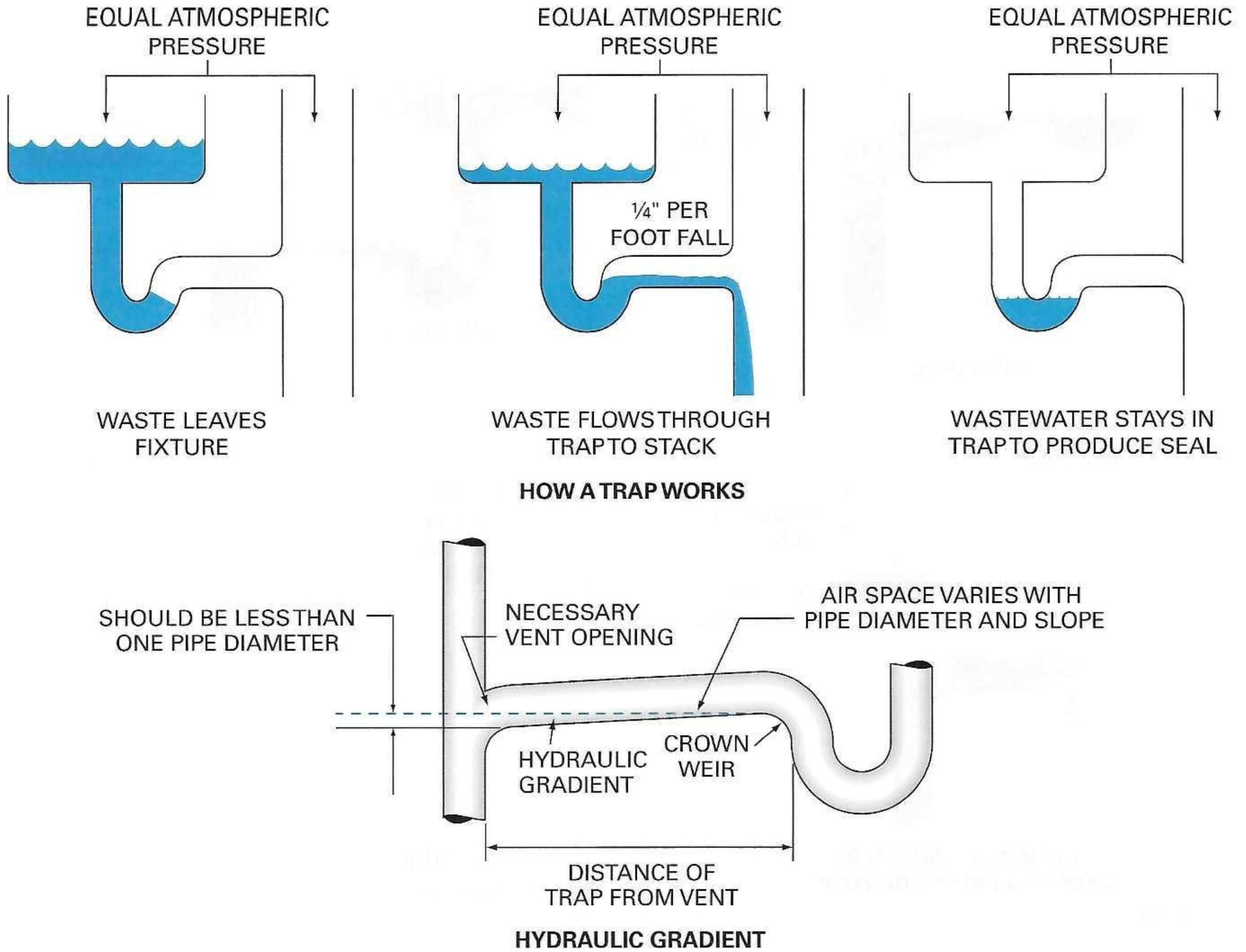


Figure 10 How a trap works.

Fixtures with S-traps are the most vulnerable to aspiration. Although modern plumbing codes prohibit S-traps, you may still encounter them in older buildings. Where an S-trap is installed, you can detect a failed seal by the smell of sewer gases or by a gurgling sound in the pipe. Drainage systems must provide adequate circulation of air in the piping to prevent siphonage and aspiration and to protect trap seals.

WARNING!

Many toxic gases do not emit an odor. Always test for gas before working in an area where toxic gases may be present. Use a smoke, water, or peppermint test to locate gas that may be entering the system through a leak in the piping. Use a toxic gas detector to monitor potentially dangerous levels of gas before working in a confined area.

2.3.5 Momentum

The momentum of water—the combination of its speed and mass—rushing through a pipe can force the standing water out of a trap and empty it, thus breaking the seal. Water can gain enough speed to empty a trap when the vertical distance between the fixture outlet and the trap is too long. In most cases, that distance should be limited to around 12", although longer vertical distances may be required for certain types of standpipe.

2.3.6 Oscillation

Oscillation, or wind effect, is one of the least likely ways a trap can lose its seal. Where there are strong upward or downward air currents, the pressure or suction of the moving air may cause the water in the trap to rise or fall in a sloshing or oscillating motion. If it rises enough to spill over into the waste pipe, less water remains in the trap and the seal is weakened. Lower than normal back pressures could break the seal.

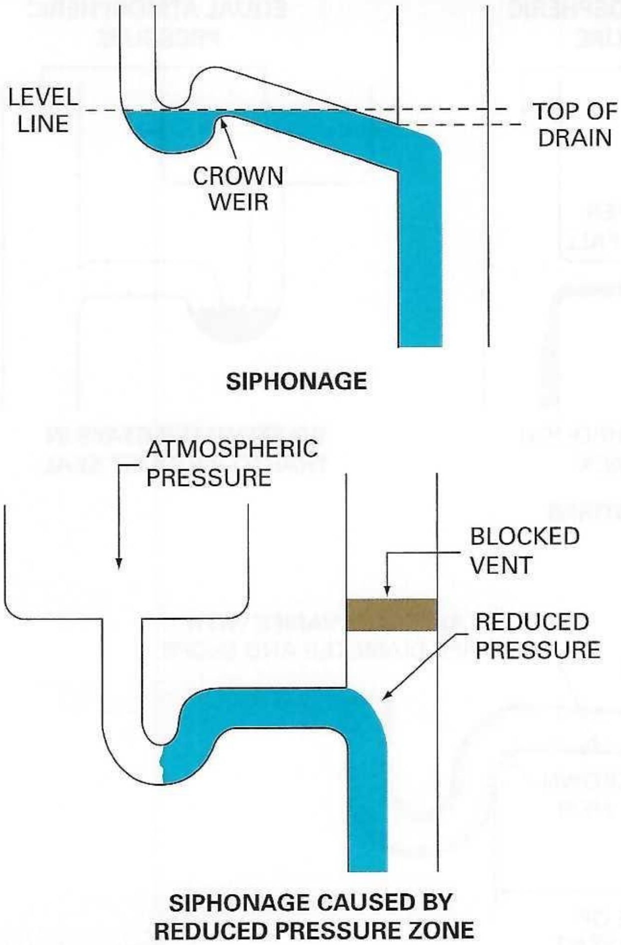


Figure 11 Siphonage.

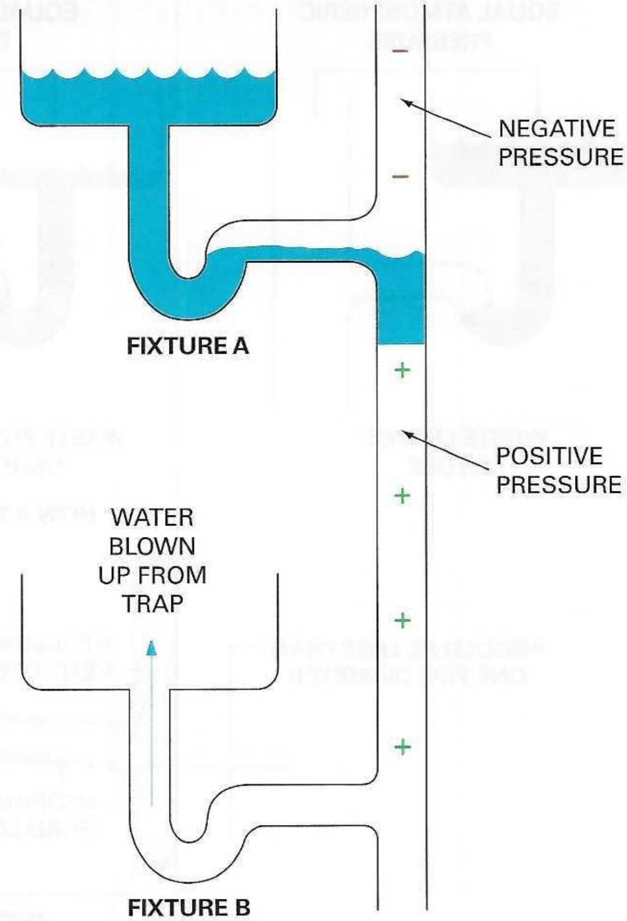


Figure 12 Back pressure.

2.3.7 Back Pressure

Back pressure (*Figure 12*) can cause a trap seal to break. Back pressure is pressure inside the DWV piping that is greater than atmospheric pressure. If enough wastewater from fixture A enters the stack so that a slug of water forms a moving plug, the air in the stack below the plug is compressed. This excess pressure tries to escape through the trap in fixture B illustrated in *Figure 12*. To prevent normal back pressure from destroying the trap seal, the stack must be properly sized, and the trap must be properly sized and protected by a vent. Also, the seal must be deep enough; generally, a trap seal of 2" to 4" is required.

2.3.8 Evaporation

A trap may lose its seal as a result of evaporation. This is most likely to happen in traps that are seldom used. The water evaporates, causing the seal to break. If the DWV piping is properly designed, evaporation only becomes a problem during long periods of nonuse. When sewer gas enters a structure, unused floor drains are often the cause. If you anticipate long periods of nonuse, you can install extra-deep traps. Many codes require trap primers where evaporation of the trap seal is likely. Trap primers are connected to a regularly used water line. Water flows through a small tube into the trap so that it can keep its seal.

2.3.9 Capillary Action

Capillary action (*Figure 13*) may cause a trap seal to break if a porous material, such as string or paper, is caught in the trap and waste line. The porous material acts as a wick and draws the water out of the trap by capillary action. Cleaning the trap solves this problem.

2.3.10 Cracks

A more common cause of waste and sewer gas leaking into a building is a crack in the trap. Cracks can be caused by worn washers, or by a broken nut, solder joint, or glue joint.

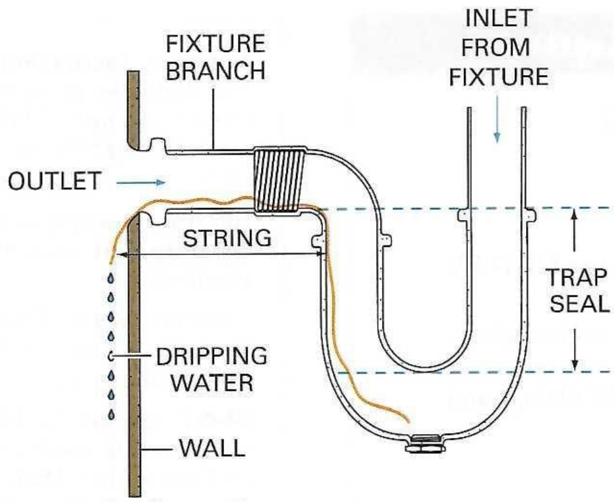


Figure 13 Capillary action.

Additional Resources

Plumbing Venting: Decoding Chapter 9 of the IPC, Bob Scott. 2014. Procodeclasses.

2015 International Plumbing Code Commentary (Includes IPSDC), 2014. International Code Council (ICC).

2.0.0 Section Review

1. Which of the following is the most common type of DWV trap?
   a. K-trap
   b. P-trap
   c. R-trap
   d. S-trap

2. The level of water in a trap is determined by the _____.
   a. crown weir
   b. top dip
   c. crown
   d. drain connection

3. Loss of a trap seal due to flow of water past a trap's drain line connection is called _____.
   a. siphonage
   b. oscillation
   c. aspiration
   d. back pressure

SECTION THREE

3.0.0 DWV FITTINGS

Objective

Describe the types of fittings used in DWV systems.

a. Describe the materials used in making DWV fittings.
b. Identify the types of DWV fittings and their requirements.

Performance Task

1. Sketch an isometric drawing of a simple DWV system and label its components.

Trade Terms

Double ¼ bends: Fittings used to collect and combine the flow from two opposite runs into a single run of pipe.

Drainage fittings: Fittings installed in the drainage sections of the DWV system to remove waste from a building.

Heel inlets: Openings in the curved, heel portion of bend fittings in line with the bend, used to connect smaller lines to the main line.

Inverted wyes: Fittings used to join the upper end of vents to the top of soil and waste stacks. The have the appearance of the upside-down letter Y.

Long sweep ¼ bends: Long-radius bends commonly used at the base of DWV stacks and elsewhere when the longer radius is needed to greatly decrease flow resistance and back pressure. Their use is regulated by code.

Pipe scale: A flaky, adherent coating on pipe walls resulting from the corrosion of metals, especially iron or steel. Also, a heavy oxide coating on copper or copper alloys resulting from exposure to high temperatures and oxygen.

Runs: Lengths of pipe that continue in a straight line.

Sanitary combination: A fitting that combines a wye and ⅛ bend. It is used to connect horizontal branch lines that intersect other horizontal branch lines. It offers less resistance to the flow of material than a sanitary tee. Also called a tee-wye.

Sanitary fittings: Fittings used to connect DWV branches to the main DWV system and to serve as cleanouts.

Sanitary increasers: Fittings used to enlarge the diameter of vent stacks. They are usually placed at least 1′ below the penetration of the stack through the roof. Their use is regulated by code.

Sanitary upright wyes: Fittings used to connect separate vent stacks to the lower ends of soil and waste stacks.

Sanitary wyes: Drainage fittings, shaped like the letter Y, that join branches to the main run of pipe at an angle.

Short sweep ¼ bends: Bend fitting with a short radius used at the base of a DWV stack and elsewhere. Their use is regulated by code.

Side inlets: Openings in ell or tee fittings at right angles to the line of the run, used to connect smaller lines to the main line.

Spigot: When referring to DWV systems, the pipe end or the male portion of a fitting that inserts into the hub of a downstream fitting.

Test tees: Tees installed as test locations for pressurizing the DWV system to test for leaks before placing it in operation.

Vent branch: A vent connecting one or more individual vent lines with a stack vent.

Vent ells: Plastic fittings with a sharp turn radius, used only in vent piping systems. Their use is regulated by code.

Vent tees: Fittings used in venting systems or as cleanouts. They may not be used in the drainage system because it restricts the flow of material. Their use is regulated by code.

Fittings are devices used to connect pipe. Those used in DWV systems or in specialty drainage systems are called **drainage fittings**. This section describes the various types of drainage fittings and their uses within the DWV piping system.

3.1.0 DWV Fitting Materials

DWV fittings are made from many different materials, including copper, brass, lead, steel, cast iron, clay, glass, and various types of plastic. Cast iron and plastic are the most commonly used materials (*Figure 14*). Not all fittings are available in all materials.

Although the fitting materials may vary, fittings of the same design have the same names. For example, a plastic sanitary tee and a cast-iron sanitary tee are basically identical, even though they are made from different materials.

CAST-IRON PIPE AND FITTINGS

PLASTIC PIPE AND FITTINGS

Figure 14 DWV fittings.

A number of fittings are available for copper pipe for DWV purposes. Those fittings include 90-degree ells, 45-degree ells, 22½-degree ells, male adapters, tees, cleanout tees, reducing tees, and reducers.

3.2.0 DWV Fittings and Applications

Most codes state that drainage fittings may not slow or block the flow of materials in the pipe. Because of this, sanitary drainage fittings are made with a sweeping design (*Figure 15*) to allow for the smooth flow of material in the system.

Another code requirement is that the direction of hub-type fittings should not go against the flow of the system—that is, the wastes should flow from the bell end to the spigot end of the pipe.

3.2.1 Vents

Every trap requires a vent of some type. Vent pipes are critical for plumbing fixtures to function correctly as part of the sanitary drainage system. Venting prevents back pressure or siphonage from breaking the water trap seals that serve the fixtures. All the vent pipes of a building create the vent system and are connected to the drain pipes. The system may include one or more pipes. Vents are installed to provide a free flow of air and to maintain equalized pressure throughout the drainage system. There are many types of vents, one of which is shown in *Figure 16*.

As *Figure 16* shows, sanitary fittings are available in single and double patterns. The double pattern is used to connect two branch lines entering the system from opposite directions. This allows for central placement of horizontal runs and vertical runs. Sanitary branch fittings consist of tees, wyes, and combinations of the two.

3.2.2 Bends

Sanitary fittings are used to connect DWV branches to the main DWV system. The branch inlets of these fittings may be reducing (going from a larger pipe to a smaller pipe). If so, they can be joined to the system without reducers.

The term *bend* is often used in reference to cast-iron fittings. With other types of fittings, the terms *elbow* or *ell* are more common. Bends are used to change the direction of a run of pipe. A run is one or more lengths of pipe in a straight line. Bends are available in different sizes. Some sizes may be available in only one type of material, such as cast-iron. Pipe and fitting manufacturers' catalogs show all available sizes according to the material of the fitting. You can see examples of common bends in *Figure 17*.

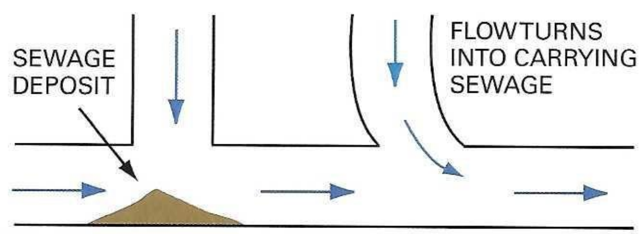


Figure 15 Sweeping design.

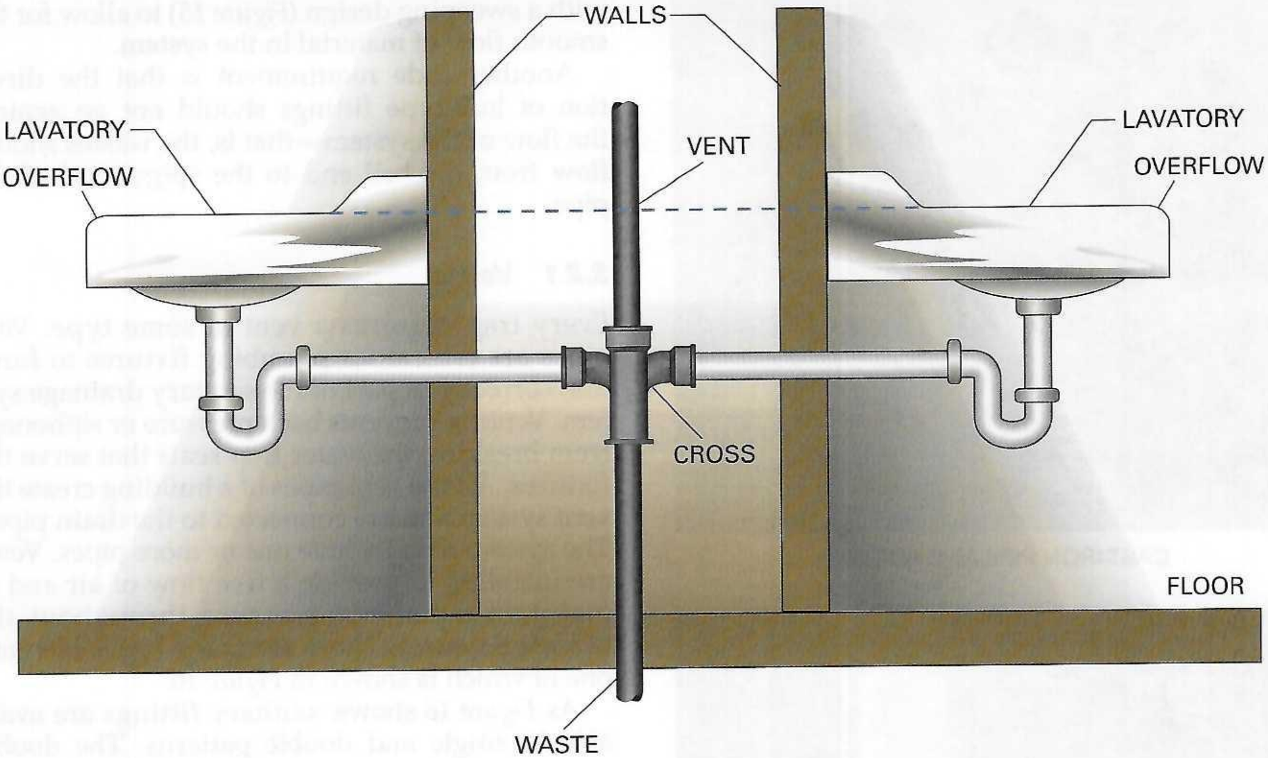


Figure 16 Common vent.

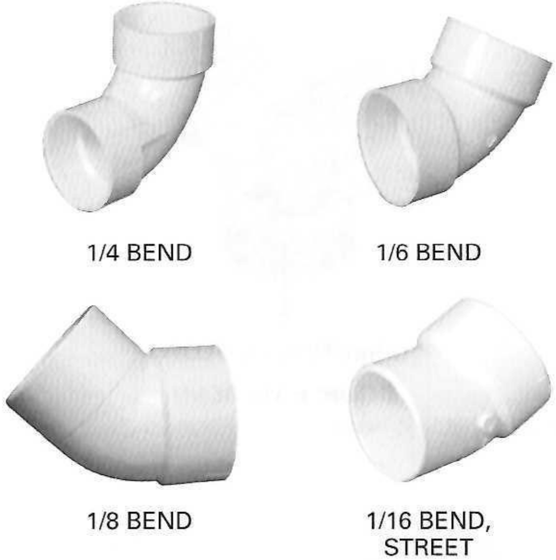


Figure 17 Bends.

The plumbing design tells you which bends are used and where they are placed in the system. Bends are expressed as fractions of a complete circle. A circle contains 360 degrees. You can easily determine the number of degrees a given bend turns or changes the direction of flow by multiplying the bend fraction by 360 degrees. For example, to determine the bend angle of a $\frac{1}{4}$-bend, multiply the bend type ($\frac{1}{4}$) by 360 degrees:

$$\frac{1}{4} \times 360° = 360° \div 4 = 90°$$

Bends are available with **heel inlets** and **side inlets** to allow smaller lines to be connected to the bend (*Figure 18*). It is important to note that a high- or low-pattern side inlet bend cannot be used as a vent if the inlet is horizontal.

Bends with side inlets are available with single and double side inlets. To determine whether the inlets are right or left inlets, place the spigot of the bend down and look through the hub (or bell) end (this is the same direction water would be flowing down the drain) (*Figure 19*). Left inlets are on the left side, and right inlets are on the right side.

Three patterns of $\frac{1}{4}$ bends are available (*Figure 20*). The basic fitting is simply called a quarter bend.

Figure 18 Bends with heel and side inlets.

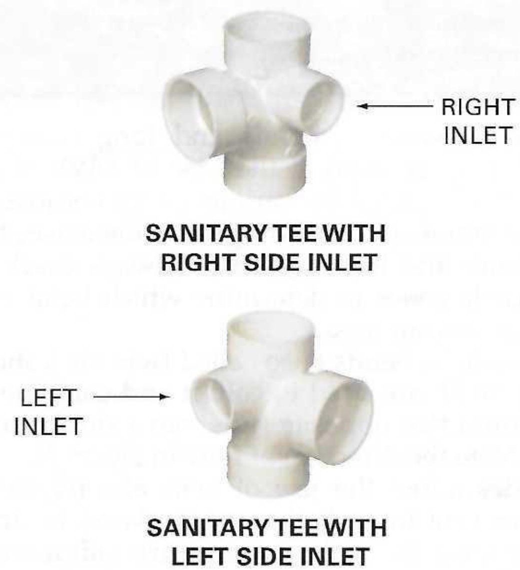


Figure 19 Determining left- or right-side inlet.

Did You Know?

The name "street fitting" comes from the fact that the fitting's male connection always points toward the street (away from the building) when installed correctly.

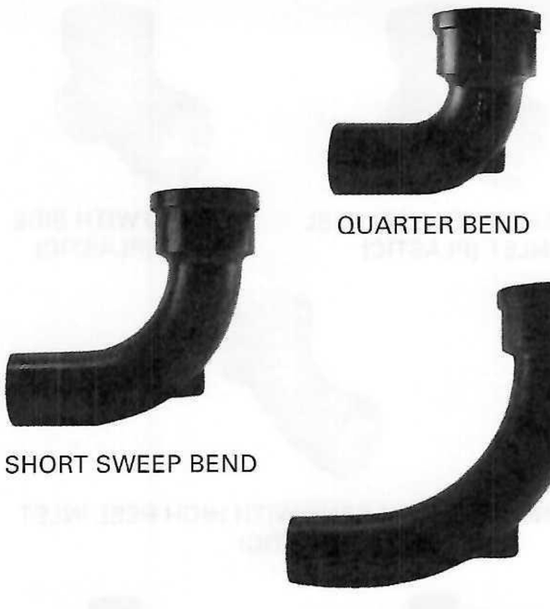


Figure 20 Variations of ¼ bends.

Did You Know?

The triangular extension that protrudes from the bottom of a bend is designed to help the plumber pull the fitting into the spigot by fitting a strap around the extension and pulling up.

Short sweep ¼ bends and **long sweep ¼ bends** may be used at the base of DWV stacks. They are required by various codes because the longer radius of their turn greatly decreases flow resistance and back pressure. Always check the applicable codes to determine which bend must be used in your area.

Double ¼ bends (also called twin ells), shown in *Figure 21*, are used to collect and combine the flow from two opposite runs into a single run of pipe. Note the direction of flow in *Figure 21*.

Codes allow the use of **vent ells** (*Figure 22*) only in vent lines. If they were placed in drainage or waste lines, their sharp turn radius would severely restrict the flow of materials. They are available only in plastic fittings.

3.2.3 Adapters

DWV fittings are most often used with pipe made from the same material. However, adapters (*Figure 23*) can be used to join pipe of different materials. For instance, adapters can be used to join copper tubing to galvanized iron pipe or plastic to cast-iron pipe. Adapters are also useful for joining pipes of different sizes, when permitted by code.

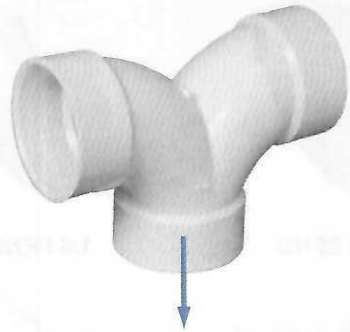


Figure 21 Double ¼ bend.

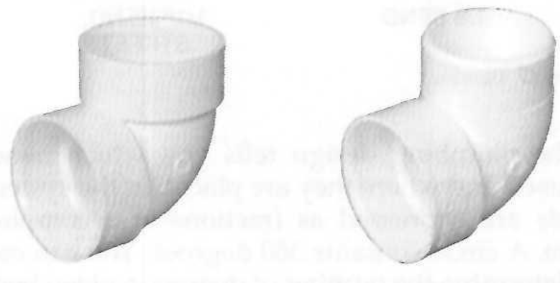


Figure 22 Vent ells.

3.2.4 Cleanouts

Fittings are also available for cleanouts. Cleanout fittings have internal threads on the branch fitting to accept a threaded cleanout plug. A cleanout adapter (*Figure 24*) may be installed in one end or branch of a fitting to provide a cleanout access. In both cases, a cleanout plug is provided to permit access to the DWV piping system to remove blockage and to prevent leakage.

3.2.5 Tees

Sanitary tees, shown in *Figure 25*, are used for branches that run from horizontal to vertical. Model codes restrict their use to sanitary drainage systems where the flow of material is from the horizontal to the vertical. Double sanitary tees are also called sanitary crosses.

Sanitary tees are available with side inlets. The side inlet allows smaller drains to be connected from the right or left.

Most codes restrict the use of **vent tees** (*Figure 26*) and they may not be used to vent lines or as cleanout fittings. They are prohibited for use in drainage systems because their design restricts the flow of material. This design restriction may allow wastes and **pipe scale** to collect within the fitting.

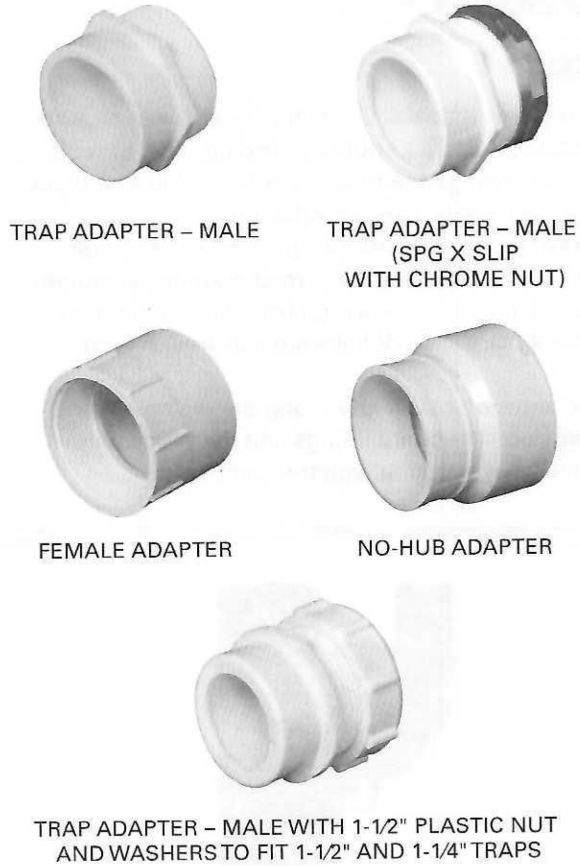


Figure 23 Adapters.

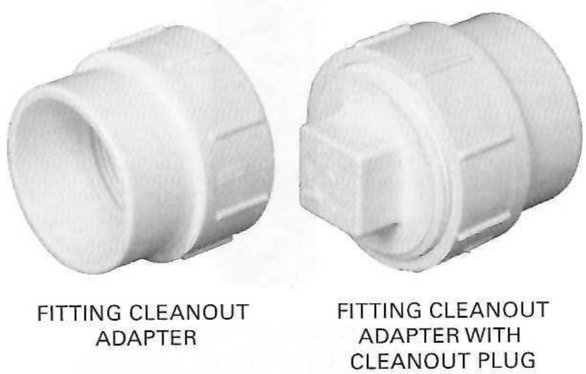


Figure 24 Cleanout adapters.

Test tees (*Figure 27*) are installed in the DWV plumbing system as required by various codes. These tees serve as test locations from which the system is pressurized to test for leaks.

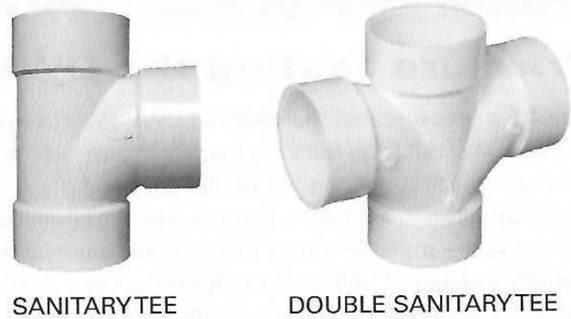


Figure 25 Sanitary tee and cross.

Figure 26 Vent tee.

Figure 27 Test tee.

3.2.6 Wyes

Sanitary wyes (*Figure 28*) are used to provide a smooth-flowing DWV system, in keeping with code requirements. Codes require vertical branch lines that intersect with horizontal branch lines to connect with long-turn fittings, such as wyes, with 45-degree angles or sweeps. If the correct fittings are not used, soil and wastes may collect on the pipe wall opposite the branch.

Sanitary upright wyes (*Figure 29*) are used to connect the vent stack to the lower end of the soil and waste stacks.

A **vent branch** (or branch vent) (*Figure 30*) is used to join the upper end of the vent to the top of the soil and waste stacks.

Pressure Testing the DWV System

Plumbers pressure test the installed DWV system to ensure that it is free of leaks. Generally, local codes require this test, and the local building inspector may also conduct a follow-up test. To perform a pressure test, turn off the main water supply and block the vent and drain pipes at T-fittings close to the main stack. You must also block all openings such as drains, fixtures, and stubouts using solvent-glued plastic caps or inflatable test balloons. Following the manufacturer's instructions, connect the air compressor and pressure gauge at an access point (usually a cleanout fitting). Run the compressor until the pressure gauge registers the correct pounds per square inch (psi) recommended by the manufacturer or by local code. Check the pressure gauge from time to time for at least 15 minutes. If the pressure remains unchanged at the correct psi, the DWV lines are leak free. Falling pressure indicates a leak.

Even if the pressure does not change, you should also listen for signs of a slow leak along the piping. Slow leaks may not register on the gauge. If you locate a leak, repair any loose or faulty fittings and then repeat the pressure test. You must follow the manufacturer's safety guidelines when working with the compressor.

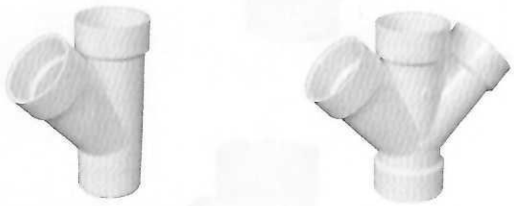


Figure 28 Sanitary wyes.

Figure 29 Sanitary upright wye.

Inverted wyes (*Figure 31*) may be used in place of vent branches. A sanitary combination is a fitting that combines a wye and a ⅛ bend. Also called a tee-wye, this fitting is available with single or double inlets (*Figure 32*). Sanitary combinations are used to connect horizontal branch lines that intersect at 90 degrees with other horizontal branch lines. They are also used to connect a vertical stack with a horizontal drain. Whenever space permits, they may be used in place of sanitary tees because they offer less resistance to the flow of materials than sanitary tees do. Combination fittings also reduce the number of fittings needed. *Figure 33* shows that a sanitary wye and a ⅛ bend would be needed to do the same job as a combination fitting. Reducing the number of fittings also reduces the number of joints to be made and the amount of time needed to make them.

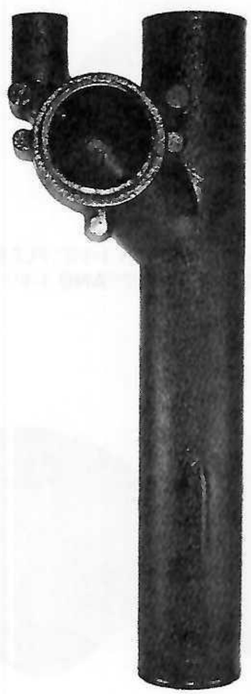


Figure 30 Vent branch.

Figure 31 Inverted wye for venting.

3.2.7 *Miscellaneous Fittings*

Sanitary increasers (*Figure 34*) are used to enlarge the diameter of vent stacks and are usually placed at least 1 foot below the stack's intersection with the roof, although this distance may vary by code. Sanitary increasers are necessary in cold climates to keep condensing water vapor from freezing and gradually closing the vent opening. The loss of the vent could cause the loss of the trap seals, allowing sewer gas to enter the building.

COMBINATION WYE AND 1/8 BEND

DOUBLE COMBINATION
WYE AND 1/8 BEND

Figure 32 Sanitary combinations.

COMBINATION WYE AND
1/8 BEND, REDUCING
(TWO PIECE)

COMBINATION WYE
AND 1/8 BEND
(ONE PIECE)

Figure 33 Combination fittings.

As you have already learned, offsets (*Figure 35*) are used to change the path of the pipe to avoid obstruction. They can offset the run of the pipe from 2" to 12".

PIPE INCREASER-REDUCER

Figure 34 Sanitary increaser.

OFFSET CLOSET FLANGE, ADJUSTABLE
(WITH METAL RING)
1-1/2" OFFSET

Figure 35 Offset.

Additional Resources

Plumbing Venting: Decoding Chapter 9 of the IPC, Bob Scott. 2014. Procodeclasses.

2015 International Plumbing Code Commentary (Includes IPSDC), 2014. International Code Council (ICC).

3.0.0 Section Review

1. DWV pipe and fittings can be made of all the following materials *except* _____.
   a. cast iron
   b. melamine
   c. clay
   d. glass

2. A ⅛ bend changes the direction of flow _____.
   a. 22½ degrees
   b. 30 degrees
   c. 45 degrees
   d. 90 degrees

SECTION FOUR

4.0.0 DWV CONSTRUCTION

Objective

Describe the construction of various DWV systems.

a. Explain the importance of grade.
b. Describe the construction of sewer and waste treatment facilities.
c. Identify the health concerns associated with DWV systems.
d. Explain how plumbing codes affect the construction of DWV systems.

Trade Terms

Branch interval: A distance along a soil or waste stack corresponding, in general, to a building story height, but in no case less than 8', within which the horizontal branches from one floor or story of a building are connected to the stack.

Elevation: The height above an established reference point, such as a grade reference point on a construction drawing.

Grade: When referring to DWV and especially sewer systems, the slope of a run of pipe. Also referred to as slope or percent of grade.

Sludge: Semi-liquid matter that settles out in a holding tank during the waste treatment process.

Velocity: Technically, the speed and direction of a moving object. Commonly used in place of speed for describing the motion of fluids in pipes.

Plumbers need to be familiar with the bigger picture of waste water system design and sewage management. Connections to municipal and private sewage systems must be made so that the effectiveness of these systems is not compromised.

4.1.0 Grade

Drainage and waste systems (*Figure 36*) rely on gravity to move solid and liquid wastes, so these piping systems must be installed at a slope toward the point of disposal. In the plumbing industry, this slope is called grade. Grade is also often referred to as percent of grade. Drainage and waste piping systems are designed with the grade engineered into the system. The architects and engineers who design the piping system normally determine the grade. However, in some cases, such as in residential plumbing, the plumber selects the grade according to applicable code.

4.1.1 The importance of Grade

In a system with the proper grade, the liquid wastes flow at the right velocity, or speed, to scour the insides of the pipe, and the solids are carried away. If too much grade is used, the liquid wastes may flow too fast, leaving the solids behind. If too little grade is used, the liquid wastes will not flow fast enough to scour the pipe and remove the solid wastes. If the grade of a pipe does not remain constant, the velocity of the liquid wastes change at the point where the grade changes. In any of these cases, the pipe soon becomes blocked with solid wastes.

Plumbers must determine the grade before they begin their work. This information may be in the local plumbing codes, in the specifications (specs) for the structure, or in the construction drawings. If it is not in any of these places, contact the local plumbing inspector for a decision.

4.2.0 Sewer Construction and Waste Treatment

DWV systems within a building collect wastes to be delivered for treatment. Plumbers need to be familiar with the systems beyond the building walls that collect, treat, and discharge processed wastes to the environment. Familiarity with the health issues and codes relating to sewage and waste water is essential for the professional plumber.

4.2.1 The Building Drain

The building drain is the main horizontal pipe inside a building. It carries all sewage and other liquid wastes to the building sewer. Codes usually define the building sewer as standing 2 to 3 feet outside the building foundation. The building drain is the principal artery to which other drainage branches of the sanitary system may be connected.

Any vertical pipe, including the waste and vent piping of a plumbing system, is considered a stack. A soil stack is a vertical section of pipe that receives the discharge of water closets, with or without the discharge from other fixtures. The soil stack is connected to the building drain.

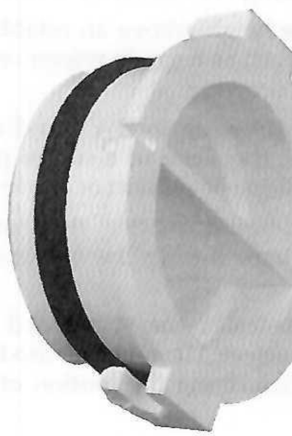
Figure 36 Grade.

A **branch interval** is a section of a stack. The branch interval usually corresponds to a story height (the height of one floor in a building), but it can never be less than 8′ long.

A horizontal branch is the part of a drain pipe that extends laterally (sideways) from a soil or waste stack and receives the discharge from one or more fixture drains.

4.2.2 Cleanouts

Cleanouts (*Figure 37*) are fittings with removable plugs. The plugs provide access to the inside of drainage and waste piping systems so that blockages can be removed. As mentioned earlier, cleanout adapters may be used to convert other fittings so they can be used as cleanouts.



PVC DWV TWISTLOK ™PLUG

Figure 37 Cleanout adapter with recessed hubs.

Torpedo Level

The torpedo level is a tool similar to a general-purpose level, but it is much smaller—usually less than 1-foot long—and more streamlined. Its major advantage is in measuring grade for small runs of pipe—for example, fixture branch lines that run a short distance to the stack. The torpedo level is also light and easy to manipulate in tight places.

4.2.3 Building Sewer

The building sewer or house sewer is the drainage piping that runs from the building's foundation to the sewer main or septic tank (private waste-disposal system). It normally starts approximately 2' to 3' outside the building.

Building sewers are commonly made using ABS (acrylonitrile-butadiene-styrene) or PVC (polyvinyl chloride) plastic, cast-iron, or vitrified clay (a hard, nonporous clay) pipe. When sewers are laid, the ground must be tamped to keep the pipe from settling and losing its grade. Sometimes the pipe is installed over a bed of gravel that supports it. In some parts of the country, plumbers lay the entire sewer from the foundation wall to the sewer main. In other areas, the municipal sewer crew may be in charge of the installation from the property line to the sewer main. All operations associated with building sewers are regulated by code.

Vitrified Clay

Vitrified clay is typically only used in sewers and falls under the purview of municipality work. Plumbers will rarely work with vitrified clay directly but may encounter it on a jobsite after it's already been placed by a pipelayer. Vitrified clay is used because it is corrosion resistant to common sewer chemicals; it stands up to abrasive cleaning; and has a an extremely long life.

Manholes must be provided for underground piping that is 8" or larger in diameter. They should be located at intervals not more than 400' apart and at every major change in direction, grade, elevation, or pipe size. To meet applicable codes for traffic and loading conditions, the manholes must have metal covers of sufficient weight and strength.

4.2.4 Sewer Main

A public or municipal sewer is installed, maintained, and controlled by the local municipality or town. The sewer main is usually located in a street or alleyway or within an easement on privately owned land. Sewer mains carry waste to the treatment plant.

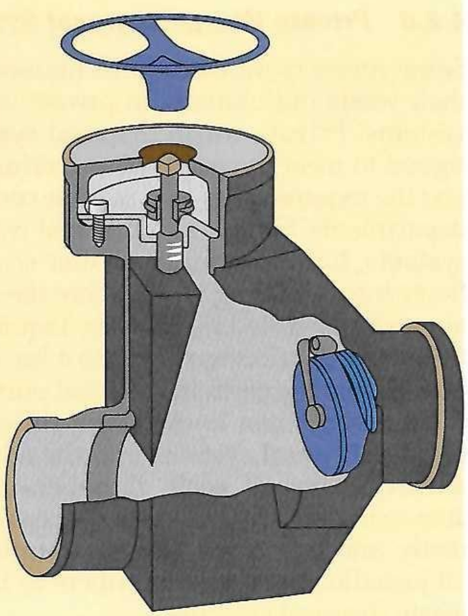
Municipalities or towns usually install a 6" sewer laterally from the sewer main to the edge of each building lot. This lateral pipe connects the building sewer to the public sewage system.

4.2.5 Municipal Waste Treatment Systems

Many municipalities have sewer systems in which wastes are collected and treated at a sewage plant, then discharged back into the ecosystem. Municipal waste treatment plants (*Figure 38*) are highly sophisticated facilities, as public health and safety depend on their operation.

Backwater Valves

The backwater valve is a specially designed check valve for drainage pipe systems. A check valve prevents fluid from going backwards in the pipe system; the backwater valve prevents the backflow of sewage in the system. When plumbers install backwater valves underground, they usually install them in a valve box or vault so they can be accessed easily. Backwater valves are for special applications only, and they are the only type of valve that some jurisdictions allow.



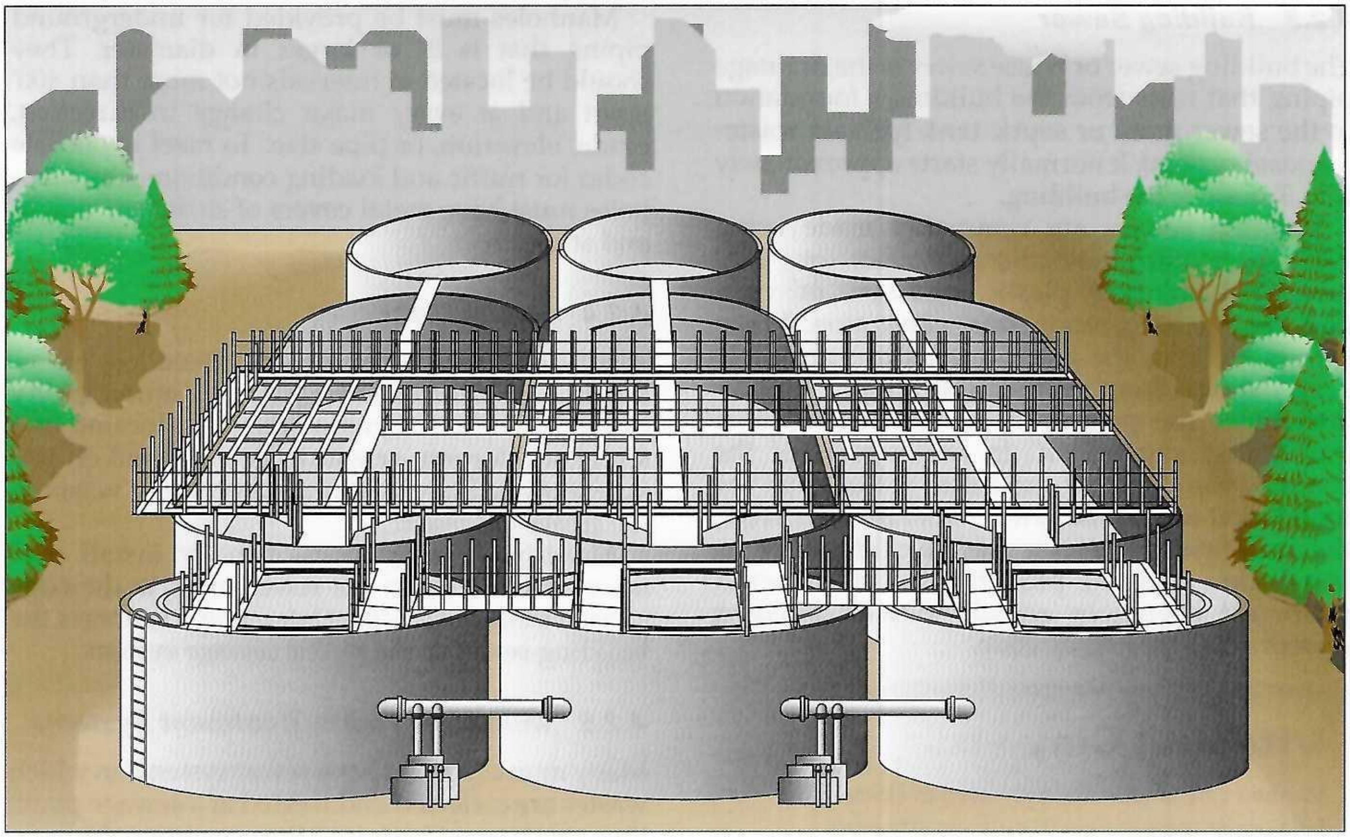


Figure 38 Municipal sewage treatment plant.

These systems are designed to handle thousands of gallons of sewage each day. The treatment facilities receive sewage into huge holding tanks, where heavier substances settle to the bottom and lighter substances float to the top. The heavier layer is called sludge. Both the sludge and the wastewater are then treated.

4.2.6 Private Waste Disposal Systems

Some municipalities require households to treat their waste individually in private waste disposal systems. Private waste disposal systems are designed to meet the needs of individual households and the requirements of applicable codes and health departments. Similar to municipal waste treatment systems, but on a much smaller scale, the waste flows into a holding tank, where the sludge settles out and is digested by bacteria. Liquid waste flows through a distribution box into a leach field, where it seeps into the earth in a natural purification cycle.

Plumbers must know about different types of private disposal systems and the advantages and disadvantages of each. Plumbers also must be able to install private waste disposal systems correctly and according to code requirements. Not all jurisdictions allow plumbers to install private waste disposal systems.

A conventional septic system consists of a septic tank, a distribution box, a leach field, and piping between those parts (*Figure 39*). A septic tank system provides partial treatment of raw wastewater. It protects the soil absorption system from becoming clogged by solids that are suspended in the raw wastewater. Applicable codes strictly regulate the use of these systems.

4.3.0 Health Concerns

Properly designed and installed DWV systems are essential to public safety. Without DWV systems, the public would be at great risk of waste-borne illness and disease. The plumbing profession has improved public health, safety, and comfort over the past 150 years. Many serious health risks have been dramatically reduced as a direct result of good plumbing, especially properly designed and installed DWV systems, and the enforcement of plumbing codes.

The health issues related to the improper design, installation, and maintenance of DWV systems are significant. In the past, diseases such as cholera, typhoid fever, typhus, and dysentery have been traced to failures in DWV systems. These diseases can spread rapidly when bacteria from the sewer system enter buildings through damaged or improperly installed vents and traps.

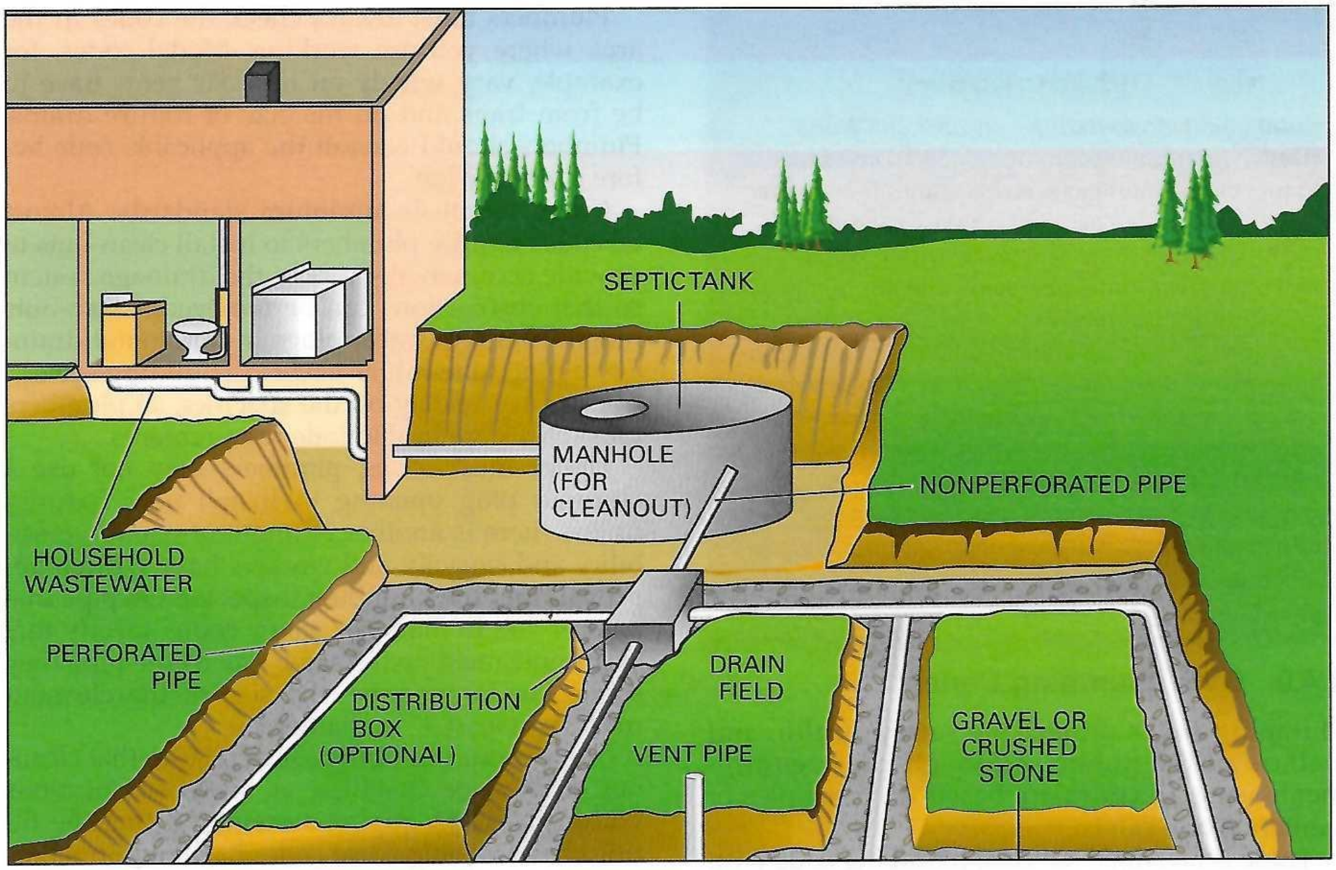


Figure 39 Parts of a septic system.

Another health issue related to DWV systems is the accumulation of toxic sewer gases. Explosions, fires, and suffocation can occur when sewer gases are not properly released through good ventilation. Control of sewage through DWV systems can eliminate many public sanitation and health problems.

Did You Know?

The Babylonians had sewer systems around 5,000 years ago. The Romans later built sewer systems for both storm water and wastewater. However, water treatment methods were unknown then, so wastewater was often returned to the river just below a city or town.

GOING GREEN

Energy Efficient Fixtures

Each year, the average US household may waste up to 450,000 gallons water. Plumbers can help reduce the flow of water "down the drain" by installing modern, energy efficient fixtures. Low-flow showerheads combine air with water pressure to deliver a good shower using less water. Instant hot water dispensers and tankless water heaters can reduce the amount of water consumers run in sinks, tubs, and showers while waiting for the water to warm up. High-efficiency toilets may use as little as 1.28 gallons of water per flush. Learning how to help your customers use sustainable features adds a lot of personal satisfaction to your work while also helping to sustain our natural resources.

Did You Know?

Good plumbing saves lives. In 2003, the World Health Organization commissioned an investigation to find out if plumbing systems contributed to the outbreak of severe acute respiratory syndrome (SARS) in Hong Kong. The investigation stated that poor installation, operation, and improper plumbing applications were likely contributors. Virus-rich droplets re-entered apartments through sewage and drainage systems where there were strong upward airflows, inadequate traps, and nonfunctioning water seals. Investigators also noted that plumbing, when properly designed, installed, and maintained, is an important tool in stopping transmission of disease through a building's drainage system.

4.4.0 DWV Plumbing Codes

Plumbing codes protect the safety, health, and welfare of the public. Although code requirements vary, all codes are based on principles of sanitation and safety.

There is no single national plumbing code with requirements adopted by all states and localities. Model codes are developed and revised on a regular basis. They can recognize international and national codes as well as other standards. States and other jurisdictions can use these model codes as a basis for developing their own plumbing codes. DWV piping requirements are also defined by counties and municipalities and enforced by their inspectors.

Plumbers must always check the codes in the area where you are working. Model codes, for example, vary widely on how far vents have to be from traps and on the size of fixture drains. Plumbers should consult the applicable code before starting a job.

Codes establish minimum standards. Almost all codes require plumbers to install clean-outs to provide access to all parts of the drainage system so that obstructions can be removed. Clean-outs range from removable plugs in horizontal drainage piping to manhole covers in building sewers. Codes vary widely on the specifics, so plumbers must check applicable code requirements.

Under most codes, plumbers may not use a cleanout plug opening to install new fixtures, unless there is another cleanout of equal accessibility and capacity and workers have written approval from the plumbing inspector. On pipe that is 4" or less in diameter, many codes specify that clean-outs must be the same size as the pipe they serve. For larger pipe, the size of the cleanout must be at least 4" in diameter.

The various plumbing codes require that cleanout fittings be installed at specified locations within the DWV piping system and that the fittings be accessible. Most codes have requirements for cleanout locations in horizontal runs of pipe. In horizontal drain lines 4" in diameter or less, cleanouts generally must be installed no more than 50' apart. For larger lines, cleanouts cannot be more than 100' apart. Local codes may differ regarding these distances. Always refer to the applicable code.

Some codes also require cleanouts at or near the foot of each waste or soil stack and near the junction of the building drain and the building sewer.

Think About It

For most people, turning on a faucet and getting clean drinking water or flushing a toilet is so routine they don't even think about it. However, millions of people worldwide struggle to get these basic services. They also must deal with the many diseases that result when sanitation is poor or nonexistent. The United Nations had a program called "Water for Life Decade 2005–2015" and were joined in this effort by the World Plumbing Council and the World Health Organization. To reach its goals, the program hoped to provide access to drinking water and basic sanitation services to hundreds of millions of people globally. Sadly, at the end of the Water for Life Decade, the program study estimated that 663 million people still drew water from unimproved sources.

Additional Resources

"Design of Sewer System." Civil Engineers PK. Updated 2017. **https://civilengineerspk.com/**

2015 International Plumbing Code Commentary (Includes IPSDC), 2014. International Code Council (ICC).

Plumbing Venting: Decoding Chapter 9 of the IPC, Bob Scott. 2014. Procodeclasses.

4.0.0 Section Review

1. The drop of a drain or sewer pipe for a given horizontal distance traveled is called _____.
   a. rise
   b. elevation
   c. altitude
   d. grade

2. Ordinarily, the distance along a DWV stack between the horizontal branch drains on one floor and those on the next is called the _____.
   a. drop
   b. hydraulic gradient
   c. branch interval
   d. elevation

3. What has been reduced as a result of modern DWV systems?
   a. Health risks to the general public
   b. Volume of sewage
   c. The types of infectious bacteria and viruses
   d. The production of explosive gases from sewage

4. Most plumbing codes require cleanouts in piping 4" or less to be spaced apart no more than _____.
   a. 10'
   b. 25'
   c. 50'
   d. 100'

SUMMARY

The DWV system of a building is part of a plumbing system designed to protect the health and safety of the people who use its facilities. The system carries wastewater out of the building, treats it, and returns it to the ecosystem.

Drain and waste piping removes wastewater from a building. The type and size of the piping system selected depends on critical factors such as the amount of fluids expected to flow through the piping, the types of fluids to be carried, and the grade. Drainage and waste systems rely on gravity to move solid and liquid wastes, so the plumber must install piping at the correct grade toward the building sewer where the wastes leave the building and enter the public or private waste disposal system. Grade determines the velocity of the liquid waste flowing through the piping. If the grade is too shallow, the liquid waste moves too slowly and does not scour the pipe and remove solid wastes. If the grade is too steep, the liquid waste flows too fast and leaves solids behind in the piping.

The vent system is an important part of the overall DWV system. Vent piping provides for the free flow of air in the drainage system. This air equalizes the atmospheric pressure inside the pipes and prevents back pressure or siphoning from destroying the water trap seals in the fixtures. The water trap seals keep sewer gas and odors out of the building. Traps provide a way for the wastewater or sewage to flow through the fixture and into the piping system while protecting the occupants of the building from bacteria and potentially explosive gases.

The DWV piping system relies on different kinds of fittings to join the lengths of pipe. The fittings may be made of copper, brass, lead, steel, cast iron, clay, glass, or plastic. The type of installation determines the best piping and fitting material to use. The fittings are designed so they do not block or slow the flow of materials in the pipe. The sweeping design of DWV fittings allows for the smooth flow of material within the system. Different fitting shapes serve specific purposes, depending on whether a pipe runs horizontally or vertically. Correct selection and installation of fittings are vital for the system to function properly.

Review Questions

1. An example of a fixture drain is a(n) _____.
   a. P-trap
   b. pop-up plug
   c. sanitary bend
   d. interceptor

2. LEED standards for commercial and industrial applications encourage the development and use of _____.
   a. graywater systems
   b. sewage treatment plants
   c. septic systems
   d. vent stacks

3. Which DWV component should be considered specifically for a fast-food restaurant?
   a. Fixture drain
   b. P-trap
   c. S-trap
   d. Interceptor

4. The size of the trap seal is the distance between the _____.
   a. top dip and bottom dip
   b. the crown weir and the top dip
   c. crown and the bottom dip
   d. entrance to the fixture drain and the crown weir

5. The total drop from a trap's crown weir to the bottom of the trap's connection to the vent must be _____.
   a. less than one drain pipe diameter
   b. more than one drain pipe diameter
   c. less than one vent pipe diameter
   d. more than one vent pipe diameter

6. Trap siphonage occurs when _____.
   a. gusts of wind affect stack pressure
   b. water flows by the trap's connection to the vent
   c. vent pressure is less than air pressure at the fixture
   d. porous materials get caught in the trap connection to the vent

7. If a fixture outlet drain line is too long, which effect can break a trap seal?
   a. Siphonage
   b. Oscillation
   c. Momentum
   d. Back pressure

8. The most common materials for DWV systems are cast iron and _____.
   a. glass
   b. copper
   c. clay
   d. plastic

9. To maintain the water seal in a trap, every trap needs a(n) _____.
   a. interceptor
   b. vent
   c. side inlet
   d. drain

10. The main difference between a vent ell and a drain bend is their _____.
    a. turn radius
    b. diameter
    c. material
    d. pipe size

11. If a drain's grade does not remain constant, what could be the result?
    a. Drain flow could cause siphonage.
    b. Waste treatment could become inefficient.
    c. Solid wastes could accumulate in the pipe.
    d. Sewer gas could accumulate above the flow.

12. A building's sewer connection begins _____.
    a. at the building foundation
    b. about 2' to 3' from the foundation
    c. at the point where the building's drain line connects to the sewer main or septic tank
    d. at the bottom of the building's DWV stack

13. Conventional private waste disposal systems include a _____.
    a. composting system
    b. graywater system
    c. connection to the municipal waste treatment plant
    d. septic tank and leach field

14. Common entry points in the DWV system for serious diseases are _____.
    a. damaged or faulty vents and traps
    b. septic tanks
    c. manhole covers
    d. leach fields

15. With regards to plumbing codes you will be required follow, they comply with the _____.
    a. international plumbing code
    b. national plumbing code
    c. state plumbing code
    d. codes established and recognized by state, local, and applicable jurisdictions

16. The drainpipe buried outside a building is called a(n) _____.
    a. underground sewer
    b. building sewer
    c. main sewer
    d. out sewer

17. All of the following are major components of a DWV system except for _____.
    a. soil stack
    b. traps
    c. tees
    d. flanges

18. According to code requirements, the direction of hub-type fittings should not _____.
    a. be installed horizontally
    b. be larger than three inches in diameter
    c. go against the flow of the system
    d. be made of the same material as the pipe

19. The most common materials for DWV fittings are _____.
    a. copper and lead
    b. cast-iron and copper
    c. cast-iron and plastic
    d. plastic and lead

20. Bends are available with _____ inlets.
    a. heel
    b. forward
    c. branch
    d. wye

Trade Terms Quiz

Fill in the blank with the correct term that you learned from your study of this module.

1. DWV branches are connected to the main DWV system using ________.
2. ________ describes the attachment of one trap to another trap, such as with a water closet.
3. The substance that settles on the bottom of holding tanks is ________.
4. The underground drain pipe that carries waste from the building to the public sewer is called a(n) ________.
5. ________ allow pipes made from different materials to be connected.
6. The flow from two opposite runs into a single run of pipe are collected and combined in ________.
7. ________ are bend fittings with a short radius that are used at the base of a DWV stack.
8. In cold climates, ________ can prevent vent openings from closing as a result of frozen condensation in pipes.
9. ________ may not be used in drainage systems because their design can cause waste to collect in the fitting.
10. The sharp turning radiuses of ________ severely restricts the flow of materials, making their use allowable only in vent lines.
11. ________ are designed to keep undesirable or hazardous materials from entering a building drainage system, a public or private sewer, or sewage treatment plant or process.
12. Vertical branch lines that intersect with horizontal branch lines must be joined at an angle with ________.
13. ________ serve as locations to conduct leakage tests.
14. ________ collects on fittings, especially on iron or steel, as a result of metal corrosion.
15. Horizontal branch lines that intersect with other horizontal branch lines at a 90-degree angle are connected using ________ fittings.
16. ________ is one of four factors that must be considered when determining the intervals for manholes.
17. The ________, also called slope, of the piping system works with gravity to move solid and liquid waste through DWV systems.
18. The discharge overflow lip or ledge at the trap outlet is the crown ________.
19. ________ strain the wastewater before it enters the drainage piping.
20. ________ are lengths of pipe that continue in a straight line.
21. When pressure inside the DWV piping is greater than atmospheric pressure, it is called ________.
22. A(n) ________ is the access point to connected parts of the drainage system for the removal of blockages.
23. ________ allow smaller lines to be connected in line to a bend.
24. A(n) ________ is the section of stack between points where branch pipes connect to the main DWV stack.
25. An imbalance in pressure between the inside and outside DWV piping can cause ________.

26. Code generally requires the use of ________ at the base of stacks.

27. ________ is a general term for most vertical line including offsets of soil, waste, vent, or inside conductor piping.

28. A one-piece or two-piece trap with a union nut is called a(n) ________.

29. A(n) ________ consists of a circuit of piping inside a building.

30. Improvements in plumbing have replaced ________ with the P-trap.

31. Porous or fibrous material caught in a trap can cause a seal to be broken by ________.

32. The infrequent use of a trap can cause ________ of the seal.

33. ________ are devices used to connect pipe in DWV systems.

34. The upper ends of vents are joined to the top of soil and waste stacks by a(n) ________.

35. Vent stacks are attached to the lower end of the soil and waste stacks by ________.

36. Connectors that may be used in place of vent branches are called ________.

37. The level at which water tends to flow through the trap is the ________.

38. ________ is the speed at which waste flows through pipes.

39. The ________ in a horizontal pipe from crown weir to vent must not exceed one pipe diameter.

40. ________ is wastewater generated from domestic processes such as laundry and bathing.

41. ________ permit connecting smaller lines to wyes and tees.

42. The downstream end of a pipe or the male end of a fitting that can be inserted into another DWV fitting is called the ________ end.

Trade Terms

Adapters	Evaporation	Pipe scale	Sludge
Back pressure	Fall	Runs	Spigot
Branch interval	Fixture drains	S-traps	Stack
Building sewer	Grade	Sanitary combination	Test tees
Capillary action	Graywater	Sanitary fittings	Velocity
Cleanout	Heel inlets	Sanitary increasers	Vent branch
Double ¼ bends	Hydraulic gradient	Sanitary upright wyes	Vent ells
Double trapping	Interceptors	Sanitary wyes	Vent tees
Drainage fittings	Inverted wyes	Short sweep ¼ bends	Weir
DWV system	Long sweep ¼ bends	Side inlets	
Elevation	P-trap	Siphonage	

Trade Terms Introduced in This Module

Adapters: Fittings that join pipes of different sizes or materials, such as copper and galvanized pipe or cast-iron and plastic pipe.

Back pressure: A condition which may occur in the DWV system whereby a higher pressure than atmospheric pressure is created in the drain/vent piping, causing a reversal of the normal flow through drain piping and traps. Also referred to as backpressure backflow.

Branch interval: A distance along a soil or waste stack corresponding, in general, to a building story height, but in no case less than 8 feet, within which the horizontal branches from one floor or story of a building are connected to the stack.

Building sewer: The part of the drainage system that extends from the end of the building drain and conveys its discharge to a public sewer, private sewer, individual sewage-disposal system, or other point of disposal.

Capillary action: The tendency of water to be drawn into porous or fibrous material against gravity above the level of the water source.

Cleanout: An access point to connected parts of the drainage system for the removal of blockages.

Double 1/4 bends: Fittings used to collect and combine the flow from two opposite runs into a single run of pipe.

Double trapping: A situation in which one trap is attached to another, creating negative pressure that stops the intended flow of drainage.

Drainage fittings: Fittings installed in the drainage sections of the DWV system to remove waste from a building.

Drain-waste-vent (DWV) system: Refers to the combined sanitary drainage and venting systems. This term is technically equivalent to soil-waste-vent (SWV).

Elevation: The height above an established reference point, such as a grade reference point on a construction drawing.

Evaporation: The natural change from liquid to vapor of water at a temperature below its boiling point.

Fall: The amount of slope given to horizontal runs of pipe expressed as a height in inches per foot of run.

Fixture drains: The drains from traps of fixtures to the junction of those drains with any other drain pipe.

Grade: When referring to DWV and especially sewer systems, the slope of a run of pipe. Also referred to as slope or percent of grade.

Graywater: Wastewater generated from domestic processes other than human-waste disposal. These include laundry, dishwashing, and bathing. Graywater comprises 50 to 80 percent of residential wastewater.

Heel inlets: Openings in the curved, heel portion of bend fittings in line with the bend, used to connect smaller lines to the main line.

Hydraulic gradient: The level of the surface of water flowing in a partially-full pipe by gravity alone.

Interceptors: Devices designed and installed so as to separate and retain deleterious, hazardous, or undesirable matter from normal waste, while permitting normal sewage or liquid wastes to discharge into the drainage system by gravity.

Inverted wyes: Fittings used to join the upper end of vents to the top of soil and waste stacks. The have the appearance of the upside-down letter Y.

Long sweep 1/4 bends: Long-radius bends commonly used at the base of DWV stacks and elsewhere when the longer radius is needed to greatly decrease flow resistance and back pressure. Their use is regulated by code.

Pipe scale: A flaky, adherent coating on pipe walls resulting from the corrosion of metals, especially iron or steel. Also, a heavy oxide coating on copper or copper alloys resulting from exposure to high temperatures and oxygen.

P-trap: A trap constructed in the shape of the letter P with the loop facing downward, which provides a water seal in a waste or soil pipe, used mostly at sinks and lavatories.

Runs: Lengths of pipe that continue in a straight line.

S-traps: Traps with long downstream legs, which tend to promote siphonage. S-traps are no longer permitted by code for new installations but are still found in older buildings.

Sanitary combination: A fitting that combines a wye and 1/8 bend. It is used to connect horizontal branch lines that intersect other horizontal branch lines. It offers less resistance to the flow of material than a sanitary tee. Also called a tee-wye.

Sanitary fittings: Fittings used to connect DWV branches to the main DWV system and to serve as cleanouts.

Sanitary increasers: Fittings used to enlarge the diameter of vent stacks. They are usually placed at least 1′ below the penetration of the stack through the roof. Their use is regulated by code.

Sanitary upright wyes: Fittings used to connect separate vent stacks to the lower ends of soil and waste stacks.

Sanitary wyes: Drainage fittings, shaped like the letter Y, that join branches to the main run of pipe at an angle.

Short sweep ¼ bends: Bend fitting with a short radius used at the base of a DWV stack and elsewhere. Their use is regulated by code

Side inlets: Openings in ell or tee fittings at right angles to the line of the run, used to connect smaller lines to the main line.

Siphonage: Loss of water in a trap seal started by unequal pressure inside and outside DWV piping. The water initially flows in the direction of the lower pressure. Sustained siphonage, even in the absence of pressure differences, results from the cohesive property of water.

Sludge: Semi-liquid matter that settles out in a holding tank during the waste treatment process.

Spigot: When referring to DWV systems, the pipe end or the male portion of a fitting that inserts into the hub of a downstream fitting.

Stack: A general term for certain vertical DWV pipes, including offsets of soil, waste, vent, or inside conductor piping. This does not include vertical fixture and vent branches that do not extend through the roof or that pass through not more than two stories before being reconnected to the vent stack or stack vent.

Test tees: Tees installed as test locations for pressurizing the DWV system to test for leaks before placing it in operation.

Velocity: Technically, the speed and direction of a moving object. Commonly used in place of speed for describing the motion of fluids in pipes.

Vent branch: A vent connecting one or more individual vent lines with a stack vent.

Vent ells: Plastic fittings with a sharp turn radius, used only in vent piping systems. Their use is regulated by code.

Vent tees: Fittings used in venting systems or as cleanouts. They may not be used in the drainage system because it restricts the flow of material. Their use is regulated by code.

Weir: When referring to plumbing, a ledge or lip in a fixture that controls the level of water inside the fixture. The word comes from Old English, meaning dam.

Additional Resources

This module is intended as a thorough resource for task training. The following reference works are suggested for further study.

"Design of Sewer System." Civil Engineers PK. Updated 2017. **https://civilengineerspk.com/**.

2015 International Plumbing Code Commentary (Includes IPSDC), 2014. International Code Council (ICC).

Plumbing Venting: Decoding Chapter 9 of the IPC, Bob Scott. 2014. Procodeclasses.

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Greyter Water Systems Inc., Figure 2

Watts, Figure 3 (bottom)

Genova Products, Inc., Figure 3 (top), Figure 37

Interceptor image used by permission of Josam (*www.josam.com*), Figure 5

Charlotte Pipe and Foundry, Figure 15, Figure 17, Figure 35

The Stanley Works, 02111 SA01

Section Review Answer Key

Section 1.0.0

Answer	Section Reference	Objective
1. c	1.0.0	1a
2. b	1.2.0	1b

Section 2.0.0

Answer	Section Reference	Objective
1. b	2.1.0	2a
2. a	2.2.0	2b
3. c	2.3.4	2c

Section 3.0.0

Answer	Section Reference	Objective
1. b	3.1.0	3a
2. c	3.2.2	3b

Section 4.0.0

Answer	Section Reference	Objective
1. d	4.1.0	4a
2. c	4.2.1	4b
3. a	4.3.0	4c
4. c	4.4.0	4d

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