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Introduction to Continuing Education Class on What Can Go Wrong? [Common Plumbing Problems] for Utah Plumbers (Video)

Hello and welcome to this class on everything that can go wrong in plumbing.

I’m not being entirely serious. We all know there are a LOT of things that go wrong with plumbing. Some problems are going to arise, no matter how well we do our jobs or how well-made the materials are that we install.

This class will focus, as much as possible, on the kinds of problems that CAN be avoided. They’re among the most common ones reported by plumbing inspectors or griped about by the next plumber who has to fix what wasn’t done right the first time. The material presented in the class may not be new to you. By reviewing and discussing it, the goal is to draw your attention to areas of vulnerability and offer some practical approaches. We’ll look at, for example:

- ➔ Noisy pipes;
- ➔ Cleanouts;
- ➔ Clearances around fixtures;
- ➔ Traps and vents;
- ➔ Corrosion; and
- ➔ Cross-Connection.

Before looking at some of these topics in depth, the first lesson in the class is a brisk survey of a wide array of where we might get it wrong from time to time, such as with slopes for drainage piping, mismatched pipes, air gaps, floor drains, T&P valves, and combustion air. It’s a nice wide assortment of topics to kick off the class, so let’s get to it.

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How were the topics in this class	They’re among the most common	We took them from a poll of	Each topic to be covered is a	They’re the problems most

selected (according to the information provided in the introductory video)?	problems reported by plumbing inspectors	plumbers, nationwide	chapter title in the model codes	likely to involve illness, injury, or death when they malfunction

[QUESTIONBOTTOM]

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Ten Plumbing Problem Areas

I. Noise

You can have a plumbing system that seems to meet every need for a structure but the residents see it as troubled because it's just too darned loud. Plumbing systems are the most highly valued when they are almost entirely unnoticed and few people want to be distracted by the sounds of plumbing through a wall.

There are four sources of plumbing noise that this class will address:

1. Noisy drainage piping;
2. Noisy water supply pipes;
3. Water hammer; and
4. Pumps and other equipment.

The point is to look at systemic noise that occurs when the plumbing is operating normally. The class won't address noise that indicates a problem – when a noise that suggests a problem occurs, it's not noise abatement but repair that is needed. We WANT to hear those noises, but systemic noises are all-too-common in modern plumbing installations and need to be addressed.

Principles of Noise Transmission

There are two forms of noise transmission – airborne and vibration-caused. Hearing the sound of a toilet flushing in the next room or the sound of water gushing are examples of airborne sound. Mitigation of airborne sound is straightforward and involves blocking and absorbing the sound waves with mass (thickness of the partition) or acoustic material.

Noise transmission through vibration occurs when one vibrating object makes physical contact with another and transfers energy to the other object. This form of noise transmission bedevils plumbing systems.

Drainage Piping

As you know, whenever fluid travels through manufactured piping, it creates more or less friction against the inner pipe walls. The friction slows the speed of the liquid (i.e., it is less energetic) and the energy that's removed through friction is released in a variety of ways, most notably by making the piping vibrate. The more mass in the walls, the more energy it takes to make the walls vibrate – therefore, plastic piping vibrates far more easily than metal pipes. Similarly, the more friction that's caused – for example from the speed of the flow and diameter of the pipe relative to the volume of the flow – the more energy is released.

In a gravity system, drainage effluent in vertical pipes typically travels in a spiral motion, adhering to the inside walls of the pipe. In this mode, very little noise is generated. The effluent generates far more noise when liquids and solids hit fittings at changes in direction, particularly when vertical pipes transition to horizontal drain lines.

A second cause for noisy drainage piping is thermal expansion and contraction. Drainage piping is particularly prone to this since it is used intermittently with large flows hitting idle sections of pipe, so that the expansion or contraction can be more severe. The effects are also amplified with PVC or ABS, which expand and contract at rates eight times that of metal pipes. This can cause plastic pipes to creak and strain against supports and can amplify vibratory noise transmission if expansion pushes pipes against drywall, studs, or other structural elements.

One obvious noise mitigation method would be to use cast-iron pipe and fittings rather than plastic or copper. Regardless of the piping material used, care should be taken to avoid contact between the piping and the building's components by using isolating materials such as felt or rubber where distances can't be maintained. Since vibration is a release of energy, having very few points of contact is not much better than numerous points of contact; those fewer spots will just be noisier. Absorbent materials between piping and supporting braces can also mitigate noise.

On very large and heavy riser pipes, spring-loaded riser isolation rubber or neoprene pads are available from manufacturers in various thicknesses ranging from ¼ inch and up; spring-loaded isolation pads are also available. Acoustical sealant may also be used when penetrating walls and floors.)

A typical accoustical sealant

Sleeves intended for use to insulate pipes (generally for temperature issues) also provide noise insulation. Using material designed for the purpose is advised; wrapping pipes in discarded carpeting, for example, is to be avoided.

Water Supply Pipes

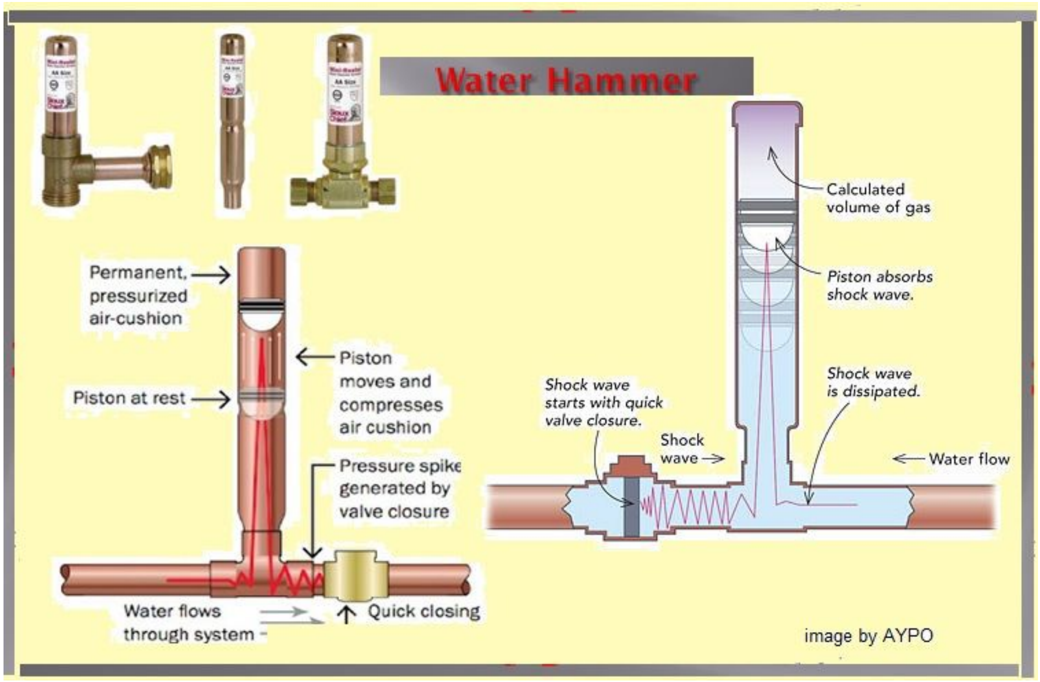
Three main causes of noise in water distribution systems

1. Water pressure
2. Water velocity
3. Number and type of constrictions and fittings

Water supply pipes are under pressure and therefore transmit noise readily, even just from the flow of water. If you've ever seen a hose flop around and vibrate wildly.when exposed to high water pressure, you can understand how the same phenomenon would happen to water supply piping. The volume will increase with higher flow rates, increased pressure, and turbulence caused by changes of direction and obstructions at valves, faucets, etc.

Since the noise is primarily vibration it's vital to keep water pipes from touching building elements. Use of tested and proven pipe isolators and clamps for through-stud situations and surface-mounted attachments is recommended. Similar to drainage piping, metal isn't as noisy as plastic but the selection of metal piping for potable water is more limited. Methods similar to those for drainage piping can cushion water supply pipes at penetrations, support clamps, etc. Heated water has more energy and therefore causes more vibration, so isolating the vibration of piping from water heaters is critical, but a rapid change from warm to cold also results in a large release of energy and can generate noise. Insulating water supply pipes for temperature maintenance helps mitigate noise; the denser the insulation, the better for noise mitigation.

Water Hammer



There are numerous reasons why the phenomenon of “water hammer” can occur. In principle, it occurs when water is moving rapidly through a pipe (especially if the pipe is of a smaller diameter relative to the flow rate) and a valve closes suddenly but there is no outlet for the pressure that has built up. With no outlet, the pressure converts to kinetic energy, which is then released as vibration of the pipe, itself, becoming audible as a loud “bang”. In many homes that experience water hammer, the rapidly closing valves are in dishwashers or washing machines, but any valve (automatic water systems, for example) can create the problem. Reducing pressure and velocity and avoiding quick-closing valves helps reduce water hammer or air-filled stubs (air chambers) can provide short-term relief. A better solution is the use of shock arrestors or water hammer arrestors, which are mechanical devices similar to spring-loaded shock absorbers meant to be installed in piping near appliances or equipment with fast-closing valves, such as washing machines.

Water hammer is an underestimated peril. It should not be reduced to the term “knocking” in the pipes. The noise itself is annoying but it can also severely jar piping, equipment or machinery housing, possibly resulting in damage not only to gaskets in junctions, but also to valve flanges or the valves themselves. In worst cases, it can be powerful enough to crack pipes, damage seals and connections, destroy pumps, etc. Where any significant potential water hammer risk exists, installation of an approved water hammer arrestor is required.

Both the IPC® and UPC® require that, where the water supply system is not designed with sufficient air pockets to alleviate water hammer, other measures must be taken. A sample code provision is shown, below:

2015 UPC® 609.11 Water Hammer. Building water supply systems where quick-acting valves are installed shall be provided with water hammer arrester(s) to absorb high pressures resulting from the quick closing of these valves. Water hammer arresters shall be approved mechanical devices in accordance with ASSE 1010 or PDI WH 201 and shall be installed as close as possible to quick-acting valves.

Pumps & Valves

Pumps are loud – there's not much that can be done about that. An undersized pump will be louder and some are simply designed noisier than others. The best solution is not to use them. Wherever systems can be engineered to avoid or replace pumps, it will undoubtedly be quieter. Isolating them and keeping them as far as possible from occupied zones is another strategy.

When connecting the piping system to pumps and equipment, especially ones that generate a great deal of vibration, pay special attention to the choice of flexible connectors and how it's strapped in or supported. Most vital is to recognize that whatever it's based on will be the most prone to vibration. A platform that uses vibration control (springs, fibrous material, etc.) or that is less prone to vibrate (solid concrete, etc.) can make a big difference.

Valves are also noisy by nature. Most valve manufacturers provide flow and turbulence data to help in selection of quieter options. Typically, valves with smooth waterways (e.g. full-way ball valves and full-way gate valves) aren't as noisy.

II. Sloping for Drainage Piping

Sloppy or incorrectly sloped drainage piping is far too common.

The slope of drainage piping is not an academic exercise. The ideal slope matched with the ideal diameter results in an efficient exploitation of gravity to fully clear drainage piping. The slope for most drainage piping drops at a rate of ¼ inch for every foot of length. The slope MUST be consistent except where trapped or where transition fittings are appropriately engineered and vented.

The problems caused by inadequate sloping are obvious. The effluent must move rapidly enough for the flow to adhere to the outside walls and provide a pathway for air and rapidly enough to bear the solids in solution through and out to the vertical drains or sewer.

It would be a mistake to assume that, the greater the slope, the more effective the drainage. If effluent that bears solid wastes moves too rapidly, the fluid will accelerate faster than the solids and evacuate the drainage piping, leaving a portion of the solids behind.

Code requirements reflect the need to maintain a consistent and sufficient slope. Sufficient may not, however, be ideal. Although it's true that a larger diameter pipe exerts less friction on flow and that a slope as little as $^1/_{16}$ inch per foot is permitted, maintaining a consistent ¼ inch per foot even as a smaller diameter pipe transitions to a larger diameter pipe is often the best design.

2015 International Plumbing Code

CHAPTER 7 SANITARY DRAINAGE

SECTION 704
DRAINAGE PIPING INSTALLATION

704.1 Slope of Horizontal Drainage Piping

Horizontal drainage piping shall be installed in uniform alignment at uniform slopes. The slope of a horizontal drainage pipe shall be not less than that indicated in Table 704.1.

TABLE 704.1 SLOPE OF HORIZONTAL DRAINAGE PIPE

SIZE (inches)	MINIMUM SLOPE (inch per foot)
$2^{1}/_{2}$ or less	$^{1}/_{4}$
3 to 6	$^{1}/_{8}$
8 or larger	$^{1}/_{16}$

III. Mismatched Piping

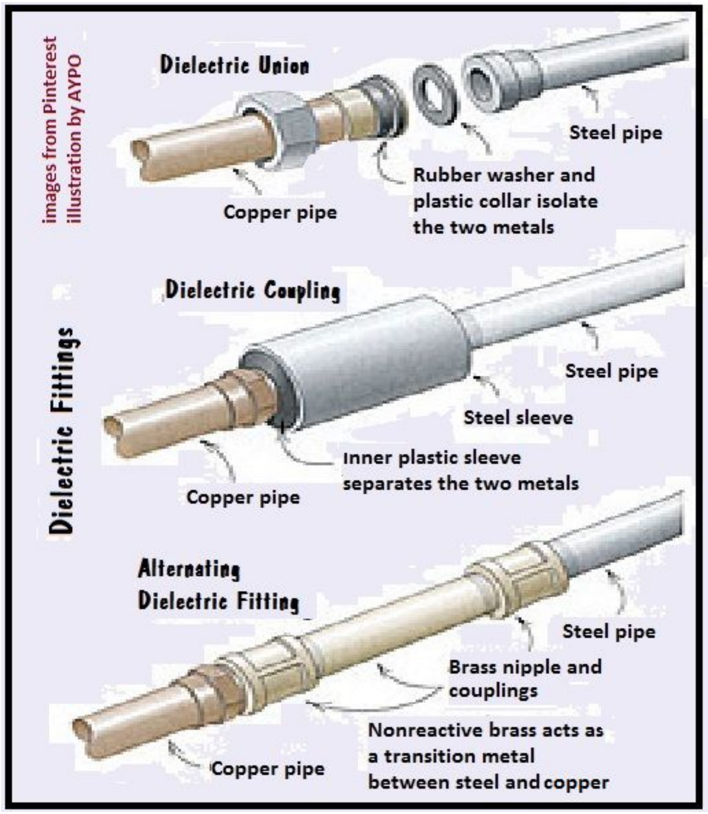
This is one of the more common plumbing mistakes and can cause serious problems. The situation arises most often when doing any remodeling or repair on an older home where galvanized or cast-iron pipe won't be matched but will need to transition to newly installed plastic or copper piping.

Galvanized metal pipe must never connect directly to copper pipe. The galvanic zinc added to threaded galvanized water pipes interacts vigorously with copper, resulting in a chemical reaction that rapidly corrodes the joint and will eventually cause it to leak.

There are two safe ways to connect copper and galvanized steel

A. Since brass is non-reactive with either copper or zinc, one method is to use an intermediary brass fitting. For example, a brass nipple connecting female ends for both the copper and the galvanized steel pipes will prevent the two reactive metals from interacting.

B. There are pre-manufactured, specialized fittings (known as dielectric joints or unions). Essentially, the fitting separates a copper portion from a steel portion with insulating, non-reactive washers so that the fitting can attach to copper on one side and to galvanized steel pipe on the other side. The two halves of the joint are then secured using a lock nut.



Connecting plastic pipe such as ABS or PVC to copper or galvanized steel piping does not have the same issue of a chemical reaction, since the plastic is nonreactive. If there is an attempt to connect a female threaded plastic slip-joint connector to a male metal threaded pipe end, pipe tape can be used, but not pipe compound since it would dissolve the plastic. Avoid wrapping the tape too thick so it doesn't push against the plastic connector. There are also numerous manufactured transition joints available such as a "band clamp," comprised of a thick rubber tube with a screw clamp on each end that is slipped over the plastic and steel pipe ends, then tightened in place. Other manufactured connectors are glued into place into the plastic and steel pipe end, respectively. Be wary because connections between plastic and metal piping are less tolerant of deformities, such as either pipe being slightly off-round or irregularities at the cut end.

See an example of how the 2015 UPC® addresses connection between mismatched piping.

2015 UNIFORM PLUMBING CODE

CHAPTER 7 **SANITARY DRAINAGE**

705.9 Joints Between Various Materials. Joints between various materials shall be installed in accordance with the manufacturer's installation instructions and shall comply with Section 705.9.1 through Section 705.9.4. Mechanical couplings used to join different materials shall be in accordance with ASTM C1173 for belowground use, ASTM C1460 for aboveground use, or ASTM C1461 for aboveground and belowground use.

705.11.1 Copper Pipe to Cast-Iron Pipe. Joints from copper pipe or tubing to cast-iron pipe shall be made with a listed compression type joint or brass ferrule. The copper pipe or tubing shall be soldered or brazed to the ferrule and the ferrule shall be joined to the cast-iron hub by a compression or caulked joint.

705.11.2 Copper Pipe to Threaded Pipe Joints. Joints from copper pipe or tubing to threaded pipe shall be made by the use of a listed brass adapter or dielectric [resistant to conducting electricity] fitting. The joint between the copper pipe and the fitting shall be soldered or brazed, and the connection between the threaded and the fittings shall be made with a standard pipe-size threaded joint. [Note: A dielectric connection is necessary to mitigate the corrosion and deterioration that occurs when an electric charge is allowed to pass through metallic piping.]

705.11.3 Plastic Pipe to Other Materials. Where connecting plastic pipe to other types of plastic or other types of piping material, approved listed adapter or transition fittings and listed for the specific transition intended shall be used.

705.11.4 Stainless Steel Pipe to Other Materials. Where connecting stainless steel pipe to other types of piping, listed mechanical joints of the compression type and listed for the specific transition intended shall be used.

IV. Inadequate or Inaccessible Cleanouts

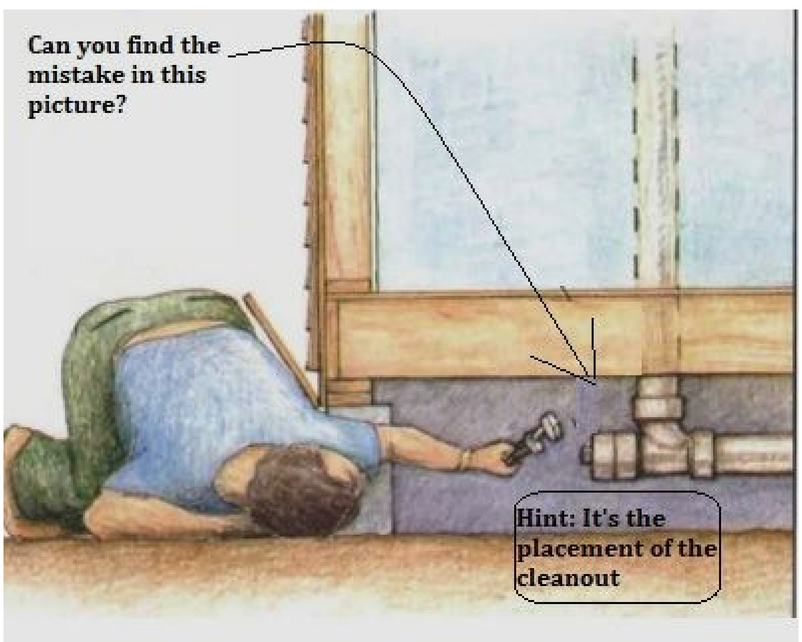
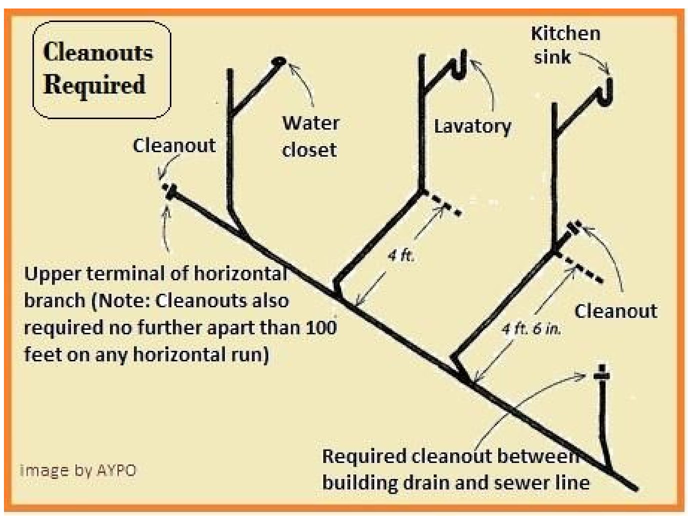


image courtesy Fine Homebuilding Magazine Oct/Nov 1999

A well-designed sanitary drainage system may, nevertheless, not make adequate provision for cleanouts. It is far too common that cleanout placement is inconvenient and not suited to its purpose.

Code requirements are minimal - one for at least every 100 feet of horizontal drainage piping, when the change of direction of the line exceeds 45 degrees, and within 10 feet of the junction between the building drain and building sewer. No cleanouts are required above the first floor. Rather than abiding by code required minimums, consider what arrangement will facilitate the system's cleaning and maintenance without dislocating occupants, including cleanouts above the first floor and spaced for ease of access rather than to meet maximum separation requirements. Problems arise far too often when cleanouts are placed in areas later used for machinery, equipment, cabinets, etc. Additional problems arise when cleanouts are on an upper floor above sensitive areas, such as food preparation areas, data centers, medical treatment areas, etc. Possible solutions would include arranging cleanouts in corridors or areas that are certain to remain clear, installing an offset extension that provides access but is at a height and location where it will be undisturbed, and installing a drain pan to catch effluent from the cleanout that might otherwise endanger floors below.



Placing cleanouts where they'll be out of the way doesn't mean they should be placed where access is impaired (see image at top of this slide). Codes make some provision for this, such as the following from the 2015 IPC®: *[Note: The full IPC Section 708.1 is reproduced at the bottom of this slide]*

2015 IPC® 708.1.10 Cleanout Access. Required cleanouts shall not be installed in concealed locations. For the purposes of this section, concealed locations include, but are not limited to, the inside of plenums, within walls, within floor/ceiling assemblies, below grade and in crawl spaces where the height from the crawl space floor to the nearest obstruction along the path from the crawl space opening to the cleanout location is less than 24 inches (610 mm).

Drains should be routed far enough from walls and obstructions that the drain cleaning machine can gain access if needed. Generally, it's best to provide a distance of about three feet from a cleanout to any obstruction or wall. Don't forget that, as water-conserving fixtures become more widely used or required by updated codes, this means lower volume drainage flows, which means that drainage lines won't flush out naturally and access to drainage cleanouts will be more important. Where graywater systems divert wastewater along with low-flow toilets, the amount of sediment in lines is bound to increase, along with a need for cleanouts.

708.1 Cleanouts Required. Cleanouts shall be provided for drainage piping in accordance with Sections 708.1.1 through 708.1.11.

708.1.1 Horizontal Drains and Building Drains. Horizontal drainage pipes in buildings shall have cleanouts located at intervals of not more than 100 feet (30 480 mm). Building drains shall have cleanouts located at intervals of not more than 100 feet (30 480 mm) except where manholes are used instead of cleanouts, the manholes shall be located at intervals of not more than 400 feet (122 m). The interval length shall be measured from the cleanout or manhole opening, along the developed length of the piping to the next drainage fitting providing access for cleaning, the end of the horizontal drain or the end of the building drain.

Exception: Horizontal fixture drain piping serving a nonremovable trap shall not be required to have a cleanout for the section of piping between the trap and the vent connection for such trap.

708.1.2 Building Sewers. Building sewers smaller than 8 inches (203 mm) shall have cleanouts located at intervals of not more than 100 feet (30 480 mm). Building sewers 8 inches (203 mm) and larger shall have a manhole located not more than 200 feet (60 960 mm) from the junction of the building drain and building sewer and at intervals of not more than 400 feet (122 m). The interval length shall be measured from the cleanout or manhole opening, along the developed length of the piping to the next drainage fitting providing access for cleaning, a manhole or the end of the building sewer.

708.1.3 Building Drain and Building Sewer Junction. The junction of the building drain and the building sewer shall be served by a cleanout that is located at the junction or within 10 feet (3048 mm) of the developed length of piping upstream of the junction. For the requirements of this section, the removal of the water closet shall not be required to provide cleanout access.

708.1.4 Changes of Direction. Where a horizontal drainage pipe, a building drain or a building sewer has a change of horizontal direction greater than 45 degrees (0.79 rad), a cleanout shall be installed at the change of direction. Where more than one change of horizontal direction greater than 45 degrees (0.79 rad) occurs within 40 feet (12 192 mm) of developed length of piping, the cleanout installed for the first change of direction shall serve as the cleanout for all changes in direction within that 40 feet (12 192 mm) of developed length of piping.

708.1.5 Cleanout Size. Cleanouts shall be the same size as the piping served by the cleanout, except that cleanouts for piping larger than 4 inches (102 mm) need not be larger than 4 inches (102 mm).

Exceptions:

1. A removable P-trap with slip or ground joint connections can serve as a cleanout for drain piping that is one size larger than the P-trap size.
2. Cleanouts located on stacks can be one size smaller than the stack size.
3. The size of cleanouts for cast-iron piping can be in accordance with the referenced standards for cast-iron fittings as indicated in Table 702.4.

708.1.6 Cleanout Plugs. Cleanout plugs shall be of brass, plastic or other approved materials. Cleanout plugs for borosilicate glass piping systems shall be of borosilicate glass. Brass cleanout plugs shall conform to ASTM A 74 and shall be limited for use only on metallic piping systems. Plastic cleanout plugs shall conform to the referenced standards for plastic pipe fittings, as indicated in Table 702.4. Cleanout plugs shall have a raised square head, a countersunk square head or a countersunk slot head. Where a cleanout plug will have a trim cover screw installed into the plug, the plug shall be manufactured with a blind end threaded hole for such purpose.
708.1.7 Manholes. Manholes and manhole covers shall be of an approved type. Manholes located inside of a building shall have gas-tight covers that require tools for removal.
708.1.8 Installation Arrangement. The installation arrangement of a cleanout shall enable cleaning of drainage piping only in the direction of drainage flow.
Exceptions:
1. Test tees serving as cleanouts.
2. A two-way cleanout installation that is approved for meeting the requirements of Section 708.1.3.
708.1.9 Required Clearance. Cleanouts for 6-inch (153 mm) and smaller piping shall be provided with a clearance of not less than 18 inches (457 mm) from, and perpendicular to, the face of the opening to any obstruction. Cleanouts for 8-inch (203 mm) and larger piping shall be provided with a clearance of not less than 36 inches (914 mm) from, and perpendicular to, the face of the opening to any obstruction.
708.1.10 Cleanout Access. Required cleanouts shall not be installed in concealed locations. For the purposes of this section, concealed locations include, but are not limited to, the inside of plenums, within walls, within floor/ceiling assemblies, below grade and in crawl spaces where the height from the crawl space floor to the nearest obstruction along the path from the crawl space opening to the cleanout location is less than 24 inches (610 mm). Cleanouts with openings at a finished wall shall have the face of the opening located within 11/2 inches (38 mm) of the finished wall surface. Cleanouts located below grade shall be extended to grade level so that the top of the cleanout plug is at or above grade. A cleanout installed in a floor or walkway that will not have a trim cover installed shall have a countersunk plug installed so the top surface of the plug is flush with the finished surface of the floor or walkway.
708.1.10.1 Cleanout Plug Trim Covers. Trim covers and access doors for cleanout plugs shall be designed for such purposes and shall be approved. Trim cover fasteners that thread into cleanout plugs shall be corrosion resistant. Cleanout plugs shall not be covered with mortar, plaster or any other permanent material.
708.1.10.2 Floor Cleanout Assemblies. Where it is necessary to protect a cleanout plug from the loads of vehicular traffic, cleanout assemblies in accordance with ASME A112.36.2M shall be installed.
708.1.11 Prohibited Use. The use of a threaded cleanout opening to add a fixture or to extend piping shall be prohibited except where another cleanout of equal size is installed with the required access and clearance.

V. Air Gaps & Air Breaks

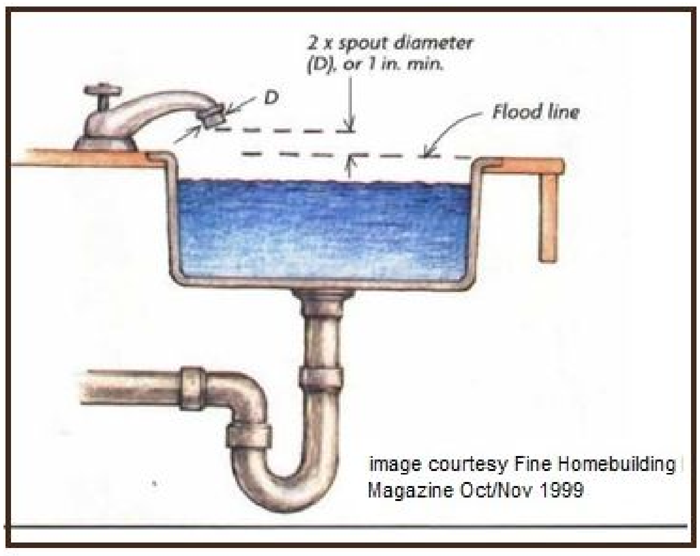


image courtesy Fine Homebuilding Magazine Oct/Nov 1999

Where sinks are manufactured with the spout and basin provided, an air gap will be designed and maintained, but a field-built or customer-designed sink may not. Where a spout comes from one source and the basin another, the required air gap of twice the diameter of the spout may not be maintained. The concern is not with water splashing back up the spout or rising from the fixture drain but a situation where siphonage can draw wastewater back into the water supply from a full basin.

If the sink has a hand sprayer that can extend out and be submerged in the basin, it must be provided with anti-siphonage or backflow protection.

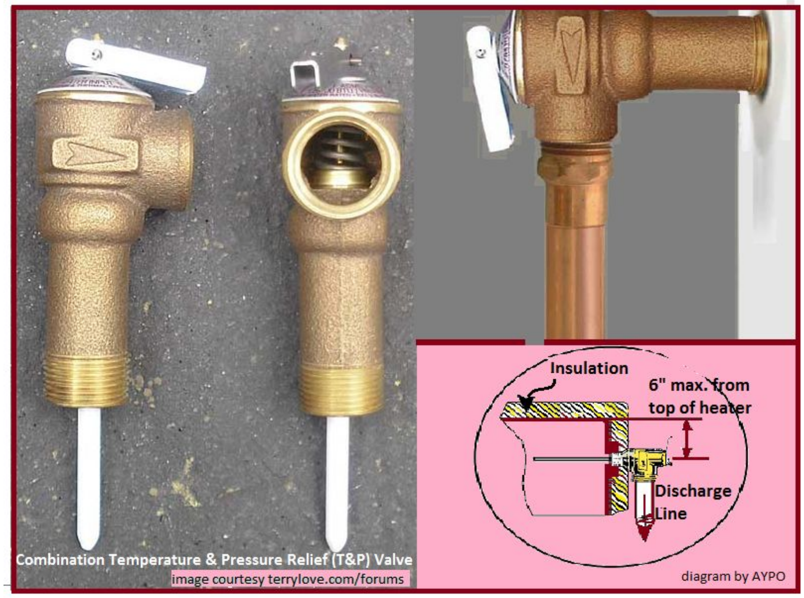
Another common problem occurs when indirect plumbing outlets are not well-matched or well-positioned with the receptors. The outlet in indirect plumbing that maintains an air break is positioned below the floor rim of the receptor and the outflow must be directed so that it doesn't splash off either wall near the flood rim and secured so that it can inadvertently be dislodged so that it is no longer positioned directly down the receptor.

VI. Floor Drains

Traps for floor drains can present unique installation challenges. Many come with integral traps and cleanout plugs; others must have those components installed independently.

Be sure to check where and when floor drains are required, whether the floor drains must indirectly connect before emptying into shared drainage piping, and how the trapping requirements can be met.

VII. Water Heater T&P Valves & Condensation



Water-heating systems must be protected from excessive temperatures and pressures by relief valves. T&P relief valves offer economical and effective protection, but only if they are properly maintained. A relief valve on a water supply system is exposed to elements such as corrosive water that attacks materials and deposits of lime that close up waterways and flow passages. For these reasons, T&P relief valves should be tested on a regular basis to ensure safe and proper operation. In addition, the minimum size of the valve should be ¾ inch for inlet and outlet connections.

Manufacturers recommend that the heat sensor of a T&P valve be immersed within the top six inches of a tank (since heat rises, the hottest part of the tank). Water with a high mineral content can cause scaling severe enough to render a valve inoperable within a few months. In locations where the water supply is very hard water, it is advisable to manually clear the valve every three months; in other areas, annual purging of the valve can verify it is operating properly.

Codes mandate that T&P valves selected for storage water heater systems must, at a minimum, relieve pressure at the maximum pressure the tank can withstand. This is a common sense regulation. What good would a pressure relief be if it didn't relieve pressure that was at the limit of the container's ability to withstand pressure? At the same time, a T&P valve cannot be set to relieve pressure that is well within the tank's capacity. The rule of thumb is 90% – the T&P valve is set to allow steam to vent and relieve pressure when the psig or temperature is more than 90% above the normal operating pressure and temperature.

Temperature and pressure (T&P) ASME, ANSI and CSA approved relief valves used on residential water heaters are typically designed and manufactured to relieve on pressure at 150 psig and on temperature at 210°F.

In normal operation of the water heater and T&P valve, no water should be discharged from the valve. A T&P valve that discharges is an indication of an abnormal condition in the system and by discharging, the T&P valve is meeting its designed safety purpose. The causes of discharge can be thermal expansion, excess system pressure, low temperature relief, too high a setting on the water heater, or something in the water heater causing excess temperatures in the heater.

The discharge from a T&P valve can be very hot. It is very important that all T&P valves be installed properly with a discharge line piped downward to an adequate drain to avoid property damage and to minimize possible human contact. In addition, frequent relief discharges can cause a buildup of natural mineral deposits on the valve seat, rendering the valve inoperative.

[Note: Instantaneous water heaters having an inside diameter of three inches or less are exempt from having a T&P valve, since such small units are without a storage reservoir (having only a heating coil) and therefore cannot experience significant thermal expansion.]

Expansion Tanks

Thermal expansion tank

When water is heated, it expands. Older homes simply allowed the expanded water to push back into the water main, which created the potential for contamination. As a result, most newer homes have backflow prevention valves (as integral valves or inside water softeners or water meters) to stop the water from re-entering the water supply.

Since the expanded water now has nowhere to go, the water pressure in the house's pipes can increase dramatically, forcing the Temperature and Pressure Relief (T&P) Valve to discharge frequently, T&P relief valves are intended to only operate on rare occasions. They are not designed for – nor capable of – routine operation.

Where a water heater may be configured so as to regularly experience spikes in pressure or where the system design would make pressure spikes more likely, the model codes now require the installation of an expansion tank. Thermal expansion tanks are manufactured with an internal air bladder (or bladders) that absorb the expanded water. A thermal expansion tank is now the only code-approved method for controlling the pressure and explosive potential of water being heated in a “closed” system. The most common situation that would need an expansion tank would be where there is a “closed” system, created by having a backflow preventer upstream of the water heater.

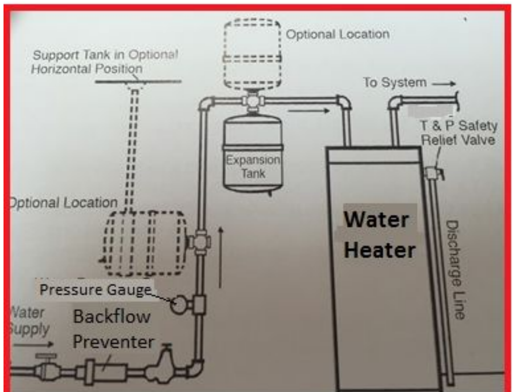


image from Watts Brands

Condensation from Water Heaters & T&P Valve Drainage

For many years, little attention was paid to the need to convey condensation that was a byproduct of gas-fired water heaters. Water vapor (along with carbon monoxide, carbon dioxide, and hydrogen or nitrogen) is a byproduct when natural gas combusts. The higher percentage of the gas fuel that is burned (i.e., more efficient), the more heat, less carbon monoxide, and the more water vapor is created. Perfect combustion (that burns 100% of the natural gas) would have a by-product of one cubic foot of carbon dioxide and two cubic feet of water vapor for every cubic foot of natural gas (and no carbon monoxide). In fact, perfect combustion is never achieved. Older water heaters might achieve up to 80% efficiency. As a result, very little water vapor was created but much more carbon monoxide than newer, high-efficiency water heaters that achieve 92% or higher ratings for percentage of fuel gas burned. Therefore, the associated condensate is much greater in high-efficiency appliances, requiring greater care than has been given in the past to preventing damage from condensation overflowing into the structure.

A similar lack of attention on the water draining from T&P relief valves has also been widespread. This had led to numerous errors in installation. The requirements, as laid out in the 2015 IPC® are reproduced in the image, below, showing how carefully this plumbing element is regulated. Emphasis is added to item 10 regarding the need to maintain an air gap. As the ICC Plumbing Code Technical Committee wrote:

“Installers often forget that the outlet of a temperature and pressure relief valve is a potable water outlet that must be protected against backflow conditions. The floor where the pipe discharges could become flooded, or the waste receptor could become clogged and overflow. The air gap of twice the pipe diameter provides a minimum level of backflow protection.”

2015 IPC® 504.6 Requirements for discharge piping. The discharge piping serving a pressure relief valve, temperature relief valve or combination thereof shall:

1. Not be directly connected to the drainage system.
2. Discharge through an air gap located in the same room as the water heater.
3. Not be smaller than the diameter of the outlet of the valve served and shall discharge full size to the air gap.
4. Serve a single relief device and shall not connect to piping serving any other relief device or equipment.
5. Discharge to the floor, to the pan serving the water heater or storage tank, to a waste receptor or to the outdoors.
6. Discharge in a manner that does not cause personal injury or structural damage.
7. Discharge to a termination point that is readily observable by the building occupants.
8. Not be trapped.
9. Be installed so as to flow by gravity.
10. **Terminate not more than 6 inches (152 mm) above and not less than two times the discharge pipe diameter above the floor or flood level rim of the waste receptor.**
11. Not have a threaded connection at the end of such piping.
12. Not have valves or tee fittings.
13. Be constructed of those materials listed in Section 605.4 or materials tested, rated and approved for such use in accordance with ASME A112.4.1.

VIII. Combustion Air

Adequate provision of combustion air is vital:

- Gas-burning and oil-burning appliances require sufficient airflow for safe combustion and to operate as they are designed. Restricted airflow can cause incomplete combustion, which results in higher releases of carbon monoxide.
- Ensure that flue gases are efficiently and completely ventilated to outside air. Not only are flue gases dangerous, but inadequate provision of air creates low pressure that will tend to draw gases that should ventilate out of the structure (i.e., from a wood stove) back into the structure.

In other words, inadequate provision of combustion air wastes energy, shortens the life of the appliance, and endangers the health of building occupants.

There are two common situations that can lead to inadequate provision of air:

1. This error often occurs when a basement remodel encloses a gas-fired furnace, dryer, or water heater in a small mechanical room with inadequate provision made for makeup air. This problem can be rectified by simply placing air circulation vents in obstructing walls, while other installations require a run of air ducts to outside air (with or without fan-powered ventilation.

- Be sure to check with the manufacturer's instructions for new or remodeling installations as well as when a customer has changed the space provided for gas-burning appliances.

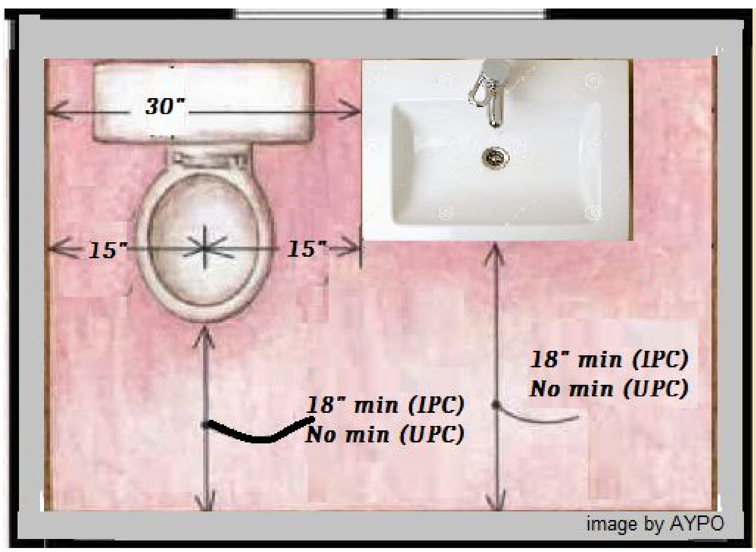
2. An increasingly prevalent cause is that energy-efficient standards are making homes more tightly sealed while range hood or other residential ventilation fans are getting more powerful [Older fans moved 40-200 cubic feet per minute (cfm); newer fans can move as much as 1,200 cfm.

IX. Leaks

It doesn't do our customers much good if we install water-saving fixtures but ignore leaks in the system. According to the EPA's WaterSense program, leaks in plumbing systems are a serious problem. The provide the following facts worth considering:

- The average household's leaks can account for more than 10,000 gallons of water wasted every year, or the amount of water needed to wash 270 loads of laundry.
- Household leaks can waste more than 1 trillion gallons annually nationwide. That's equal to the annual household water use of more than 11 million homes.
- Ten percent of homes have leaks that waste 90 gallons or more per day.
- Common types of leaks found in the home include worn toilet flappers, dripping faucets, and other leaking valves. All are easily correctable.
- Fixing easily corrected household water leaks can save homeowners about 10 percent on their water bills.
- Keep your home leak-free by repairing dripping faucets, toilet flappers, and showerheads. In most cases, fixture replacement parts don't require a major investment.
- Most common leaks can be eliminated after retrofitting a household with new WaterSense labeled fixtures and other high-efficiency appliances.
    - from the EPA WaterSense Program

X. Clearances and Handicapped Access



Whenever implementing codes, a working plumber should always remember that codes are intended to insure safe and reliable installations and a minimum standard to be met. They are not a design manual nor a guidepost for optimal installations.

There are three issues worth considering with regard to providing clearances in toilet rooms and bathrooms:

1. Providing more than the required minimum space

- One area where the code-mandated minimum is suboptimal is in providing clearances around water closets. They may be sufficient but for any larger persons are not nearly wide enough.

2. The revised 2010 ADA Standards for Accessible Design

   - ADA (The American with Disabilities Act) guidelines regulate accessible (handicap) bathrooms. It's vital to implement current ADA standards (see below for example)

3. The aging of America

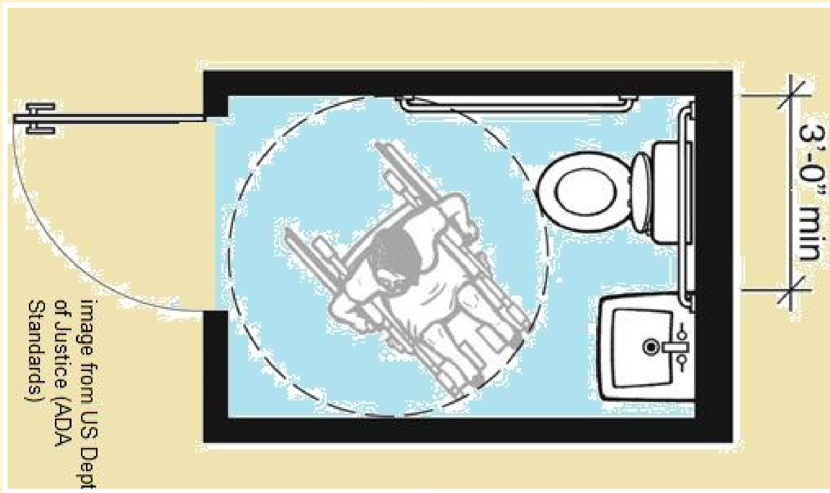
Consider shower enclosures without a finished dam curb or threshold so that it doesn't need to be retrofitted later on if and when diminished mobility becomes an issue for residents. Installing grab bars and having other modifications to anticipate future needs may be seen as an extra service by some customers but an unwelcome hint of mortality as well as unnecessary expense by others.	 wheelchair-accessible shower

Remember – verify current required codes and standards prior to construction.

Sample ADA Standards

Grab Bars – *Grab bars are not intended to be used as towel bars and vice-versa.* The grab bar handrail must be fully anchored with a smooth surface that can be easily grabbed. The diameter of the pipe used for this kind of purpose must be between 1¼ -1½". ADA grab bar handrails for accessible bathrooms must be installed between 34 and 38 inches off the ground. Furthermore, keep in mind that there must be a separation between the grab bar and the surface where it is located, of at least 1½" to provide room for the hand to grab it firmly. As a matter of security, bars must have edges rounded off.

Clearance – A clear space with minimum dimensions of at least 30" x 48" must be provided to accommodate a single wheelchair. If set high enough, some of this space can be beneath fixtures. *Don't forget that to measure clear space as a circle within which a wheelchair can turn around.*



Lavatories – At least one accessible lavatory must extend 17" or more from the back wall and have a clearance of at least 29" from the bottom of the apron to the finished floor. The lavatory, must not be installed at heights greater than 34". If the lavatory is installed with a countertop, it should be placed no further than 2" of the front edge for maximum accessibility.

Toilet Height – *Minimum width of 60" and sufficient space to accommodate the wheelchair to the sides of the toilet or in front of it*. Horizontal grab bars must be installed behind the toilet and on the nearest wall or partition, whichever is closer. Toilet seat heights must be between 17" to 19" above the finished floor. The lever for flush control must be placed on the open side of the toilet with the clearest floor space and mounted no higher than 44" above the finished floor.

Hand Dryer – One of the easiest requirements to comply with: they must be *either motion activated or touch-free devices* (i.e., push-button activated dryers *must be removed* in public facilities. If installing new hand dryer equipment, it's important to follow ADA design standards regarding the location of a hand dryer and its depth from the wall (must not protrude from the wall more than 4 inches).

[SLIDECUT]

[QUESTIONHEADER]

gn_plumbing_electives_ce_04_Q02

According to the information provided in this class, what is	¼ inch descent per foot of developed length	½ inch descent per foot of developed length	⅛ inch descent per foot of developed length	There is no general rule that can be applied to the slope of

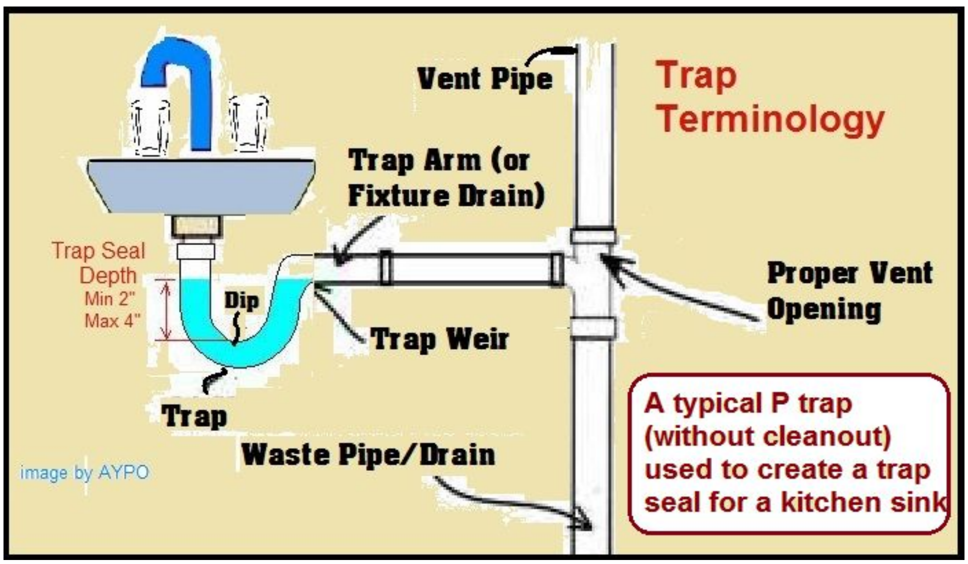
most often the optimal slope for sanitary drainage piping (regardless of the minimum slope required by codes)?				sanitary drainage piping

[QUESTIONBOTTOM]

[SLIDECUT]

Traps and Vents

Water Seal Traps



Sewer gases are lighter than air and, unless blocked from rising through fixture drains by an effective trap seal, they will travel from sewer pipes or septic tanks back into the structure. Any plumbing fixture directly connected to sanitary drainage piping must therefore be furnished with a water seal trap. In other words, unless connected to sanitary drainage by way of an air gap, or air break, every plumbing fixture that evacuates wastewater must have its own plumbing trap in which fluid remains at all times to seal out sewer gas. A fixture drain with an air gap or air break shouldn't be trapped, since the drainage piping past the receptor will be trapped.

Vents help maintain the water seal in traps as well as enabling effluent in drainage pipes to maintain sufficient velocity to clear the pipes. Vents also permit sewer gases to rise through a discrete piping system away from the drainage piping and release safely above the structure.

Sewer Gas

Sewer gases are more than a noxious odor – they are extremely hazardous. The most characteristic component of sewer gas is hydrogen sulfide (H_2S), a colorless gas known for its pungent "rotten egg" odor at low concentrations. *[Note: The presence of a "rotten egg" smell isn't proof of sewer gas since it can also emanate from a dead animal, defective wallboard, drinking water contamination, water heater bacterial growth, etc.]* It is extremely flammable and highly toxic. Effects of exposure to hydrogen sulfide range from mild (e.g. headaches or eye irritation) to very serious (unconsciousness and death). The health effects depend on how much is inhaled and for how long; however, many effects are seen even at low concentrations. It is volatile and will explode if a spark is introduced in confined spaces.

Hydrogen sulfide occurs naturally whenever organic matter breaks down in the absence of oxygen. It can be found in sewers, septic tanks, and well water and can be particularly dangerous in manholes, sewers, and any underground vault where its presence in confined spaces makes it a lethal peril.

In addition to hydrogen sulfide, sewer gases may contain ammonia, methane, carbon dioxide, sulfur dioxide, and nitrous oxide. Unlike hydrogen sulfide, some of these gases (such as methane and carbon dioxide) are odorless but all are asphyxiants and several are explosive. *[Note: Asphyxiants mimic oxygen when breathed so that they are taken up by the lungs in place of oxygen, creating a suffocation hazard even as the person continues to breathe.]*

OSHA chart - health effects of Hydrogren Sulfate

Concentration (ppm)	Symptoms/Effects
0.00011-0.00033	Typical background concentrations
0.01-1.5	Odor threshold (when rotten egg smell is first noticeable to some). Odor becomes more offensive at 3-5 ppm. Above 30 ppm, odor described as sweet or sickeningly sweet.
2-5	Prolonged exposure may cause nausea, tearing of the eyes, headaches or loss of sleep. Airway problems (bronchial constriction) in some asthma patients.
20	Possible fatigue, loss of appetite, headache, irritability, poor memory, dizziness.
50-100	Slight conjunctivitis ("gas eye") and respiratory tract irritation after 1 hour. May cause digestive upset and loss of appetite.
100	Coughing, eye irritation, loss of smell after 2-15 minutes (olfactory fatigue). Altered breathing, drowsiness after 15-30 minutes. Throat irritation after 1 hour. Gradual increase in severity of symptoms over several hours. Death may occur after 48 hours.
100-150	Loss of smell (olfactory fatigue or paralysis).
200-300	Marked conjunctivitis and respiratory tract irritation after 1 hour. Pulmonary edema may occur from prolonged exposure.
500-700	Staggering, collapse in 5 minutes. Serious damage to the eyes in 30 minutes. Death after 30-60 minutes.
700-1000	Rapid unconsciousness, "knockdown" or immediate collapse within 1 to 2 breaths, breathing stops, death within minutes.
1000-2000	Nearly instant death

Trap (and Interceptor) Types

A plumbing trap is defined as an area within drainage piping that retains a small amount of liquid every time the fixture is used, which (if sufficient to block the passage of air and other gases through that area) is called a trap seal. A trap seal is defined as the maximum vertical depth of liquid a trap will retain, measured from the trap (or crown) weir to the top of the dip of the trap. The trap seal prevents sewage system odors, gases, and vermin (mice, insects, etc.) from passage through, up, and out of the fixture. A fixture trap ideally retains a water seal without significantly impairing drainage flow.

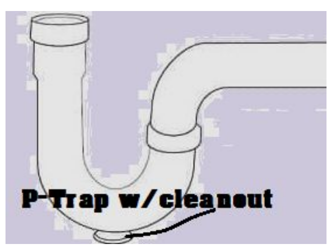
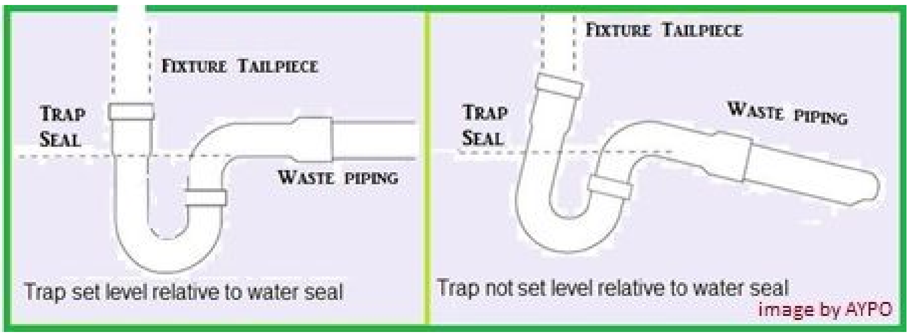


image by AYPO

The most common type, the P-Trap, is used with kitchen sinks, laundry sinks, and lavatories. It must meet the following conditions:

- Not depend on moving parts to retain its seal;
- Be no larger than the fixture drain it serves;
- Be self-cleaning (i.e., able to flush away all previously retained fluid along with all but the heaviest settled matter and replenish with new effluent);
- Be level in relation to its trap seal;

- Be the only trap for that fixture
    - Trap seals prevent the passage of air – therefore, a second trap would trap air between the two traps, creating back-pressure and blocking drainage. Where double trapping can't be avoided, a vent before the second trap can allow the air to escape and not create back-pressure, making the installation more complex and expensive.



P-Traps are made both with or without a cleanout. Distance from the bottom of the fixture to the trap inlet is critical – it must be long enough that the effluent will be moving at sufficient velocity to clear the trap but not long enough to make the effluent move fast enough to create siphonage and not allow the trap to retain sufficient effluent to make a trap seal. Typically, the minimum drop is 18 inches and the maximum drop is 24 inches – achieving the minimum drop is not as critical as abiding by the maximum limit.

For the same reason, there is a maximum length and slope for the waste outlet piping from the trap to a vertical drain to prevent the effluent from attaining velocity sufficient to create siphonage in the trap.

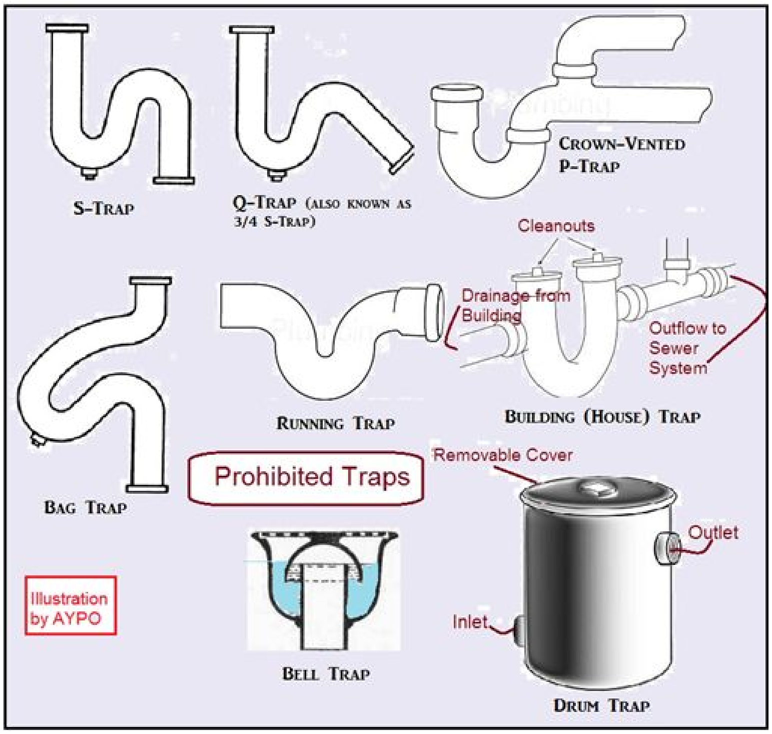
Traps for showers and bathtubs are often below the floor; where that isn't possible, the most common solution is to place them on a platform under which a trap can be installed.

Note: Toilets use the water in the toilet bowl as a trap seal (with the trap seal immediately replenished with fresh water from the fill tube rather than retained effluent), so an additional trap seal in piping from the toilet is not needed – nor is it permitted, since it would prevent the siphonage needed to fully empty the bowl.

Grease Traps (Interceptors)

Another widely used type of trap in commercial applications was formerly known as a "grease trap" but has been renamed the "grease interceptor". Unlike a P-Trap, interceptors intentionally slow the effluent flow to allow most of the suspended FOG to separate and be removed before the effluent is released to the building drain.

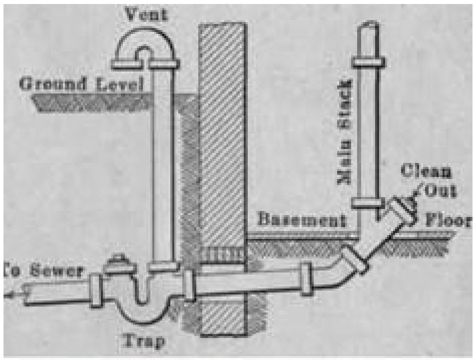
Illegal Traps



The S-Trap was formerly in wide use but is now prohibited in new construction or new installations (although it need not be removed if already in use). The reason it is no longer used is the velocity permitted as it rapidly turns downward can cause siphoning of the trap seal.

Crown-vented P-Traps are prohibited. The reason for this is that they draw enough effluent from the outflow up into the crown vent that cavitation occurs, disrupting drainage and placing undue stress on piping materials. Drum traps are banned as well; they are, essentially, crude interceptors, poorly designed for the purpose.

House Traps



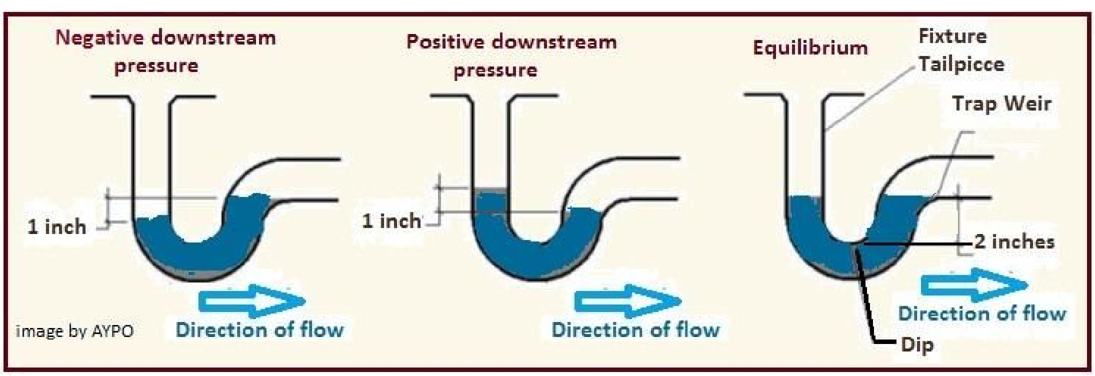
Building (house) trap

Image from antique plumbing book, courtesy of Pinterest

Most plumbing codes from the first half of the 20th century required a trap where the building drain left the structure as a secondary means for preventing sewer gases from entering the building. Most times, the building trap was a large diameter S-trap. Some older homes or other structures may still have a building or house trap. Their design is less intended to block sewer gas than a relic of the outmoded belief that a trap for the home can prevent rat incursions through the sanitary drainage piping.

Since the 1960s, however, it has been determined that 1) rats easily defeat this impediment; and 2) building traps create a major obstruction to the flow of sewage. As a result, they often cause stoppages. It has become industry practice in the past 50 years, therefore, to eliminate building traps, and most codes now forbid them.

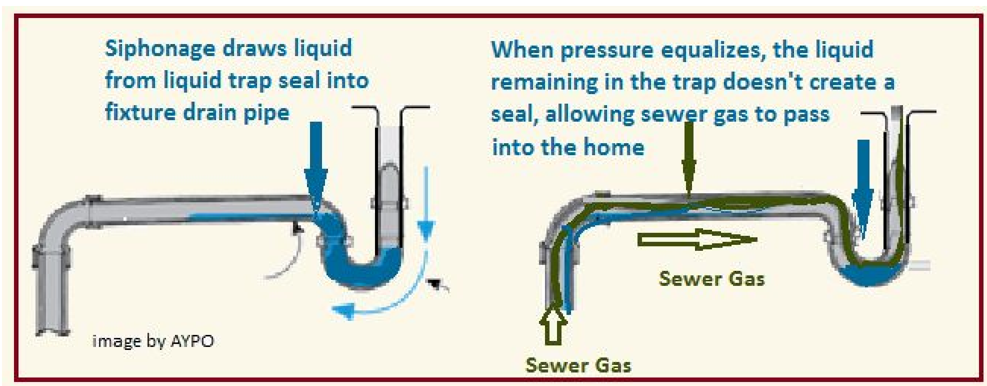
The Effect of Pressure Differentials on Trap Seals



Trap water seals are not stable but fluctuate whenever pressure differences develop upstream and downstream of the trap. A pressure difference of 0.0361 pounds per square inch (psi) is enough to raise or lower the water in a typical sink trap one inch. As long as the fluctuation stays within the typical safe range (two inches for a typical sink P-Trap) the trap seal is maintained. If the pressure differential increases to more than two inches in such installations, air and other sewer gases will pass into the room.

Another trap issue occurs when the momentum of water flowing from the sink causes most of the water to evacuate from the trap. When the pressure in the drain returns to neutral, the water level may be below the dip point, and sewer gases will move freely from the drain system into the room. The loss of a trap seal is prevented by providing a fixture vent.

What Can Go Wrong with Traps



Siphonage
As shown in the previous slide, negative air pressure downstream can draw liquid from the trap into the horizontal drain and, unless there is a means to replenish it, the amount of liquid that will settle back in the trap won't reach the dip, providing a passage for the lighter-than-air sewer gas to return from drainage piping up through the fixture drain. This problem can be caused by pipes that are too small or a stoppage that clears so that the pipe is filled with liquid, pushing air ahead, drawing air from above the fixture down into the trap. Overlong fixture tailpieces or overlong horizontal drains can also result in a flow rapid enough to push water from the trap into the horizontal piping.

Wind Effect
Far less common than back-pressure or trap siphonage from drainage issues, strong winds above vents can pull air out of the system, potentially pulling liquid from the trap.

Back-Pressure
If downstream wastewater is pushed back toward the fixture by too large a volume or pressure differentials downstream, the water will compress the air in front of it and will blow out the trap if the fixture at the point of compression has no proper ventilation.

Evaporation
The water in a trap seal must be replenished regularly from the fixture, which will usually occur if the fixture is regularly used at a rate of not much more than once a week. If, however, the fixture is used only sporadically or there is a long period of disuse (such as in a vacation property) water in the trap will evaporate, particularly in warm weather. Laundry room floor drains, remote

floor drains, floor drains in large warehouses, and basement fixtures are other places where this can occur. A trap seal primer or deep seal trap can prevent or minimize loss of the trap seal from evaporation. A permeable membrane for floor sinks or floor drains that allows liquids through but contains water vapor (known as a trap seal) can protect against evaporation. Where a long period of disuse is anticipated, mineral oil down the fixture drain can maintain a liquid seal, since it does not evaporate nor congeal and easily washes away when the fixture comes back into use. [Note: Some trap primers also use liquids other than water to avoid scaling problems or other blockages that can arise if a trap primer is used repeatedly.]

Wicking

This least common reason for losing a trap seal occurs only when the residue in the trap can conduct water, such as a wet wipe, cotton fibers, mop strings, etc. If it lodges against the drain side of the trap, the normal capillary action of water will cause it to wick up toward the horizontal drain, potentially drawing away enough water to break the seal.

Cracks and Leaks

Pipes that have bends are more prone to wear, stress, and cracking, with the damage intensified with extremes of temperature, corrosive liquids in the pipes, pressure changes, etc. Many customers may simply put a bucket below the trap to catch leaking water. If the leak is slow and the fixture used frequently, this may be a bad, but not dangerous expedient. In other cases, it is a very bad and could possibly dangerous strategy.

Deep Seal Traps

Where evaporation of the trap seal is an issue, deep seal traps may be appropriate. Deep seal traps have vertical depths of 4 inches or more, collecting a deeper liquid trap which won't evaporate as quickly. These traps can also prevent large volumes of wastewater to pass without pushing the trap seal liquid out into the horizontal piping. They are similarly less vulnerable to siphonage, back-siphonage, or back-pressure.

That doesn't mean they should be used in situations where there is no need for a deep seal trap. They need more space and are more expensive, but more importantly they take more water pressure down the fixture drain to clear and maintain drainage flow velocity, so they can impair the performance of the sanitary drainage system.

Venting System

Venting systems are defined as follows:

> A separate piping system joined to a gravity drainage system at certain connection points, sized to keep the air pressure in drainage piping from fluctuating above design limits, as well as providing air circulation sufficient to prevent the accumulation of volatile substances in a drainage system and to provide a pathway to exhaust harmful gases to spaces outside the structure.

Note that the definition specifies that it applies only to venting that serves gravity-based drainage systems (which may be sanitary, chemical wastes, graywater or clear wastewater drainage).

One of the principal tasks of venting is to keep the air pressure in the drainage system from disturbing the water seals of fixture traps by keeping air pressure within design limits. Generally, air pressure must stay within one inch of water column above or below atmospheric pressure. Wherever drainage lines have a change of direction, change in amount or rate of wastewater flow, or a constriction where there would be a higher fill rate within piping, a vent or similar means of equalizing pressure is often required.

Design Considerations

Since a typical gravity drainage venting system has no moving parts, they are quiet and can operate without maintenance or decay for decades. Use of fans within drainage system ventilation to facilitate air movement is almost never needed. Typically, problems may arise only at vent openings to the outside or when the network of vents isn't designed well enough for the drainage system. The key variables in vent design are diameter and elevation. Vent diameters are engineered as a ratio of the diameter of the drainage piping they serve so that the air pressure within the vent is sufficient to mix into the drainage piping but not so great as to prevent exhausting of gases. The correct ratios may be set by codes and regulations but are also available from plumbing engineering handbooks. *[See below for an example taken from the 2015 IPC®. The sizing chart ends at 12 feet of developed length, an additional incremental pipe size is required above 12 feet.]*

There are alternative means such as automatic air admittance valves (AAVs) to ventilate drainage where connection to a venting system is impractical. These alternatives must be designed for their specific purpose and are almost always used out of exigency, not as a choice. Nonstandard alternative vent designs require a technical submission to the AHJ. The submission must include technical support to substantiate how it will meet the intent of code requirements. It may be a one-time submission of a product or a submission of each building using the alternative design.

Sovent or single-stack engineered venting systems for taller buildings are beyond the scope of this class.

2015 International Plumbing Code

CHAPTER 9 VENTS

SECTION 906 VENT PIPE SIZING

906.1 Size of stack vents and vent stacks.

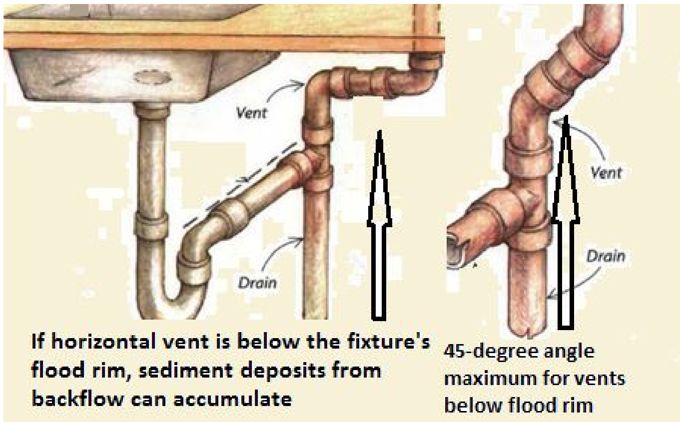
The minimum required diameter of *stack vents* and vent *stacks* shall be determined from the *developed length* and the total of *drainage fixture units* connected thereto in accordance with Table 906.1, but in no case shall the diameter be less than one-half the diameter of the drain served or less than 1 1/4 inches (32 mm).

TABLE 906.1 SIZE AND DEVELOPED LENGTH OF STACK VENTS AND VENT

a. The developed length shall be measured from the vent connection to the open air.

DIAMETER OF SOIL OR WASTE STACK (inches)	TOTAL FIXTURE UNITS BEING VENTED (dfu)	MAXIMUM DEVELOPED LENGTH OF VENT (feet)[a] DIAMETER OF VENT (inches)										
		1 1/4	1 1/2	2	2 1/2	3	4	5	6	8	10	12
1 1/4	2	30										
1 1/2	8	50	150	—	—	—	—	—	—	—	—	—
1 1/2	10	30	100									
2	12		75	200								
2	20	30	50	150		—	—	—	—	—	—	—
2 1/2	42	26	30	100	300							
3	10		42	150	360	1,040						
3	21	—	32	110	270	810	—	—	—	—	—	—
3	53		27	94	230	680						
3	102		25	86	210	620						
4	43	—		35	85	250	980	—	—	—	—	—
4	140			27	65	200	750					
4	320			23	55	170	640					
4	540	—	—	21	50	150	580		—	—	—	—
5	190				28	82	320	990				
5	490				21	63	250	760				
5	940	—	—	—	18	53	210	670	—	—	—	—
5	1,400				16	49	190	590				
6	500					33	130	400	1,000			
6	1,100	—	—	—	—	26	100	310	780	—	—	—
6	2,000					22	84	260	660			
6	2,900					20	77	240	600			
8	1,800	—	—	—	—		31	95	240	940	—	—
8	3,400						24	73	190	729		
8	5,600						20	62	160	610		
8	7,600	—	—	—	—	—	18	56	140	560		—
10	4,000							31	78	310	960	
10	7,200							24	60	240	740	
10	11,000	—	—	—	—	—	—	20	51	200	630	—
10	15,000							18	46	180	571	
12	7,300								31	120	380	940
12	13,000	—	—	—	—	—	—	—	24	94	300	720
12	20,000								20	79	250	610
12	26,000								18	72	230	500
15	15,000	—	—	—	—	—	—	—		40	130	310
15	25,000									31	96	240
15	38,000	—	—	—	—	—	—	—	—	26	81	200
15	50,000									24	74	180

Fixture Trap Vents



The liquid seal of all fixture traps must be protected against siphonage or blowout by the proper installation of a venting system. This means:

1. Providing an adequate supply of air at the terminus of drainage stacks;
2. Providing a means to relieve excess pressures at the base of the drainage stack; and
3. Providing relief for excessive pneumatic effects in the branch drains when other fixtures discharge into the branch.

The connection of a vent to a fixture drain should not be so close as to become clogged with debris washed through the trap, and it should not be so far away that it becomes blocked by water that will accumulate if downstream piping is obstructed. Some codes require every fixture trap to be individually vented, but most permit alternate methods, including:

- Common venting (more than one fixture vented through the same pipe)
- Wet venting
- Stack venting
- Circuit and loop venting
- Combination waste and vent system
- Island Vent

Common Vent

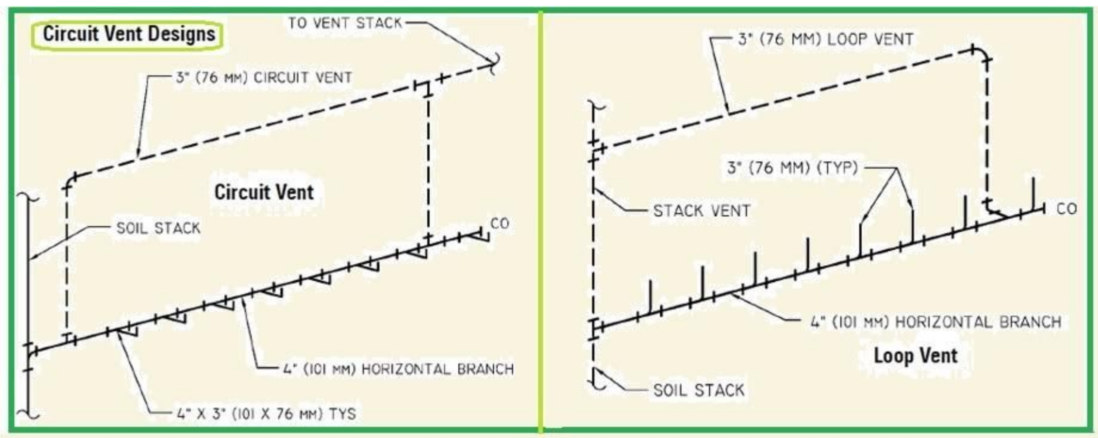
It's common for more than one fixture to share a vent. They must be at the same elevation and connect through either a double wye or double sanitary tee, with the vent connecting downstream of the wye or tee. The vent is sized for the combined drainage fixture units of both fixtures.

In some cases, two wall-outlet fixtures at different elevations can still use a common vent (called a vertical wet vent), but the diameter of the vent piping must be increased.

Private Fixture Group Wet Venting

Only in a private residence (where the toilet, lavatory, and either shower or bath are unlikely to drain simultaneously), wet vent design connects an individual vent only to the lavatory, and its drain is the vent for the other fixtures (only allowed if the toilet is downstream from the lavatory drain). In some cases, a relief vent may be needed in addition to the individual vent.

Circuit Venting



The drawing, above, provided by ASPE shows how numerous fixtures can be vented by one or two horizontal branch vents. With a large enough diameter, the upper half of the cross-sectional area of the common horizontal branch is able to prevent pressure differentials from affecting the trap seal of any non-flowing fixture in the group. This design is variously known as circuit venting, loop venting, and battery venting. Public toilet rooms typically use this design for venting floor-outlet water closets and floor drains. The branch is a uniform size along the distance between the connected fixture drains, with one vent connected between the two upstream fixtures and the other vent connected downstream of the last fixture. The number of fixtures permitted on a circuit vent is limited by codes.

Waste Stack

If there are no offsets in the main drainage stack and space for venting pipes is limited, a single vent on top of the drain stack can be used. It only works where the waste stack serves identical wall layouts on multiple floors and can't be used where there are varying wall locations among floors. Codes may not permit toilets to connect to this type of vent and usually require each fixture to connect individually to the stack, with the diameter to be constant from the base to the stack vent.

Combination Drain and Vent

Another way to deal with venting in limited space is to use a Combination Drain Waste Vent (DWV) design. In order to allow room for venting in the same pipes used for drainage, the pipe size is increased one standard pipe size. Dedicated vent pipes at the upstream end of a building drain are required. The design is often used for venting the basement floor drain in residential construction. Diameters, connection points, floor drain branch lengths, limitations on toilets served, and possible downstream relief vents are prescribed in the plumbing codes.

Island Vent

The increasing popularity of kitchen “islands” with sinks requires its own type of venting system design. Unlike an individual vent that rises above the sink rim level before turning horizontal, an island vent turns horizontal just below the rim and drops below the floor. Codes may require a cleanout and may require an individual vent before the building stack drain.

Relief Vents

In addition to fixtures, where a drain stack changes from vertical to horizontal, effluent can mass, and pressure must be relieved. If not connected to the venting system, a relief vent may be suitable. Although it is most critical at the base of a drain stack where it turns to the building drain, air is more or less constricted at the upstream end of each offset of 30 degrees or more. For 90-degree offsets, a relief vent is provided upstream and downstream of the horizontal portion of the offset, while 30- and 45-degree offsets only need a vent relief upstream of the offset. The diameter of the relief vent matches the vent stack.

Another air restriction in plumbing occurs from detergents whose suds collect at changes of direction. These so-called “suds pressure zones” can only be cleared by water and solids, but not by air. These zones most have additional ventilation and be kept separate from venting to other horizontal branches.

[SLIDECUT]

[QUESTIONHEADER]

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Which of the following is NOT a required condition when installing a P-Trap for a sink?	It must have a cleanout at the dip	It can be no larger than the fixture drain it serves	It cannot depend on moving parts to retain its water seal	It must be self-cleaning

[QUESTIONBOTTOM]

[SLIDECUT]

[VIDEOHEADER]

Midway Through the Class (Video)

After looking at a wide array of potential plumbing problems in the first half of this class, the next two lessons will be in-depth discussion of two major issues – cross-connection and corrosion.

At the start of this class, we promised to focus on avoidable problems. The final lesson in the class will, instead, look at something over which we may not have much control – the ways plumbing is misused and abused by the general public or even by our own customers. It may be worthwhile to remember that we aren't just there to make the mechanical connections, but we also need to educate the people who'll be using the fixtures on their proper use and upkeep – to the extent that we're able.

On the other hand, it's kind of fun to look at all the ways customers make our jobs harder. If we can help change those behaviors, maybe we can also avoid having our customers call us with a crisis at ten o'clock at night.

We'll begin with the more serious issue of cross-connection.

[VIDEOBOTTOM]

[SLIDECUT]

[QUESTIONHEADER]

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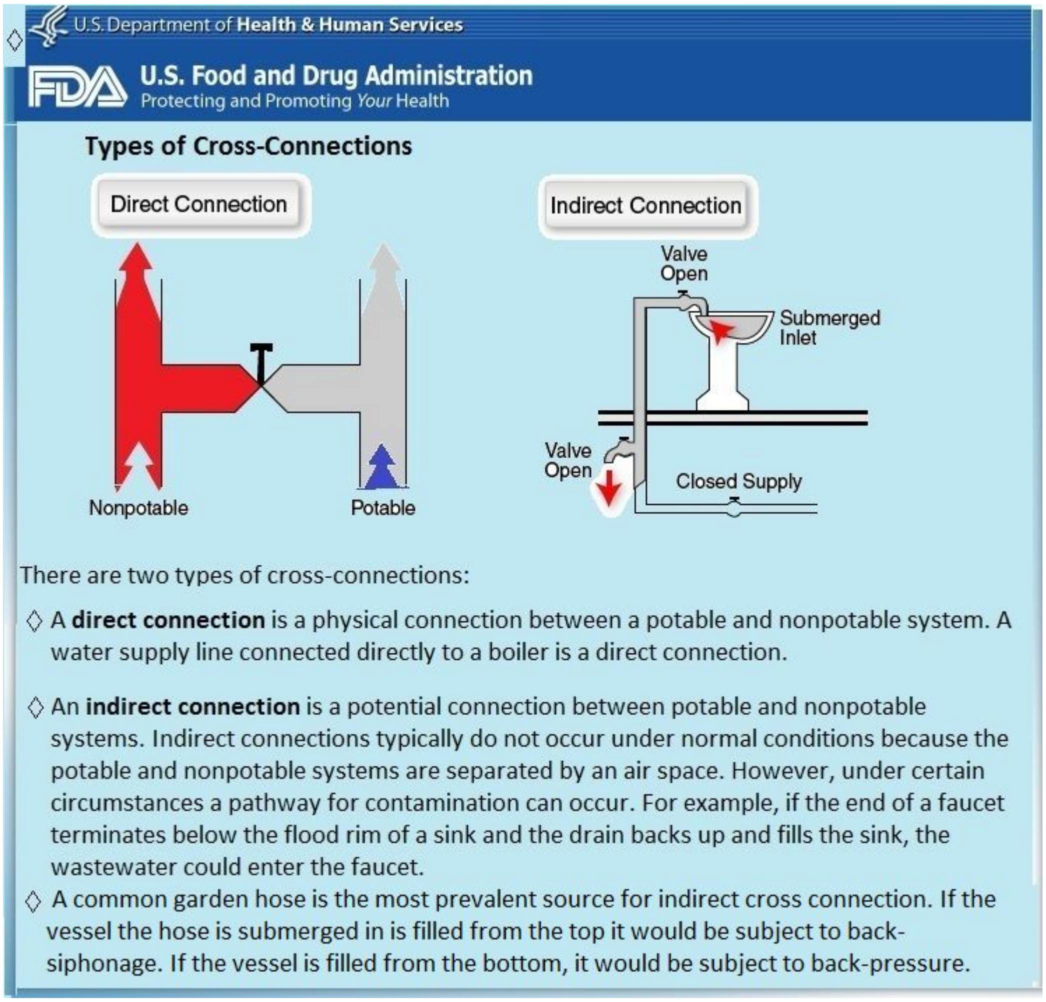
(T&P) relief valves for residential water heaters are typically designed and manufactured to relieve on pressure at the following:	150 psig/ 210 degrees Fahrenheit	180 psig/ 180 degrees Fahrenheit	210 psig/ 150 degrees Fahrenheit	80 psig/ 200 degrees Fahrenheit

[QUESTIONBOTTOM]

[SLIDECUT]

Cross-Connection



Cross-connection is defined as follows:

> A fluid-conveying structural arrangement with the potential to permit the unintentional exchange between two separate piping systems, one that conveys potable water and the other containing any used water, industrial fluids, gas, or substance other than the intended water with which the potable system is supplied.

Since ”potential” unintentional exchange is enough to qualify, every direct-connected plumbing fixture provided with potable water is, by definition, cross-connected. The potable water, once flushed through the fixture, is borne away by the sanitary drainage system which, with sufficient pressure differential, is capable of reverse flow back up and out through the fixture drain and back into the structure. Even where a cross-connection control device is in place, therefore, cross-connection still exists but is protected against. The determinant as to whether protective measures need to be taken is therefore NOT whether cross-connection exists but the degree of hazard.

Indirect connection is also at risk of cross-connection if the inlet is flooded. Water from a hose that creates a pool of any kind (contained or otherwise) or even a spout of inadequate elevation potentially may flow in a reverse direction. Submerged irrigation systems or yard hydrants with a submerged drain point have the potential for soil contaminant backflow into the water supply system.

The chart, below, prepared by ASPE shows how many connections they consider at some level of risk for cross-connection.

Plumbing System Hazards

Direct Connections	Potential Submerged Inlets
Air-conditioning, air washer	Baptismal font
Air-conditioning, chilled water	Bathtub
Air-conditioning, condenser water	Bedpan washer, flushing rim
Air line	Bidet
Aspirator, laboratory	Brine tank
Aspirator, medical	Cooling tower
Aspirator, herbicide and fertilizer sprayer	Cuspidor
Autoclave and sterilizer	Drinking fountain
Auxiliary system, industrial	Floor drain, flushing rim
Auxiliary system, surface water	Garbage can washer
Auxiliary system, unapproved well supply	Ice maker
Boiler system	Laboratory sink, serrated nozzle
Chemical feeder, pot type	Laundry machine
Chlorinator	Lavatory
Coffee urn	Lawn sprinkler system
Cooling system	Photo laboratory sink
Dishwasher	Sewer flushing manhole
Fire standpipe	Slop sink, flushing rim
Fire sprinkler system	Slop sink, threaded supply
Fountain, ornamental	Steam table
Hydraulic equipment	Urinal, siphon jet blowout
Laboratory equipment	Vegetable peeler
Lubrication, pump bearings	Water closet, flush tank, ball cock
Photostat equipment	Water closet, flush valve, siphon jet
Plumber's friend, pneumatic	
Pump, pneumatic ejector	
Pump, prime line	
Pump, water-operated ejector	
Sewer, sanitary	
Sewer, storm	
Swimming pool or spa equipment	

The chart presented in the next slide shows how the level of hazard is determined *[Low or High Potential for Harm & Low or High Likelihood of Occurrence]*.

Risk Assessment

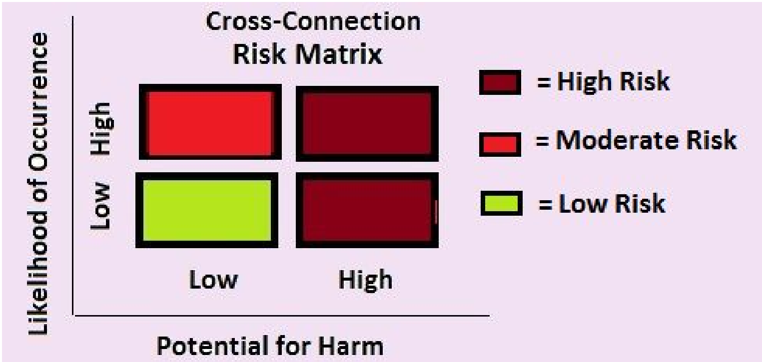
Low potential for harm could include such annoyances as discoloration or unpleasant odor. High potential for harm could include varying exposure levels of biological growth, chemical contamination, or radioactive material, which could present risks anywhere from mild toxicity to lethal peril. A framework for categorizing potential for harm is:

- A pollutant – any substance that affects the color or odor of the water but would not pose a health hazard [low hazard].
- A contaminant – any substance that would cause a health hazard in the form of illness or death if ingested.
- A lethal hazard – raw sewage or radioactive materials due to the severe illnesses and epidemics associated with sewage and the tremendous dangers associated with radioactive material.

- Cross-Connection of moderate to high likelihood of occurrence:
    - Connection of the water supply system to any part of the drain system
    - Connection of the water supply system to a non-potable water piping system
    - Any faucets, hydrants, or cocks that attach to hoses except when used to drain or test the system, when used by firefighters, or when connected to a single residential washing machine
    - Connection of a public and private well water supply system

Where two systems are only separated by a valve, likelihood of an occurrence is high; other situations are evaluated based on how they are configured [relative heights, pipe size, venting, etc.] The safety of the water supply depends on effective control at each connection point; safety is not assured if the effectiveness of one point is unknown despite controls at all other points.

Unlike a typical hazard matrix, cross-connection hazard is considered “high” even in low likelihood, high potential for harm situations. Only with low probability, low potential for harm is it considered a “low” risk hazard, where cross-connection control is not needed. Where there is a high likelihood of occurrence but low potential for harm, cross-connection control could be considered optional, unless required by codes or regulations, but should be considered for all such cases depending on what the potential for harm is predicated upon.



The Problem

One abiding problem related to cross-connection is that the hazard is hard to recognize because (in most plumbing systems) the pressure is rarely sufficient to produce measurable reverse flow and the contaminant may not be present at a perceptibly dangerous level. For example, if a mop basin fitted with a detergent dispenser has a disconnected vacuum breaker, only rarely is there likely to be a pressure interruption sufficient to have its outflow contaminate the drinking water on lower floors and, even then, those drinking the contaminated water may only find it mildly distasteful. Since it's so uncommon and un-noticeable, the incentive to install protection against cross-connection is low – some customers will disable controls or remove protective devices if they leak or interfere and not have them replaced.

Even among plumbing professionals, cross-connection control is often poorly understood or regarded as superfluous. In order to understand this problem more fully, we'll look at:

- Causes of cross-connection;
- Passive, active, and hybrid protection strategies;
- Recommended devices for different applications; and
- Potential installation and operational problems.

Causes

There are two main causes for cross-connection contamination:

1. Back-pressure; and
2. Back-Siphonage.

In essence, back-pressure pushes and back-siphonage pulls. For the purposes of cross-connection, back-pressure relates to water pressure differentials and back-siphonage relates to air pressure. Water pressure greater downstream than upstream creates the conditions for back-pressure. Air pressure lower upstream than downstream creates the conditions for siphonage – typically, that means that air pressure in an upstream portion of the system is below atmospheric pressure, a condition defined as a “partial vacuum”. *[Note: Trapped air and gases can also create back-pressure, which is relieved with vent design, not cross-connection protection devices.]*

Back-Pressure

Back-pressure generally occurs when there is a pressure interruption (e.g. the normal water supply is cut or eliminated) but can also occur if the downstream water source is greater than the hydrostatic design of the system can contain. There are two sources of water pressure that create the right hydrodynamics – relative elevation or the action of a pump, and the direction of flow, as determined through general fluid mechanics. The water source with the higher elevation has the greater water pressure unless that pressure is enhanced by mechanical means (a pump).

Water supply is vulnerable to any changes that disturb normal network water pressure distribution. For example, when a valve anywhere in a water supply system closes and disconnects a part of the system from the source of supply reservoir, another source (such as any fixture, equipment, or connected sanitary system) may now have adequate pressure to infiltrate or flood that section of the water supply. Other pressure interruptions include broken pipes, broken outlets, airlock, pressure caused by thermal energy sources, malfunctioning pumps, malfunctioning pressure-reducing valves, and uncommon water accumulations downstream.

Because it cannot be predicted where a valve may close or where another type of pressure interruption may occur, each water supply connection point becomes a potential pathway for reverse flow.

Siphonage and Back-Siphonage

Differences in air pressure in different parts of a plumbing system means that there are fewer air molecules filling available space or their motion is because of temperature differences – higher temperature caused the molecules to move more quickly (think of a hot air balloon) so that they can fill the same amount of space as would fewer molecules. The net effect is akin to the creation of a partial vacuum where the pressure is lower and, like a vacuum cleaner, a vacuum exerts a powerful attractive force. If you have any doubts about how powerful this force is, consider that airplanes fly because air moving more swiftly over the wing than under it is enough to create a partial vacuum above the wing, which lifts a massive vehicle bearing hundreds of people and suitcases, etc., into the sky.

Just as with the lift on an airplane’s wing, where air in piping is moving more quickly, air pressure is lower. Unless the atmospheric pressure is restored (usually through a vent), the suction (siphonage) of the air pressure differential is sufficient to draw water from protective water traps, opening the pathway for potential cross-connection contamination or can result in back-siphonage, where the lower air pressure in an upstream portion of drainage piping creates backflow of effluent moving back upstream through that section of pipe.

Siphonage sufficient to diminish a trap’s water seal can be caused by the fixture’s wastewater outflow, itself, the momentum of which is sometimes sufficient to suck out a large part of the seal. Another possible siphonage or back-siphonage situation occurs where two fixture drainage pipes branch into the same pipe – the passage of effluent from one fixture may fill the pipe sufficiently to push air ahead while the friction of the effluent draws air behind it, thereby pulling air out from the other drainage pipe and creating a partial vacuum upstream.

Another situation that can create this phenomenon is when a fixture with a long line of horizontal waste experiences a temporary stoppage in the horizontal part of the drain piping – when the stoppage is relieved, effluent flow can be vigorous enough to produce a vacuum behind it and cause back-siphonage.

Finally, the passage of a heavy or overly fast effluent flow down a vertical stack may produce a partial vacuum at the entrance into the stack of another drainage line which can pull the trap seal out into the horizontal drainage as well as create back-siphonage in the horizontal drain. Fixtures on lower flowers are more vulnerable to siphonage than those nearer the top of the stack due to a heavier accumulation of effluent per pipe diameter and increased velocity. The more a pipe perpendicular at a junction is filled and the faster it moves, the stronger the partial vacuum that can be created in the slower moving, empty, or less-full pipe.

Protection Strategies

Passive

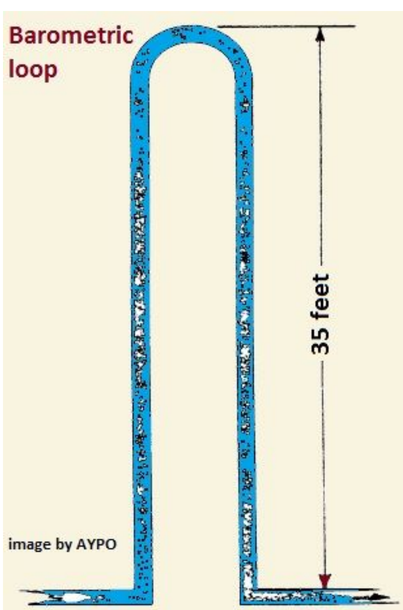
Air Gap

An air gap is a physical separation of the supply pipe by at least two pipe diameters (never less than one inch) vertically above the overflow rim of the receiving vessel. An air gap is regarded as effective if the outlet of the flow discharge is adequately above the rim of the receiving basin. Some codes increase the distance to three times the diameter if the outlet flow is too close to the basin wall. An air gap provides the highest level of backflow protection and is the only acceptable means of protecting against lethal hazards. An air gap may also be used to protect against a contaminant or a pollutant and, if properly designed, will protect against both back-siphonage and back-pressure.

The theory behind the operation of an air gap is that the loss of water pressure by having an empty space makes back-pressure virtually impossible. If an air gap is not at a fixture but in the course of a longer supply line, a booster pump would be needed to overcome the loss of line pressure unless there is sufficient gravity to create necessary water pressure downstream. *[An interim air gap, such as this, may be used to protect water supply from an overly long or insufficiently sloped supply line or because the equipment itself presents a hazard as water enters it.]* The air gap is NOT sufficient to prevent all back-siphonage – just the opposite, since the downspout creates a partial vacuum in its wake, drawing in atmospheric air to balance the pressure. If the gap is not great enough, water from the receiving basin could also be drawn in, explaining the need for the gap to be sufficiently large.

Note, also that an air break (where the outlet of flow discharge is below the lip of the receiving pipe or basin) is not the same as an air gap. A washing machine drain into a standpipe is a typical air break connection and is not considered cross-connection protection. Air gap requirements are found in several ASME standards, including A112.1.2 (Air Gaps in Plumbing Systems for Plumbing Fixtures and Water-Connected Receptors); A112.1.3: (Air Gap Fittings for Use with Plumbing Fixtures, Appliances, and Appurtenances); 1002 (Performance Requirements for AntiSiphon Fill Valves for Water Closet Tanks); 1004 & 1006: Backflow Prevention Requirements for Commercial Dishwashing Machines & Residential Use Dishwashers.

Barometric loop



A barometric loop is an installation in the piping system, locally fabricated, that effectively protects against back-siphonage. It does not protect against back-pressure. It consists of a continuous section of supply piping upstream to the source of cross connection that abruptly rises to a height of at least 35 feet above the highest point in downstream piping and then returns down to the originating level, based on the principle that an atmospheric air pressure water column (at sea level) will not rise above 33.9 feet. No outlets for potable water use may be installed downstream of the loop and not all municipalities allow them as cross-connection protection.

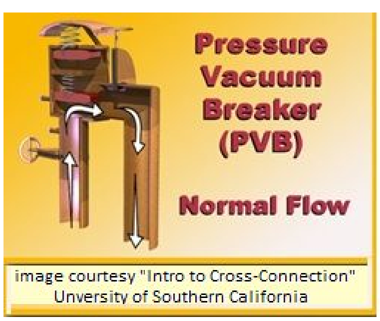
Active

There are two basic strategies incorporated into mechanical devices installed where cross-connection exists to prevent contamination from occurring:

1. Have the device be configured and act such that it will only allow flow in one direction
    - Generally categorized as a back-pressure backflow preventer and typically utilizes a disc that lifts from a seat to maintain normal flow; and
2. Provide protection by opening the pipe to atmospheric pressure
    - Generally categorized as a vacuum breaker, which has greater application restrictions.

A device of either broad category uses a specially designed, fabricated, tested, and certified assembly. For high hazard applications, the assembly often includes supply and discharge valves and testing ports.

Pressure-Type Vacuum Breaker



Pressure-type vacuum breaker assemblies (PVB) are the most common, inexpensive type of whole-system backflow preventer. It consists of an inlet shutoff valve at the bottom, a single valve body consisting of a pressure vacuum breaker designed to open when the internal pressure is 1 psi above atmospheric pressure so that no non-potable liquid may be siphoned back into the potable water system, check valve designed to close with the aid of a spring when flow stops, and two test cocks, and an outlet shutoff valve. As well as being inexpensive, PVBs are relatively simple in design, and are easy to install, maintain and repair. Some pressure vacuum breakers also offer built-in freeze protection; however, this only protects the PVB assembly. Inlet and outlet pipes can still freeze if the system isn't properly winterized.

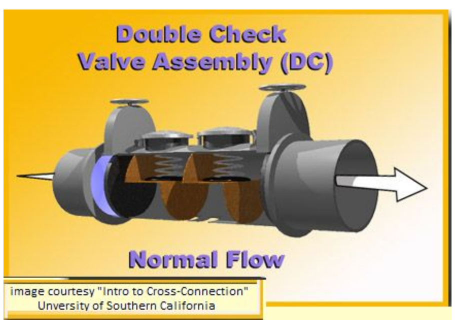
One of the downsides of PVBs is that they will occasionally eject some water. Choose a "spill-resistant" model of PVB for indoor installations or any time spillage would create a nuisance. An air gap drain is also required if the valve is installed in a basement or other interior space.

- Must be installed at least 12" above the highest downstream point on the system
- Must be installed vertically (with the inlet at the bottom)
- Prevents back-siphonage only, not back-pressure; installation not allowed where back-pressure is a potential threat
- Spillage is an issue; more often used in exterior applications
- Designed to protect against pollutants and contaminants

Spill-Resistant Vacuum Breaker

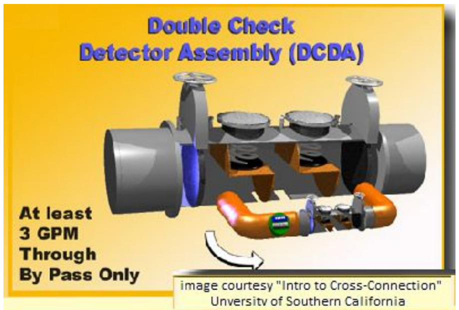
This control is similar to the pressure-type vacuum breaker, but it employs a diaphragm joined to the vacuum breaker disc. It is used to isolate a water supply from a high hazard system and to eliminate splashing from the vent port.

Double Check Assemblies



Double check valves, double check assemblies, and double check detector assemblies (DCV, DCA, or DCDA) and are a good choice and the most common type of approved backflow prevention device for underground, in-line (horizontal), or indoor installations. A DCA consists of an inlet shutoff valve, two independently operating spring-loaded check valves (usually inside a single valve body) together with tightly closing resilient seated shut-off valves upstream and downstream of the check valves, four test cocks, and an outlet shutoff valve. Double check assemblies should only be installed vertically if allowed by local building codes.

A small version of a double check for cross-connection protection has been developed for residential water services.

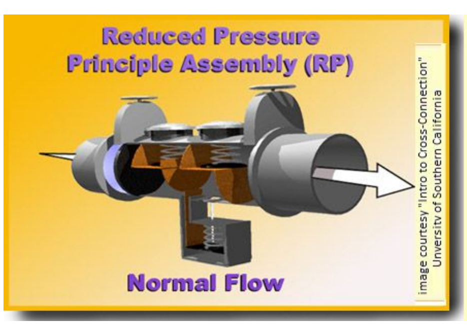


The DCDA adds a meter that registers very low flow rates to detect any unauthorized use of water. This assembly is used when the protection of a double check valve assembly is required, yet where the added requirement of detecting any leakage or unauthorized use of water exists. Normally these assemblies are reserved for use on fire sprinkler lines

It is possible to build a double check valve assembly from new components, but this is not the best option as there is a high risk of built assemblies not meeting local code. A better option, for convenience, cost-effectiveness, and coding restrictions, is to purchase a pre-assembled double check valve assembly.

- Unlike the PVB, the DCA does not have to be installed 12" above the highest point in the system
- (Some areas do require above-ground installation, so check with local authorities before installing below ground)
- May be installed horizontally or vertically, but horizontally is preferred
- Protects against back-siphonage and back-pressure
- Designed to protect against pollutants

Reduced Pressure Principle Assemblies



Reduced pressure zone assemblies also called a reduced pressure principle assembly (RPPA), is the most complex and expensive backflow preventer. However, when working properly, RPPA’s are the most secure and reliable of all backflow prevention devices. A reduced pressure zone assembly consists of an inlet shutoff valve, two independently operating spring-loaded check valves and a mechanically independent, hydraulically dependent relief valve located between the check valves designed to maintain a zone of reduced pressure between the two check valves at all times, four test cocks, and an outlet shutoff valve.

The Reduced Pressure Principle Detector Assembly (RPPDA) is similar to the double check detector assembly (DCDA) except that the RPPDA is designed for situations requiring the protection of a reduced pressure principle assembly and detection of unauthorized use of water or leaks. This assembly is normally used on fire lines which may contain contaminants, such as antifreeze additives or foamite.

RPPA’s come in a variety of configurations. Choose an "inline" or "straight" configuration for installation underground. For above-ground installation, consider an "n" configuration assembly for a very small footprint.

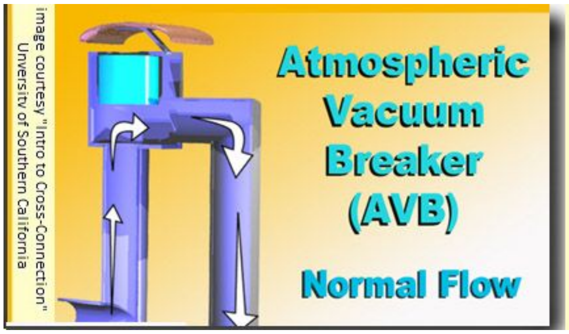
- Compatible with both above-ground or below-ground installation, above-ground preferred
- Chemigation is approved with RPPAs (and with no other device or assembly)
- Horizontal installation required unless factory-configured for alternate installation
- Protects against both back-siphonage and back-pressure
- Designed to protect against pollutants and contaminants

Dual Check with Atmospheric Vent

This control is similar to the reduced-pressure principle type, but the diaphragm design is replaced by a piston combined with the downstream check valve. It effectively isolates a water supply from a low hazard such as beverage machines and equipment with non-toxic additives. The function of its design is not sufficiently precise for high hazards. The relief port is generally hard-piped with its air gap located remotely at a similar or lower elevation.

A vacuum breaker is of a similar design, but it is elevation-sensitive for effective isolation of a hazard. Permitted maximum back-pressure ranges from 4.3 psig (29.7 kPa) to zero depending on the type.

Atmospheric Vacuum Breaker (Anti-Siphon)



Atmospheric vacuum breakers (AVB) are the simplest and least expensive backflow preventer for one or two-zone irrigation systems. Its air inlet valve closes when the water flows in the normal direction. But, as water ceases to flow the air inlet valve opens, thus interrupting the possible back-siphonage effect. An AVB must be installed on the pipe directly after every control valve, so for systems with more than about six control valves, AVBs are not cost-effective. AVBs are also the least reliable and least often recommended. Most large cities and suburbs do not allow the use of atmospheric vacuum breakers in lawn sprinkler systems. If piping or a hose is attached to this assembly and run to a point of higher elevation, the back-pressure will keep the air inlet valve closed because of the pressure created by the elevation of water; the same effect can occur if a downstream valve is shut off or there is a downstream obstruction. AVBs cannot be used where they would be subjected to constant pressure, where shutoff valves would be located downstream, or where there is a potential for back-pressure.

- Must be installed at least 6" above the highest outlet in the zone
- Must be installed vertically with the bonnet on top, prevents back-siphonage only
- Requires one unit per zone installed downstream from zone control valves
- Not usable where it will be under continuous pressure for more than 12 hours at a time
- May not be installed where the potential for back-pressure is present
- No control valve may be placed downstream of a pipe-applied atmospheric type vacuum breaker
- Designed to protect against pollutants and contaminants

Hose Connection Vacuum Breaker

This control is similar to the atmospheric vacuum breaker in function but varies in design and application. The disc is more elastic, has a pair of sliced cuts in the center, and deforms with the presence of water supply pressure to allow the water to pass through the cuts (see Figure 9-11).

The deformation also blocks the vent port. A more advanced form employs two discs, and the design allows performance testing.

Flush Valve Vacuum Breaker

This control is similar to the hose connection vacuum breaker in function but varies somewhat in the design of the elastic part.

Recommended Passive and Active Device Types for Specific Applications

The following is a graph compiled by the ASPE outlining the typical selection criteria and applications for various means of cross-contamination protection.

Application of Cross-Connection Control Devices

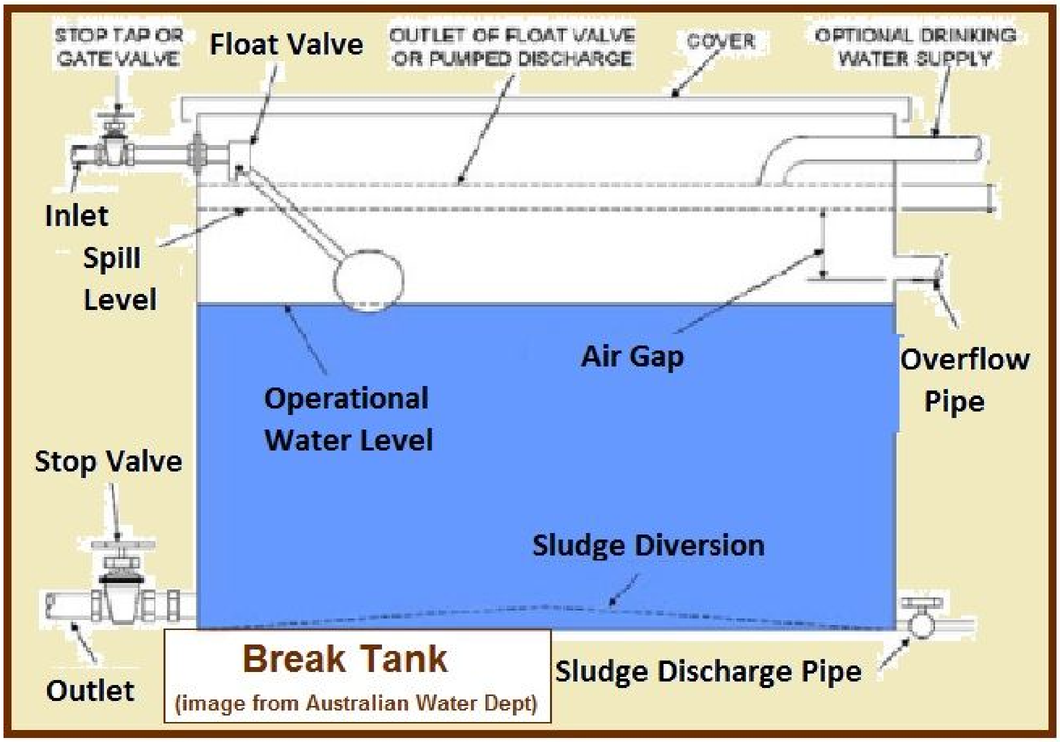
Standard	Device or Method	Type of Protection[a]	Hazard	Installation Dimensions and Position	Pressure Condition[b]	Comments	Use
ANSI A 112.2.1	Air Gap	BS and BP	High	Twice effective opening; not less than 1 inch above flood rim level	C		Lavatory, sink or bathtub spouts, Residential dishwasher (ASSE 1006) and clothes washers (ASSE 1007)
ASSE 1001	Pipe-applied vacuum breaker	BS	Low	6 inches above highest outlet; vertical position only	I		Goosenecks and appliances not subject to back pressure or continuous pressure
ASSE 1011	Hose bibb vacuum breaker	BS	Low	Locked on hose bibb threads; at least 6 inches above grade	I	Freeze-resistant type required	Hose bibbs, hydrants, and sillcocks
ASSE 1012[c]	Dual-check valve with atmospheric vent	BS and BP	Low to moderate	Any position; drain piped to floor	C	Air gap required on vent outlet; vent piped to suitable drain	Residential boilers, spas, hot tubs, and swimming pool feedlines, sterilizers; food processing equipment; photo lab equipment; hospital equipment; commercial dishwashers; water-cooled HVAC; landscape hose bibb; washdown racks; makeup water to heat pumps
ASSE 1013	Reduced-pressure zone backflow preventer	BS and BP	High	Inside building: 18–48 inches (centerline to floor); outside building: 18–24 inches (centerline to floor); horizontal only	C	Testing annually (minimum); Overhaul five years (minimum); drain	Chemical tanks; submerged coils; treatment plants; solar systems; chilled water; heat exchangers; cooling towers; lawn irrigation (Type II); hospital equipment; commercial boilers, swimming pools, and spas; fire sprinkler (high hazard as determined by commission)
ASSE 1015	Dual-check valve assembly	BS and BP	Low	Inside and outside building: 18–24 inches (centerline to floor); horizontal only; 60 inches required above device for testing	C	Testing annually (minimum); overhaul five years (minimum)	Fire sprinkler systems (Type II low hazard); washdown racks; large pressure cookers and steamers
ASSE 1020	Pressure-type vacuum breaker	BS	High	12–60 inches above highest outlet; vertical only	C	Testing annually (minimum); overhaul five years (minimum)	Degreasers; laboratories; photo tanks; Type I lawn sprinkler systems and swimming pools (must be located outdoors)
ASSE 1024[c]	Dual-check valve	BS and BP	Low	Any position	C		Fire sprinkler systems (Type I building); outside drinking fountains; automatic grease recovery device
ASSE 1035	Atmospheric	BS	Low	6 inches above flood level per manufacturer	I/C		Chemical faucets; ice makers; dental chairs; miscellaneous faucet applications; soft drink, coffee, and other beverage dispensers; hose sprays on faucets not meeting standards
ASSE 1056	Spill-resistant indoor vacuum breaker	BS	High	12–60 inches above highest outlet; vertical only	C	Testing annually (minimum); overhaul five years (minimum)	Degreasers; laboratories; photo tanks; Type I lawn sprinkler systems and swimming pools (must be located outdoors)

[a] BS – Back-siphonage; BP – Back-pressure
[b] I – Intermittent; C – Continuous
[c] A tab shall be affixed to all ASSE 1012 and 1024 devices indicating installation date and the following statement: "FOR OPTIMUM PERFORMANCE AND SAFETY, IT IS RECOMMENDED THAT THIS DEVICE BE REPLACED EVERY FIVE (5) YEARS."

Hybrid

A break tank is only appropriate where the higher initial and operating costs can be justified, such as an entire building's water supply or an industrial installation. It employs a mix of passive and active controls consisting of a vented tank, an inlet pipe with an air gap, and a pump at the discharge, a break tank provides effective control for any application.

In addition to noise, energy consumption, and maintenance, break tanks are prone to microbial growth, which means the water must be treated. In addition, the overflow pipe must be inspected periodically to prevent obstructions, since an obstructed overflow pipe could make the water level rise and impinge on the air gap.



Break Tank
(image from Australian Water Dept)

Potential Problems

There are many ways to improperly install cross-connection protection.

- All cross-connection controls require space and the controls require service access as well as access for regular inspection. If a water supply cannot be interrupted for the routine testing of a control device, a pair of such devices is recommended.
- Air gaps, though relatively simple, must be able to maintain the gap when subjected to abuse. An air gap cannot be confined to a sealed space or to a subgrade location and the general openings around the gap must not be covered. The rim of the basin must be wide enough to capture attendant splashing that occurs from fast discharges. A common

design of potable water filling a tank through an air gap that is below the tank rim, but where the tank has an overflow standpipe, is found in water closet tanks. The generous standpipe empties into the closet bowl so the air gap is never compromised.

- ➢ Vacuum breakers also have several shortfalls. A vacuum breaker may fail to open if it is placed in a ventilation hood or sealed space. A vacuum breaker mounted too low may allow back-siphonage because the vacuum is too low for the disc to respond. A valve downstream of the vacuum breaker will send shock waves through the vacuum breaker every time it closes, causing the disc to drop, which momentarily opens the vent port, allowing a minute amount of water to escape.
- ➢ A backflow preventer is limited to certain orientations. Backflow preventers with relief ports cannot be placed in a subgrade structure that is subject to flooding because the air gap could potentially be submerged.
- ➢ Manufacturers of reduced-pressure principle backflow preventers recommend an inline strainer upstream of the backflow preventer (which needs periodic flushing) and a drain valve permanently mounted at the strainer's upstream side.
- ➢ Back-pressure backflow preventers require a floor drain or indirect waste receptor which complicates their installation, especially in existing structures
- ➢ Reduced-pressure principle backflow preventer requires space for its large size and its accessibility requirement. Another hazard exists with this backflow preventer in fire protection supplies because of the additional pressure drop in the water supply in contrast with a single check valve. Reduced-pressure principle backflow preventers also represent a significant flood hazard during low-flow conditions if the upstream check has a slight leak because the pressure will equalize, which opens the relief to the supply pressure.

[SLIDECUT]

[QUESTIONHEADER]

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According to the information provided in this class, what type of installations are typically suitable for the use of a break tank to ensure	In installations where the higher initial and operating costs can be justified such as an entire building's water supply or an industrial site	Where there is a high volume of Fats, Oils, and Grease in the sanitary drainage system	Where higher standards must be met such as hospitals, medical clinics, laboratories, and data centers	Break tanks are an attractive option for any residence

cross-connection control?				

[QUESTIONBOTTOM]

[SLIDECUT]

Corrosion

Corrosion of any metal and plastic elements of plumbing systems exposed to the environment is inevitable. The goal of corrosion protection is to delay and lengthen the process so that the components of the plumbing system last as long as possible.

One way of looking at the phenomenon is to think of the process of refining and shaping plumbing system components (such as cast-iron piping) as taking a disordered element (iron ore) and, by adding energy to the system, making it orderly. The refined product now holds the energy it took to transform it and is therefore prone to losing that energy when confronted with a receptive element. The result on an iron pipe is called rust, and it is akin to the iron reverting to its unrefined form.

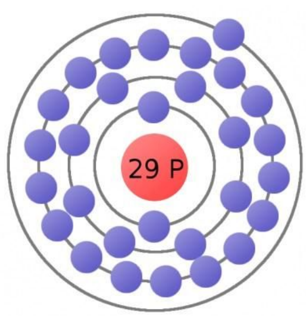
The transfer of energy in metallic corrosion is electrochemical (i.e., electrons flow based on chemical interactions in the phenomenon called electromagnetism). Without going into details, the essential principle of electromagnetism to remember is that the more negatively charged element (called the anode) will surrender electrons to the more positively charged element (cathode). A handy way to remember the terms is A (anode) is for AWAY, and C (cathode) is for CATCHER.

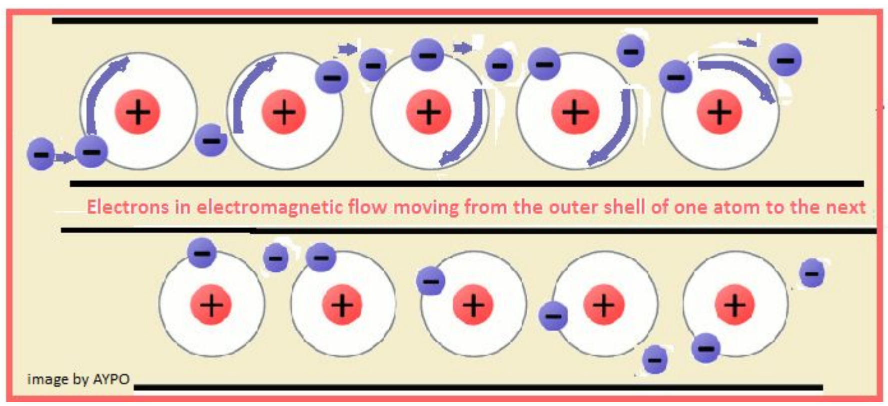
Rate of corrosion depends on three factors:

1. The difference in cathodic potential;
    - The anode corrodes; the cathode does not corrode although it may accumulate a hydrogen film,

2. The effectiveness of the medium (electrolyte) to transfer of energy from anode to cathode;
    - The electrolyte for plumbing systems is generally water – when flowing through water supply and drainage pipes, in the earth touching the outside of the pipe, as condensation on the outside of the pipe, or as water vapor;
3. A return path for the current from cathode to anode;
    - The return path completes the circuit, encouraging the flow of electrons from the higher negative charged element (anode) to the more positively charged element (cathode).

[See below for graphic representation of electron flow – the core contains positively charged protons, and where the outer shell has less than its capacity of negatively charged electrons, the electrons can flow to the next atom.]





Corrosion in Plastics

Unlike metals (which corrode through electrochemical reactions) plastics corrode due to physicochemical processes. These processes include swelling (taking on extraneous particles), dissolution (breakdown within the molecular structure), and bond (joint) rupture due to chemical reaction (oxidation), heat, and radiation (sunlight). These processes can occur singly or in combination. Unlike metals that lose mass through corrosion, plastics manifest the effects in the form of change in hardness, tensile properties, losses or gains in dimensions, elongation, and appearance.

Patterns of Metal Corrosion

Metal corrosion is usually the result an electrochemical reaction, meaning a chemical reaction requiring the flow of an electric current. There are numerous factors that can either speed or slow corrosion, including temperature, velocity of the medium, uniformity of materials, pH levels, etc. When it does occur, it will show up in one of the following patterns:

- Generalized – the most common pattern, where the entire outside of the metal corrodes in a cathodic solution (such as earth where water is the electrolyte to receptive elements in the earth);
- Galvanic – the second most common pattern when two dissimilar metals are in contact with an electrolyte.
- Selective (Leaching) - where one element within an alloy corrodes, such as dezincification of brass and graphitization of cast-iron;
- Pitting – usually the result of the localized breakdown of a protective film creating anodic areas where the film breaks and cathodic areas where the film is unbroken, resulting in localized, concentrated corrosion (pits);
- Concentrated – caused by differences in the concentration of a solution, such as different oxygen or metal-ion concentration, so that the area of low oxygen or metal-ion concentration becomes anodic to areas of higher concentration;
- Impingement (Erosion) – occurs when turbulent or high velocity fluid breaks through protective or corrosion films on a metal surface (with the pattern usually forming in a definite direction);
- Stress Cracking - wherever elements are stressed (such as at the bends of piping) corrosion fosters concentration of the stress, which eventually exceeds the yield strength of the material, resulting in cracking.

[Note: All of these forms assume a self-contained electrochemical environment. Where stray current is introduced such as a cathodic protection current from a pipeline that is not part of the system, the entire system can rapidly corrode as the stray current bears electrons away from the plumbing system back to the pipeline.]

Galvanic Corrosion Factors

One way to determine the occurrence and strength of this pattern of corrosion is the galvanic series which shows an arrangement of metals according to their corroding tendencies. The metals often used in piping are iron, steel, and copper, all of which are prone to corrosion because they are found in the middle to high range of the chart, with iron corroding the most readily of the three. The distance between two different metals on the chart also affects the corrosion rate, where two metals closer together are likely to corrode less than two metals further apart. As well as the type of metals used, other factors that affect the presence of corrosion include the size of an anode and any operating conditions such as temperature, humidity, and salinity.

The galvanic series in order from the noble or cathodic metals to the anodic metals (i.e., those less prone to corrosion to those most prone to corrode), includes:

- Gold
- Graphite
- Titanium
- Silver
- Stainless steels
- Nickel
- Monel
- Bronze
- Copper
- Brass
- Tin
- Lead
- Cast-iron
- Mild steel and iron
- Cadmium
- Aluminum alloys
- Zinc
- Magnesium

Other factors influencing galvanic corrosion include system pressure, flow rate, moisture in soil content around pipes, and stray electrical current. Water quality parameters affecting corrosion include alkalinity, temperature, pH, dissolved oxygen, hardness, chloride, and bacteria.

Biological Corrosion

When microbes make contact with plumbing elements, they can affect metallic surfaces in a chaotic pattern in which corrosion is greatest where microbe colonies infest. When bacteria-laden fluids are contained (i.e., not flowing), microbes can seek out irregularities on metallic surfaces to which they can attach. Once in residence, they begin their life-cycle activity which depletes oxygen and changes pH levels of the fluids, amplifying cathodic potentials in the surrounding environment that can rapidly corrode infested areas. In particular, biological corrosion has the potential to seriously impact the efficiency and structural integrity of water wells. Treatment of the water aimed at the specific bacteria can diminish this pattern.

Copper Pipe Erosion/Corrosion

Copper possesses excellent corrosion resistance unless that resistance is undermined by mechanically created erosion/corrosion. This process can be caused by any or all of the following:

- High velocity water (i.e., above 5-8 feet per second for cold water and 4-5 fps for hot water) which can be due to undersized piping, oversized circulating pumps, etc.
- Abrupt changes in direction of the piping;
- Poorly reamed pipe ends or protrusions in the flow stream (e.g., excess solder), causing localized high water velocity and cavitation that allow air bubbles entrained in the water to escape and scour the tube/fitting wall, resulting in pitting;
- Overly hot water: Corrosion processes increase in water above 140°F;
- Excessive amounts of dissolved gases, vapors, or suspended solids in the water increase damage resulting from velocity, high temperatures, cavitation, etc.

Corrosion on the inside wall of copper pipes often takes a horseshoe shape pointing in the direction of flow, with the deepest pitting upstream. Joints, valve settings, and bends are usually the most damaged. Without a visual inspection of interior tube surfaces, erosion/corrosion is hard to detect, although it sometimes creates a noise often described as “gravel bouncing through the line”. Once the process begins, it will accelerate and affected piping elements must be replaced. If any of the above factors is present, they should be mitigated (i.e., decrease velocity, lower temperature, treat water to remove gases or solids, etc., as needed).

Corrosion Control

As stated earlier, corrosion is inevitable. Our job is to mitigate and postpone it, as much as possible. Mitigation strategies include the following:

1. Materials selection
2. Design
3. Coating or Passivation
4. Cathodic protection
5. Dielectric protection
6. Inhibitors (water treatment)

Materials

Efforts to minimize corrosion begins with the choice of materials. Corrosion resistance along with cathodic reactions between materials should always be considered when choosing a product to fit the environment where it will be installed. When possible (unless instructed otherwise by the customer) the most economical choice suitable to the environment should be selected. In some situations, a trade-off between corrosion resistance and other selection criteria must be weighed. Other factors that may cause selection of a less corrosion-resistant choice include the following:

- Cost (initial cost as well as comparative lifetime cost)
- Availability
- Fabricating considerations (pre-cut, cast, or formed for the intended application)
- Ability to be formed or joined by welding or soldering
- Tensile and yield strength, impact resistance, hardness, ductility, etc.)
- Electrical or thermal properties
- Compatibility with other materials in the system
- Special considerations such as the effect of sunlight, etc.

Design

Some designs may minimize corrosion, including:

- Dielectric insulation between dissimilar metals (such as when copper and steel are connected at a water heater). Without such insulation, the metal higher in the galvanic series (steel) will suffer accelerated corrosion.
- Avoid surface damage or marking that can cause that area to become anodic to the adjacent untouched areas. Designing systems to minimize the need for on-site alterations can avoid this.
- Avoid excessive welding or soldering heat that can cause loss of consistent molecular structure and resultant corrosion. Designing systems with thicker walls where welding occurs can reduce this problem.
- Avoid dimpling or creation of crevices that is caused by inconsistent pressure applied to adjoining piping areas.
- Prevent the condensation of moisture from the air on cold metal surfaces by insulating where air temperature will be warmer than the water supply.

Protective Coating and Passivation

The most common mitigation method is to coat corrosion-prone materials with a corrosion-resistant layer. Materials exposed to the atmosphere that do not have the ability to form natural protective coatings, such as nickel and aluminum, are best protected by the application of an artificial protective coating. The coating may be factory-applied or field-applied; if field-applied, be sure that the surface is adequately prepared. Protective coating choice depends on whether the intent is galvanic protection (such as zinc added to galvanized steel) or biochemical (such as vinyl or epoxy). Coatings alone are usually sufficient where the pipes have little or no physical contact with environmental elements. Coatings alone, however, are not considered adequate for corrosion control of buried or submerged structures, since even small breaks in coating will create rapid corrosion at those spots.

A related process to coating is known as passivation, which is the application of a chemical that fosters the formation of a protective coating on metal pipe (primarily stainless steel, although passivation for aluminum is also under development).

Cathodic Protection

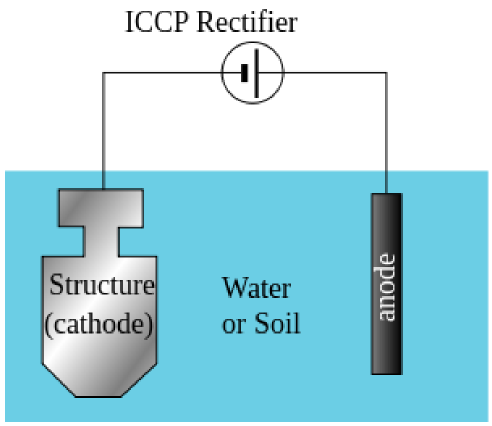
Cathodic protection is a vital means for corrosion control of metallic elements immersed in a continuous electrolyte, such as when buried in earth or the inside wall of a water heater. The goal of cathodic protection is to provide a “sacrificial anode” that transforms metallic elements in the plumbing system from being anodes, themselves, into cathodes. That metal is protected from corrosion because it emits electrons (current), while the anodic metal receiving the current becomes the “sacrificial” metal and corrodes for the both of them.

The most common sacrificial anode is made of magnesium (the least “noble” metal in the galvanic series list provided earlier in this lesson), since this means that it will exert anodic protection even where electrical resistance is relatively high. Zinc anodes may be used where electrical resistance is lower (such as water heater tanks), making the need for the more attractive anodic qualities of magnesium unnecessary.

Impressed Current Cathodic Protection

As discussed in the previous slide, some metals have a passive galvanic reaction whereby, without introducing an outside current, they emit a current flow to a sacrificial anode. Where a sacrificial anode is insufficient, a *cathodic protection system* may be necessary. Cathodic protection rectifiers provide low-voltage direct current that is absorbed by the element to be protected, turning it from an anode to a cathode. The electrical circuit also needs an inert anode material that will not become absorbed during the process. Imparting a small direct current flow into the metal induces the metal to emit electrons that flow to the sacrificial anode.

Cathodic protection systems are the most effective (and economical), when combined with the other methods of corrosion control, especially coating. Best practices would be to apply a high-quality coating, then use cathodic protection to eliminate corrosion at the inevitable breaks in the coating. The reason for this is that it takes much more current and anodes to protect bare metal than it does to protect coated metal. The amount of protective current required is proportional to the area of metal exposed to the electrolyte.



Sample Code Section

The following is drawn from Appendix E of the 2015 Uniform Plumbing Code®:

2015 UPC® E 28.1 Manufactured/Mobile Home Parks and Recreational Vehicle Parks; Cathodic Protection Requirements.; General. Cathodic protection shall be installed for corrosion control of buried or submerged metallic gas piping in accordance with the following requirements:

(1) Where amphoteric metals are included in a buried or submerged pipeline containing a metal of different anodic potential the following protection shall be provided:

(a) The buried or submerged pipeline shall be cathodically protected at a negative (cathodic) voltage of 0.85 volt measured between the structure surface and a saturated copper-copper sulfate half-cell contacting the electrolyte.

(b) The amphoteric metals shall be electrically isolated from the remainder of the pipeline with insulating flanges, or equivalent, and cathodically protected.

(2) The amount of cathodic protection shall be such that the protective coating and the pipe are not damaged.

Dielectric Protection

Wherever mixed metals are in the same plumbing system, galvanic corrosion is highly likely wherever they make physical contact. Where transitions between dissimilar metals occur, some form of dielectric [resistant to conducting electricity] protection is necessary. Areas of contact would be where copper tube branch lines and cross mains are used in connection with steel pipe feed mains, risers, and standpipes, or where they are supported by steel band or ring hangers, or penetrate or cross metal building studs, or metal sleeves used to shield tubing in wall penetrations. Protection can be maintaining a separation (space between), protective insulating sleeves, grommets, or tape, or using dielectric connectors designated for that purpose.

Inhibitors (Water Treatment)

Plant utility services such as boiler feed water, condensate, refrigerants, and cooling water require the addition of inhibitors or water treatment. Boiler feed water must be treated to maintain proper pH control, dissolved solid levels, and oxygen content. Condensate requires treatment to control corrosion by oxygen and carbon dioxide. Brine refrigerants and cooling water in closed-loop circulating systems require proper inhibitors to prevent corrosion.

Water treatment may consist of filtering, chemical additives, or promotion of elements that naturally form a film on the metal surface that repels water. Sodium silicate or sodium hexametaphosphate (where phosphate additives are permitted), in potable water, will impart a tight, thin, continuous film of silica (water glass) or phosphate that adheres to the metal surface, preventing pipe contact with the water.

[SLIDECUT]

[QUESTIONHEADER]

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What is the relationship between the anode and the cathode?	The anode sheds electrons; the cathode catches the loose electrons	The cathode sheds electrons; the anode catches the loose electrons	The anode is any reactive metal and the cathode is the transmission medium between anodes	The cathode is any reactive metal and the anode is the transmission medium between cathodes

[QUESTIONBOTTOM]

[SLIDECUT]

Customer-Created Problems

Americans overwhelmingly take it for granted that they can turn a tap anywhere, at any time of day, and have abundant, safe, fresh water pour out at just the right heat and pressure – that every sink or appliance drains and every toilet flawlessly bears away its contents without ever clogging or allowing odors to escape. Plumbing professionals, supported by elaborate and constantly updated plumbing codes, have been so successful in providing high quality, reliable plumbing that most Americans don’t realize how recent and how complicated are the systems that allow for all this. During this same period of time, Americans have enjoyed relatively low water and sewer bills and so it's only natural that they have come to expect plumbing to always work flawlessly at a very low cost.

Like anything people take for granted, a great number of our customers either neglect or actively mistreat their plumbing – some may also mistreat the plumber who comes to fix the problems. It would be impossible to list every way customers misuse or damage plumbing, so we'll look briefly at just a few, followed by a recipe for how to reduce the prevalence of customer-created plumbing problems.

DIY Plumbers

Plumbing repair and installation often appear easier to a customer than they are, so they attempt the work themselves or someone the customer knows offers to do the job. Do-it-yourself (DIY) plumbing is rarely a good idea. This has been an issue for many years but is far worse in the age of the YouTube DIY video. For every time a DIY job is done correctly, there are a dozen that are inadequate or that make the problem they hoped to fix worse. Some are comical in just how poorly they've been done [see pictures, below]:

Sample DIY plumbing errors

images courtesy Maida Plumbing, New South Wales, Australia

Rather than humorous, however, DIY plumbing errors can be dangerous. A drain line that uses a jury-rigged trap instead of the correct fixture interrupts effluent flow and can cause backflow into the home; a trap installed sideways allows poisonous, explosive sewer gases back into the home. Trying to save some money can turn into damaged property, damaged health, or even loss of life.

Along with customer-created problems, work done by non-plumbers licensed in other trades can also cause damage. In some cases, it's a jack-of-all-trades handyman who is not much more skilled than a DIY homeowner. More often, it's a building trades professional who works on (or inadvertently damages) plumbing when engaged in other work at the site, such as a kitchen remodel, electrical work, hydronic piping installation, structural repairs, etc.

Drain Abuse

More than anything else, misuse of the sanitary drainage system damages plumbing, nationwide. Generally, this takes the form of flushing harmful agents down the toilet or washing fats, oils, and grease down sink drains. Ideally, a toilet should never have to flush more than human wastes and toilet paper and a sink drain shouldn't receive much beyond soapy water.

Here's a list of some common drain abuses:

Disposable wipes:

Introduced in the early 2000s, these "flushable" products were resized versions of baby wipes made of an elastic, durable plastic material that doesn't break apart in water known as spun lace. Even though most commercial wipes have switched to cellulose, which can be broken down, it still causes clogging and requires intervention in order to fully break down. Mislabeling is a large part of the problem – most people assume that "flushable" also means "biodegradable", but manufacturers try to make them as durable as possible and when customers, following the label, flush them down the toilet, they bind with fats, oils, and grease and with each other to create massive blockages including the so-called "fatbergs" of London, "blockages caused by wet wipes and cooking fat."

Sanitary napkins, paper towels, paper diapers, etc.:

Although all of these are paper products, like toilet paper, any product designed to be absorbent will comfortably take on water instead of rapidly degrading. Toilet paper quickly disintegrates when wet; these other paper products form flattened blockages in pipes.

Dental floss and cotton balls/swabs:

They don't biodegrade. Cotton balls or swab fibers spread in the effluent and dental floss fibers, whether waxed or unwaxed, separate to become almost as good a net to catch grease and debris as a wet wipe. Even worse, if there are any moving parts (such as, for a motor) in the drainage system, the fibers wrap around and can damage or disable it. The sticks used in cotton swabs are usually plastic and can bunch into an impenetrable blockage.

Hair:

Like dental floss, hair is light, tangles easily, catches grease and grit, and will never dissolve in water. Bath, shower, and lavatory drain grates and baskets are there to intercept hair more than anything else; if the customer bypasses them in bath or sink drains or by flushing it down the toilet, nasty clogs are inevitable.

Kitty litter (and pet feces):

If flushed in small amounts, kitty litter would be fine, but a large mass dumped at once would have more mass than the water stream can transport, especially if it's a water-conserving toilet.

Kitty poop, on the other hand, would be fine except that by the time it's flushed, it's dried and hardened and won't easily dissolve.

Condoms, chewing gum, cigarette butts, etc.:

Condoms are durable and fill with other wastes, chewing gum is adhesive and doesn't degrade, cigarette filters are fibrous and may contain plastics.

Drain cleaners, bleach, harsh chemicals, paint, solvents, thinner, etc.

If diluted sufficiently, the system can handle small amounts of these. In any larger volumes, rapidly dumped, the pipes themselves and other vulnerable components can be damaged. Drain cleaner that flows past a partial blockage is corrosive downstream.

Drugs, medications:

Drugs and medication may not harm plumbing, but they become a problem for water treatment operators and pollute a high percentage of America's drinking water, so even if it isn't a plumbing problem, it would be a service to the community if customers could be dissuaded from this practice.

Fats, oils, and grease (FOG), discarded food, dead fish, etc.:

Customers reason that, as long as it's hot, grease from cooking flows easily and can go down the drain. The truth is that, unless the drainage piping is also heated, the FOG cools, congeals, and creates foul-smelling pipe blockages.

The blockages from food wastes is not as problematic as with FOG, but still exists. Food wastes can flow easily when liquefied by a garbage disposal, but larger chunks can cause stoppages as they lodge or settle in pipes and junctions while they take time to break down. Pasta and rice are the worst offenders since they continue to swell as they take on fluid in the pipes.

Flushing dead goldfish or snakes or hamsters may not seem to fit with this category but the problems they cause are similar to and even worse than large food chunks. The following should also not go down sink drains, even if put through a food waste grinder:

- Coffee grounds and eggshells (too much grit for most piping systems);
- Bones, fruit pits, and citrus fruit rinds (harm the garbage disposal blades then cause blockages);
- Flour (mixed with water makes glue); and
- Those little stickers on fruit (increasingly common).

Plumbing Fixtures Abuse

As plumbers, we're called on to attach fixtures firmly. As a result, customers begin to see the fixtures, their control and spouts, as structural elements. Soap caddies hanging from shower spouts are usually a minor kind of abuse; standing on a cold-water valve and handle to reach higher is far too common, and other ways of over stressing equipment that needs to be balanced to work properly can cause problems right away or appear as a result of persistent abuse.

MacGyvering Frozen Pipes

Everyone's dad told them how to avoid frozen pipes – keep a slow flow of water going all night long and, if need be, all day.

With all due respect to dads everywhere this is a terrible idea. First, it wastes water. Second, sending a steady trickle of cold water down the drain encourages frozen drain lines. For those who have POWTS, the additional water overtaxes the septic tank and can saturate the drainfield, where it floods the surface and freezes.

Even worse ways to unfreeze pipes are to introduce antifreeze or to use a flame source such as building a fire or using a blowtorch.

How to avoid frozen pipes:

A. Remove, drain and store hoses used outdoors. Close inside valves supplying outdoor hose bibs. Open the outside hose bibs to allow water to drain. Keep the outside valve open so that any water remaining in the pipe can expand without causing the pipe to break. Drain water from swimming pool and water sprinkler supply lines, following manufacturer or installer's directions.

B. Make sure vents are closed to your crawl space and the crawl space door itself is closed. Add insulation to attics, basements and crawl spaces to maintain higher temperatures in those areas.

C. Insulate water pipes with a "pipe sleeve" or UL-listed "heat tape," "heat cable," or similar materials on exposed water pipes.

D. Consider relocating exposed pipes to provide increased protection from freezing.

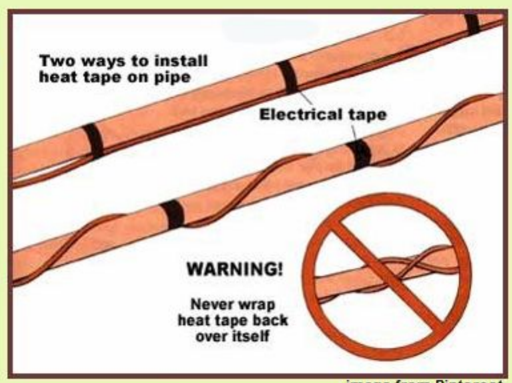

image from Pinterest

[Note: If the frozen pipe problem is localized, a stopgap can be using a hair dryer or heating pad. Longer term solutions could be to relocate pipes to pass through areas where they aren't as prone to freezing or using heat-trace tape.]

Ignoring Plumbing Problems

The last customer-caused problem to address is simple neglect. When a smaller, nagging problem appears (such as a leaky faucet, weeping water heater T&P valve, condensation overflow, or recurrent blockages treated with drain cleaner only to recur soon thereafter) it's a great clue that will guide a trained plumber to maintain, repair, or replace as need be so as to head off worse problems in the future.

Unfortunately, many customers judge the need to get the plumbing fixed based on their tolerance for the malfunction, not the plumbing system's tolerance. Hoping that plumbing problems will fix themselves if left alone is rarely a good strategy. Instead, the problem is far more likely to worsen with time and a small repair can become a large, expensive job and cause harm along the way.

What Can Be Done?

We promised to focus on avoidable plumbing problems, but almost all of the problems we've discussed in this lesson can only be avoided by changing the behavior of our customers.

There might just be something we can do about it.

It comes down to how people value our profession. We must master the physics and chemistry that applies to plumbing – the properties and behaviors of gases, liquids, and pressure under different climate conditions and how a change in one variable changes everything. Meanwhile, we need to diagnose problems and make repairs in homes we didn't build after decades of work completed by other plumbers. Despite all this, plumbers are most often depicted in popular entertainment as the butt of jokes (you know what I mean). People take for granted not only our knowledge but also the everyday luxuries of clean running water and a hot shower. They rarely appreciate the expertise, years of training, dedication, and professionalism it takes to make this happen.

Customers won't understand until we make them understand. We need to all do our part in explaining what value we've added to their home and the workmanship that went into it. It's not bragging but showing pride in our craft to draw the customer's attention to where we excelled. In truth, whatever we fail to point out won't be seen by most customers.

We have to remember that we are all representatives of our entire industry. Professionalism in our own presentation and workmanship, ethical conduct, and avoiding wherever possible criticism of others in our profession, even those in direct competition, will elevate how people view what do. If we clarify for our customers just how complicated and deadly plumbing can be when mistreated or left to "Uncle Louie, who's good with his hands" they'll be more likely to understand why plumbers go through a lengthy apprenticeship, keep up with continuing education, and why we charge a fair price for what we offer. We have one of the most critical jobs when it comes to providing quality of life. Their appreciation of that is one of the best ways to bring about changes in how they treat the work we do once we've left their home.

[SLIDECUT]

[QUESTIONHEADER]

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According to the information provided in this class, do “disposable” sanitary wipes present a problem when flushed down a toilet and, if yes, why do they cause a problem?	Yes; even though most commercial wipes have switched to cellulose, which can be broken down, it still causes clogging and requires intervention in order to fully break down	Yes; the earliest commercial wipes were made of cellulose, which can break down readily and doesn’t clog piping, newer versions are made of flexible plastic material that doesn’t break apart in water	No; flushable wipes are called “flushable” because they can be flushed in any quantity without causing a blockage	Yes; because they are made of fibrous strands, as they break down, the strands can wrap around joints and curves inside piping, diminishing the radius

[QUESTIONBOTTOM]

[SLIDECUT]

[VIDEOHEADER]

End of the Class (Video)

That completes this class on What Can Go Wrong? – Common Problems in Plumbing.

Thank you for taking this online education class from At Your Pace Online. Think of us whenever you or a colleague have future continuing education needs.

[VIDEOBOTTOM]

[SLIDECUT]

[QUESTIONHEADER]

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What is the thing to “never do” when installing heat trace tape on water supply pipes?	Never wrap heat tape over itself	Never extend heat tape through a wall or floor penetration	Never use heat tape when other options are available	Never attach heat tape to pipes in a way that will compress it, such as by using electrical tape

[QUESTIONBOTTOM]

[SLIDECUT]