

by William Rose

The Mysteries of Plumbing Drains Unveiled

How traps, vents, and drains work—and why sometimes they don't.

Water runs downhill and Friday's payday. That's all there is to plumbing.

Well, not quite. When you start thinking of all that can go wrong in a plumbing system, you realize that gravity is a part, but not the whole story. A residential plumbing system has three components: water supply, fixtures, and drain/waste/vent (DWV). The water supply can leak, freeze, hammer, and lose pressure. Fixtures can break, clog, backflow, and drip. DWV can leak, clog, gurgle, and stink. Plumbing fixtures and water supply, however, are pretty simple compared to DWV systems, which can get pretty complicated. This article hopes to shed some light on the mysteries of DWV.

The science of plumbing is, basically, the science of separating sewer gas from house air. Sewer gas is unpleasant, and gets more unpleasant every year that a plumbing layout is in operation. It contains methane, which is not particularly toxic but is combustible in high enough concentrations. Most important to the homeowner, it smells.

The trick is to get wastewater (fluids and solids) down the plumbing drain without letting the sewer gas out. This requires a trap—a U-shaped pipe that holds water called the *trap seal*. Many folks think traps are the last stopover for earrings, spoons, and contact lenses before they head for the great unknown. These folks have never had a trap siphon dry under their noses. The first fixture trap was patented in 1856, but it is probable that its history goes further back.

A plumbing drain system works at atmospheric (neutral) pressure. Nothing "sucks" or "blows" wastewater down the drainage pipes; gravity does the whole thing. This works fine as long as air can enter the drainage system and maintain neutral pressure. The bigger the pipe, the better, since air can more easily get in and pass by moving water, if needed.

Neutral pressure is lost, however, whenever "slugs" pass through the drain. Slugs are moving plugs of liquids and solids that fill the whole sectional area of a drain. Slugs act like pistons. Positive pressure (called back-pressure) is created ahead of a slug and negative pressure is created behind.

The pressures created by slugs are high enough that, if the system were closed to the outside (e.g., due to no vents or clogged vents) no trap seal could survive. Trap seals downhill from a moving slug would be blown out. This is particularly a problem on the bottom level of three or more stories. The traps here would gurgle and bubble and possibly release gas, but the trap seal would settle back in place. Traps uphill would be siphoned, and the water seal would

be lost. Sewer gas would be free to enter the home until the trap was refilled.

Vents

To prevent the loss of trap seals, there's an opening at every fixture to the great outdoors called a vent. As a plug of water rushes down a drain, air rushes in the vent and equalizes the pressure. It's like taking your finger off the top of a drinking straw and watching the water spill out the bottom.

In theory, right behind every fixture, you need one line down for solids and liquids and one line up for air. That would be called individual fixture venting. Some commercial work requires this. In residential work, however, you don't see it. What's going on?

The difference is that residential codes allow some drain lines to do double-duty as vents. And as long as the drain is free of slugs, this works.

Venting terminology seems to shift over time, and from region to region (see glossary), but pictures don't lie. So keep an eye on the illustrations.

Individual vents (or back-vents). This is conventional venting in multi-story work. The trap of every fixture is individually vented to the outside (see Figure 1), so the only pressure differences that the trap water experiences are between the inside and the outside. Commercial plumbing diagrams that show individual fixture venting look like two trees, with the drain tree looking a lot like the upside-down image of the vent tree. Costs in this kind of system can mount as the number of fixtures increases. Individual fixture vents are usually collected by horizontal vent headers (or branches), which run into a vent stack before it penetrates the roof. Don't confuse vent stacks with stack vents.

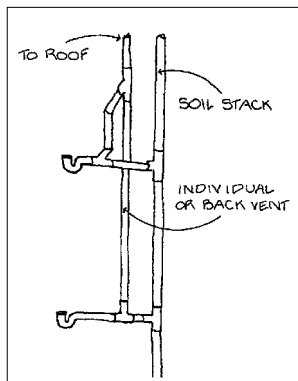
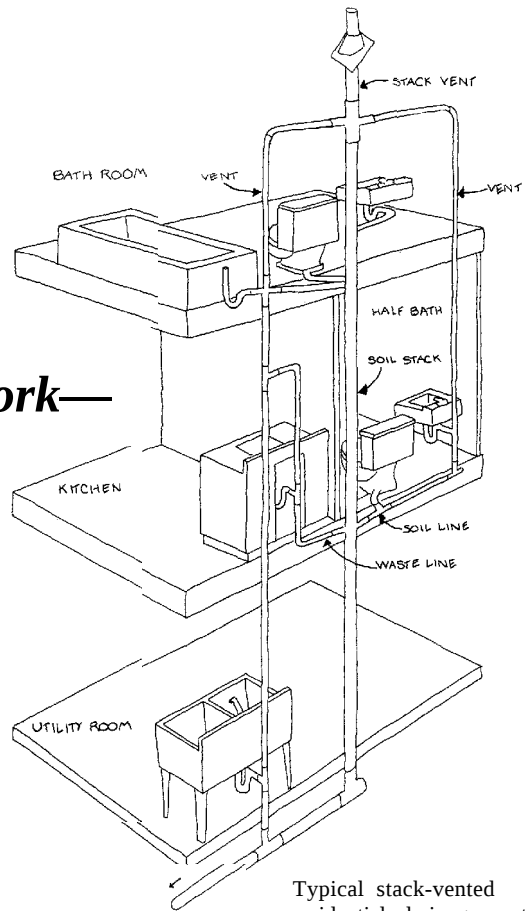


Figure 1. Individual fixture vents. Common in commercial plumbing, the trap of every fixture is vented directly to the outside through a vent stack.



Typical stack-vented residential drainage system.

Loop vents. If an individual fixture vent reconnects to the main stack, it is called a loop vent (see Figure 2). Typically the loop will tie back into the main stack above the height of the highest branch drain.

Common vents. Here, both drains connect with the vertical stack at the same level (see Figure 3). The fitting configuration and the mild slope of the drains (1/4 inch per foot) prevent the waste from one fixture from sloshing into another fixture's drain. Common vents are typical in back-to-back bathrooms. If the fixtures connect at different levels in the same story, the vent is called a wet vent.

Wet vents. If two fixtures are connected to the stack at different levels, the lower fixture is said to be wet vented (see Figure 2). The vertical pipe that drains the upper fixture and vents the

lower one must be one pipe size larger, by code, than the specified drain diameter for the upper fixture. The idea here is to make it that much harder for a slug to form in a wet vent, since it must do double duty as both a drain and vent.

Wet vents can occur only within a single story (called a branch interval) and cannot vent an entire fixture group. Water closets cannot be wet vented.

Stack vents. Every house needs a water closet, and every water closet needs a soil stack, 3 inches or larger in diameter. Since the soil stack is just the right size to vent the whole plumbing system (code requires that the vents in a house add up to plus-or-minus 15 percent of the sectional area of the house drain), why not extend the soil stack through the roof and use the upper part as the main vent? That's the principle of stack venting (see Figure 4).

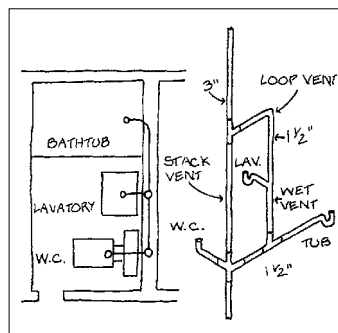


Figure 2. Loop vent and wet vent. A loop vent connects a fixture back to the main stack. A wet vent drains one fixture and vents another lower one.

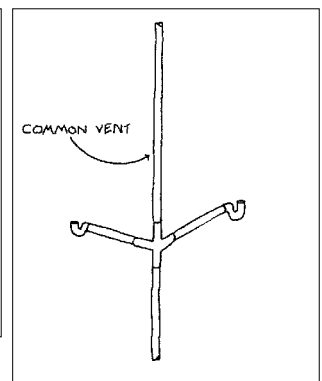


Figure 3. Common vent. Two drains can tie into the main stack at the same level.

With stack venting, the air contained in the trap arm (the horizontal section between the trap and the stack) serves to vent a fixture all the way to the stack. From there, the stack serves as the vent. The stack is presumed to be large enough to be virtually free of slugs. Stack venting is very common in single-story residential construction, and certain configurations are permitted even over two floors.

Mechanical vents. In some remodeling situations, it's difficult to install a proper back-vent without tearing up half the house. Some codes, under some circumstances, permit mechanical vents, which are check valves that allow air in, not out. An example might be where you've added a washing machine in the basement and don't want to run a vent all the way to the roof. As long as the mechanical vent continues working, it protects against negative trap pressure, which could siphon the trap dry. They don't prevent back (positive) pressure, however, so traps can still be blown out.

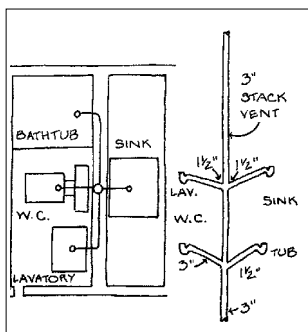


Figure 4. Stack venting. In residential plumbing, the upper part of the soil stack often serves as the main vent, and is called a stack vent.

Traps

Traps are renewable liquid plugs that stand between house air and sewer gas. Traps go bad when they leak, evaporate, siphon, or are blown. Leaks and evaporating traps are simple matters. If a trap, such as a floor drain, seldom gets replenished, it's a good idea to pour some mineral oil into the trap. Mineral oil covers the water surface and does not evaporate.

Whether or not a trap is likely to siphon depends on the configuration of the trap and trap arm (see the section below, on trap arms).

P-traps. P-traps are the standard in most modern codes. A P-trap is made up of a U-shaped section joined directly to a horizontal section called the trap arm (see Figure 5a). As wastewater passes through the arm, air entering from the vent allows the water to "relax" and spread out. This cuts the flow of wastewater at the end of each drainage cycle and prevents siphoning.

Drum traps. Drum traps are barrel-shaped and have good anti-siphoning qualities (Figure 5b). They were once commonly used for tub and shower drains, but are now prohibited by the CABO One and Two-Family Dwelling Code. To work properly, a drum trap should be installed with its removable cover accessible, either through an access panel or through the bathroom floor. Most of the drum traps I've seen are installed upside-down, with the cover facing downwards.

S-traps. Siphons occur most readily

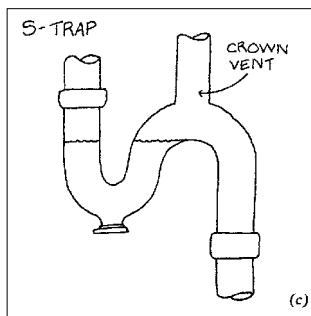
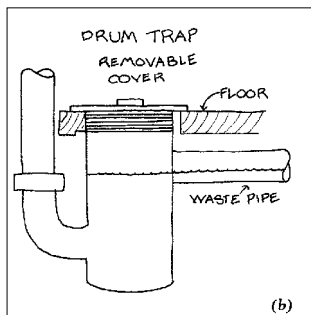
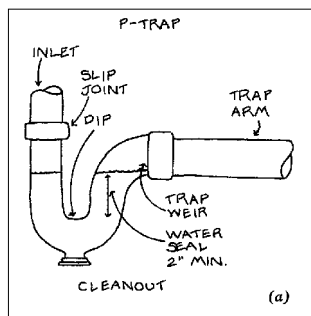


Figure 5. The P-trap (a) is now the only CABO-approved design. The drum trap (b) often requires a hole in the bathroom floor. Old-style S-traps (c) don't work well even with the addition of a crown vent.

in an S-trap, which looks like its name (Figure 5c). As the last water drains out of the basin, the looping train of wastewater is uninterrupted by air. Out goes the baby (the trap seal) with the bath water.

Crown venting. When siphonage problems began to appear with S-traps, the obvious solution was to vent the top of the upward loop of the trap. This is called crown venting. The momentum of moving water through the trap, however, creates a plug of water in the vent pipe. This permits the trap to siphon as if the vent wasn't even there. To prevent this type of problem, code requires that the vent be no closer to the trap than two diameters of the trap arm. This effectively prohibits crown venting.

House traps. In the past, a large trap would be installed in the house drain to act as a secondary defense against sewer gas from the municipal system. Now, house traps are prohibited by code

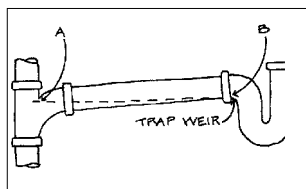


Figure 6. Trap-arm length. The length of the trap arm is determined by the pipe diameter. The open vent at point A should not be lower than point B.

GLOSSARY

Branch line: a horizontal run of drain pipe.

Branch vent: a horizontal run of vent line.

House drain: the horizontal line running to the sanitary sewer or septic system.

Soil stack: the main stack that carries waste and soil to the house drain.

Stack: any vertical pipe in the DWV system.

Stack vent: the upper portion of a soil stack that serves as a vent.

Trap arm: the length of drain from the end of the trap (the trap weir) to the

vent (or to the soil stack if the fixture is stack vented).

Trap weir: the high point of a trap's water seal on the drainage side.

Vent stack: a main vertical vent that penetrates the roof.

Water seal: the column of water in a trap (min. 2 inches) that seals out sewer gases and vermin. The depth of the seal is measured from the weir to the dip (see P-trap illustration).

Wet venting: combining two fixtures that discharge at different levels, so that the drain of the upper fixture serves as a vent for the lower fixture.

except where sewer gases are extremely "corrosive or noxious."

Trap-arm length. The trap arm is the length of drain between the trap and the vent. It should slope 1/4 inch to the foot and must be designed to permit the free passage of air from the vent into the trap arm (see Figure 6). If the trap weir (see Glossary) is above the vent opening, then air in the arm can be restricted, and the trap can siphon.

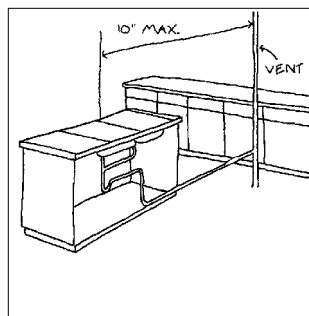


Figure 7. Island sinks. New codes permit long trap arms with doglegs for island sinks. Follow guidelines, however, or you'll end up making your P-trap into an S-trap.

In practice, this means that the maximum trap-arm length is determined by the diameter of the pipe size (see Table 1). The minimum distance (remember?) from the trap to vent is two diameters of the trap arm.

Table 1	
Drainage Line Size	Maximum Trap-Arm Length
1-1/4"	5'
1-1/2"	6'6"
2"	8'
3"	12'
4"	16'

From CABO One and Two Family Dwelling Code

Island sinks. New codes revisions permit long dogleg trap arms (Figure 7). These are particularly helpful for island sinks. If these are not done correctly the vertical leg in the trap can inadvertently convert the P-trap to an S-trap. Check the code book for permissible lengths and drops.

Sounds like a lot of trouble just to keep two inches of water in a sagging piece of pipe. But histories of medieval towns and some more recent ones, seem to tell us that we can't even imagine what life was like before plumbing traps. I'll take the low-tech over the no-tech way anyway. ■

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