Plumbing Vents Explained

A cookbook of code-approved strategies for getting air to your drain lines

Ask anyone why drain lines are vented and you're likely to hear, "To keep sewer gas from coming into the house." And that's right — it's that simple. The water trap at each plumbing fixture is the physical barrier that keeps the sewer gas out (see Figure 1). The problem has always been how to keep the water traps intact while still allowing wastewater to drain out and vent gases to escape into the atmosphere outside the building. This is the sole intent of all the venting codes.

by Rex Cauldwell

This article will show you what happens if you don't vent properly. It's written from the perspective of a plumber who installs custom plumbing and who specializes in troubleshooting and service calls — not from the perspective of someone who makes a living installing low-bid, code-minimum plumbing and who must cut corners in an attempt to make a profit. Most of the time I exceed minimum code — on purpose.

Because I live in Virginia, I mainly use the new International Plumbing Code, which has incorporated BOCA and the Southern code and is used across the East. In the West, the Uniform Plumbing Code is in effect. And then there are various state codes, which are based on one of the others but with modifications. In this article, I will be concentrating on IPC design rules. Some sections — wet venting, for example — may not apply in the West.

Some Venting Basics

Vents, like drain lines and traps, are sized according to the number of *drainage fixture units* (*dfu*) they serve (see Table A). For example, a toilet counts as 4 dfu, a shower as 2, and a lav as 1. However, bathroom fixtures can be grouped together for a total of 6 dfu, less than the sum of the parts. A bathroom group is defined as a toilet, bidet, lav, and tub or shower all on one floor level.

Oversize. By code, a vent pipe must be a minimum 1¼ inch in diameter, and it must be at least half the diameter of the

1. Typical Trap Seal

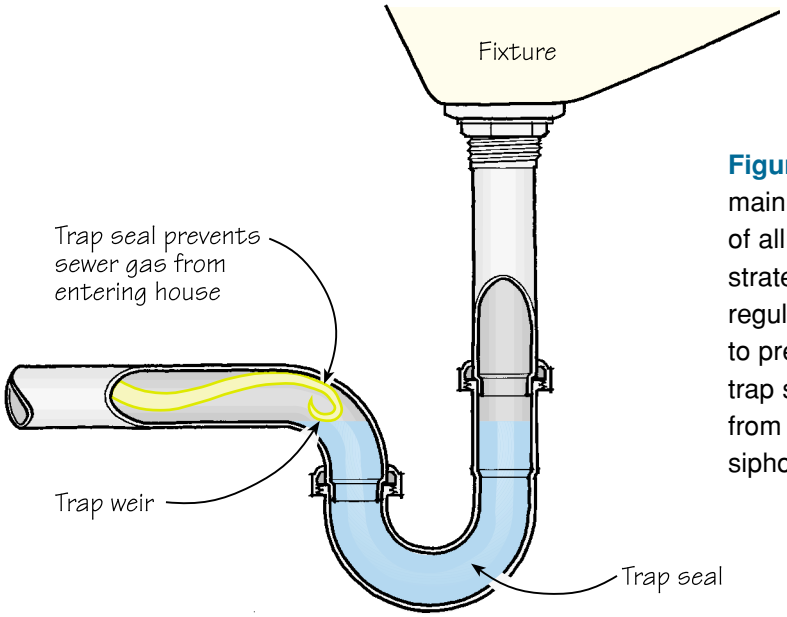


Figure 1. The main purpose of all venting strategies and regulations is to prevent trap seals from being siphoned off.

Where Does All the Water Go?

Traps lose water in a variety of ways. The water may leak out if the trap gets broken (from freezing, for example) or rusts through. Water in a little-used trap may evaporate. If a cotton string gets stuck halfway between the trap and the drain, it can wick water out of the trap by capillary action. Water moving too fast through a trap will cause the water in the trap, by attraction, to flow out with the draining water. This is one of the reasons the S-trap was banned: The quick downturn of the pipe allowed the wastewater to pick up too much speed (Figure A). But the most common reason that traps go dry is because of pressure differences in the pipe.

Pressure is the bane of traps. Positive pressure in the drain lines will push the water out of the trap and into the sink bowl. Each time this happens, a little less water will be in the trap as it sloshes back. Negative pressure in the lines will do just the opposite, and it can come from a variety of sources. The most common is a large amount of moving water, called a slug, that totally closes off a section of the drain line. As it flows down the pipe it creates a negative pressure area immediately behind it — like the piston in a vacuum pump — that sucks the water right out of any trap it passes (Figure B). The atmospheric pressure plays a role, too, by pushing the water out of the trap and into the drain line to compensate for the pressure difference.

Vents were developed to eliminate pressure changes within the drain lines. Experience taught that the horizontal drains should have enough room for both air and water (half air and half drain water in a typical cross-section),and that the vent pipe must connect to the drain line above the halfway mark, so it didn't get choked off (Figure C).

Why an S-Trap Won't Work

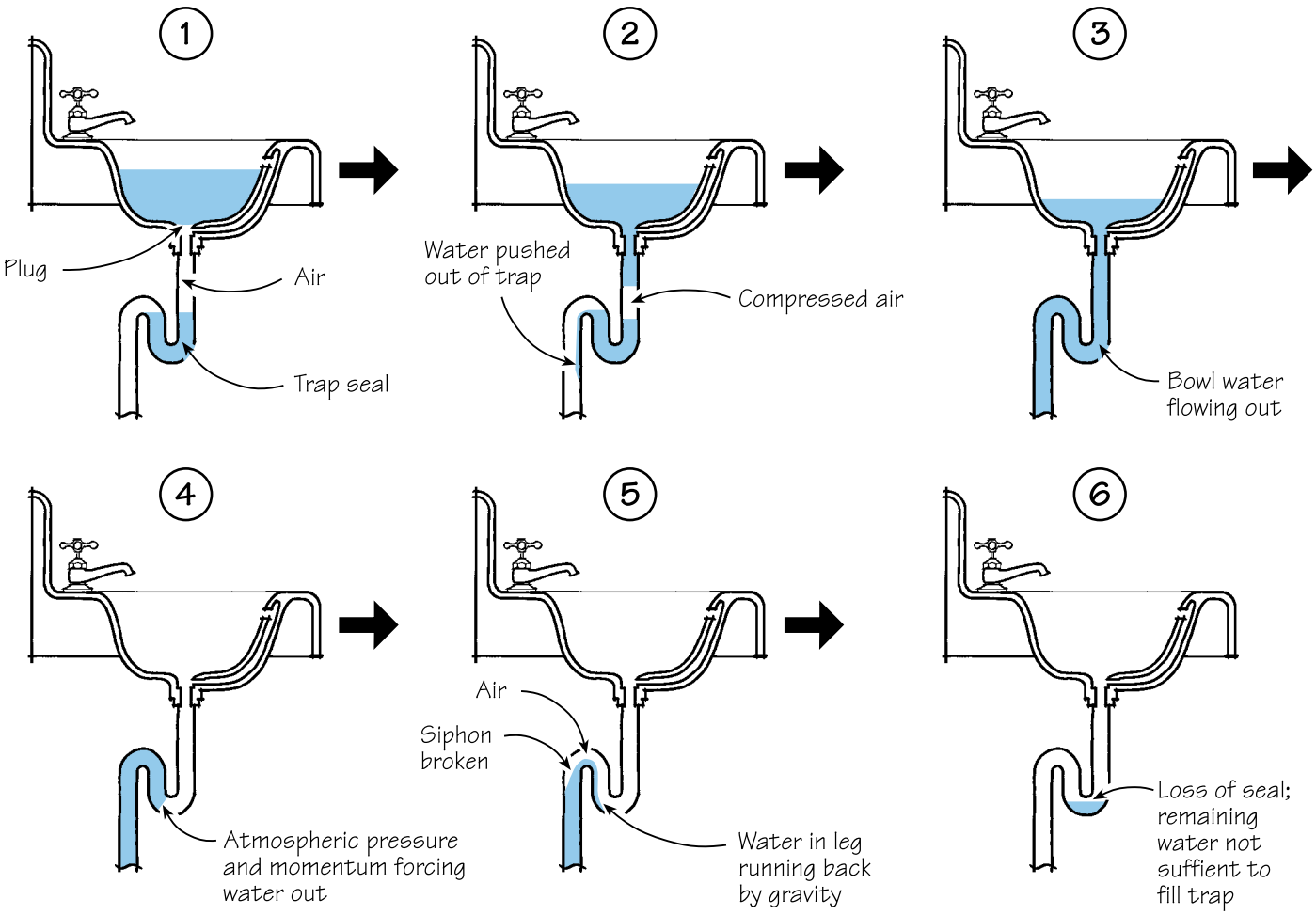


Figure A. S-traps are banned because they allow water to drain too forcefully, typically pushing and pulling the trap dry, as this sequence of illustrations shows.

How Air Pressure Affects Traps

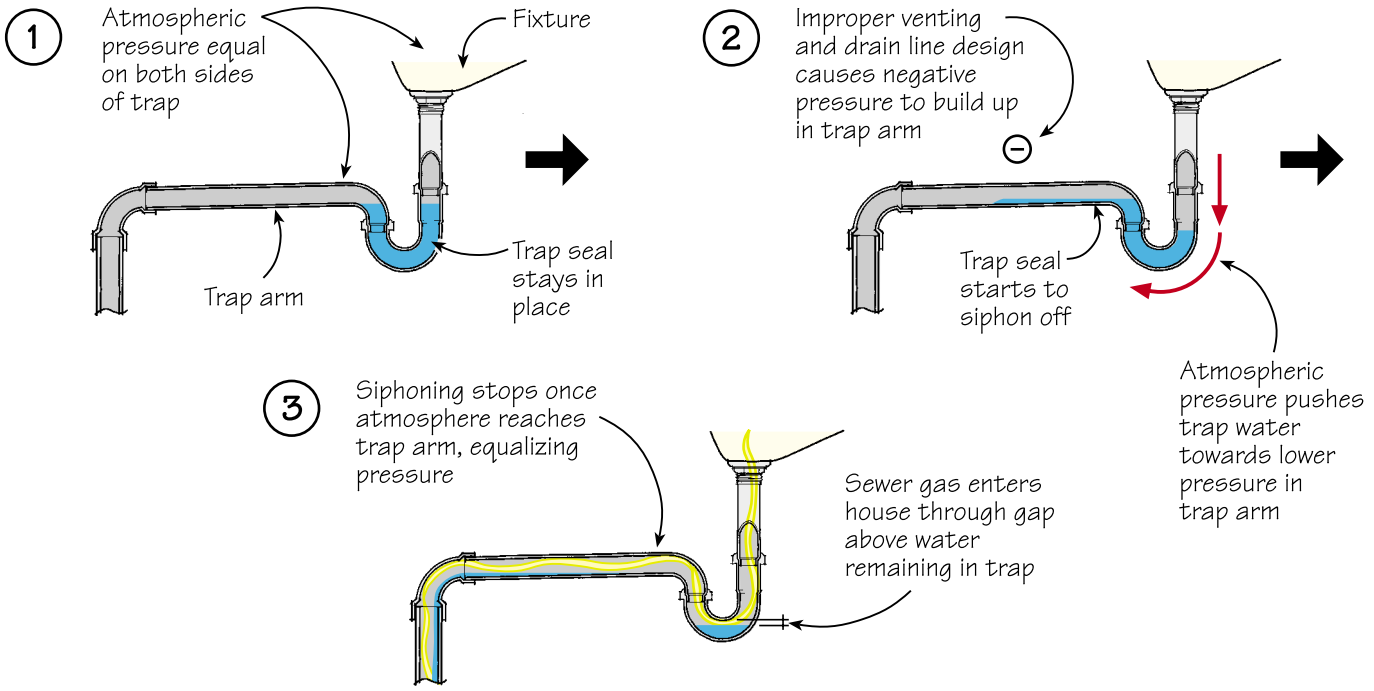
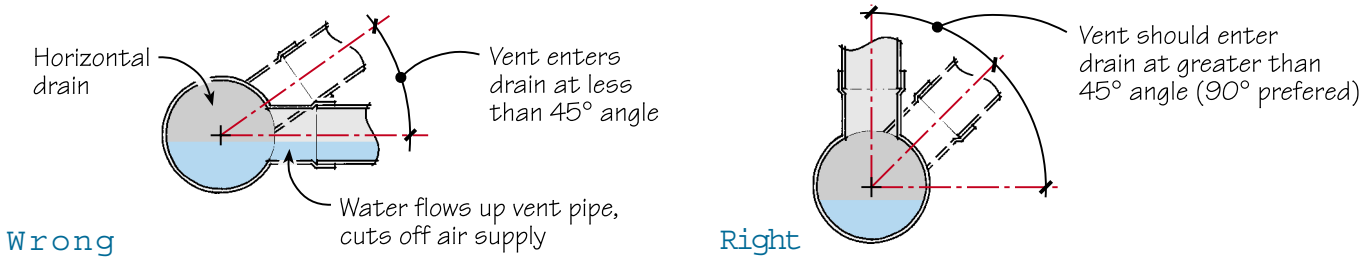


Figure B. A slug of water travelling in a drain line creates negative pressure behind it, pulling nearby traps dry. Proper venting provides the air needed for the drain to flow freely without creating pressure differences.

Orientation of Waste and Vent Connections

Dry Vent



Wet Vent

Figure C. Dry vent and wet vent connections to main drain lines are made differently. A dry vent must connect at an angle of 45 degrees or above, measured from a line cut horizontally midway through the pipe. A wet vent, because it carries water and air, must connect at an angle less than 45 degrees to this line.

drain pipe it serves. However, I typically increase the code-required pipe size by at least one diameter for traps, drain lines, and vent lines. (I never use 1¼-inch pipe for anything, except patching into an existing line.) Oversizing a DWV pipe can never get you into trouble — it costs only a little more, and it ensures trouble-free operation (unclogged drain pipes and plenty of air to the system). The pipe sizes shown in the illustrations in this article are my recommendations, and in most cases are one size larger than code requires. (The tables are taken from the codes, and are minimum requirements.)

Wet vs. dry venting. There are two basic ways to supply air to a drain line — through a dry vent or through a wet vent. A dry vent supplies only air to the drain line, while a wet vent functions as both a drain line and a vent.

Probably the most foolproof venting strategy would be to provide a separate dry vent to every fixture, just behind or above the trap. This practically guarantees that the trap seals will never be broken by air pressure problems. But it also means you have a lot of vent pipes travelling up into the walls and attic, and often several pipes penetrating the roof. Fortunately (from the standpoint of design flexibility), the code — or the IPC at least — has recognized that wet venting strategies will also work, and permits several options that use this technique. You will still need to use individual fixture vents in many cases, but usually you'll wind up with some combination of the various strategies. Here's a rundown of the different methods.

Individual Vents

This is the standard and the safest way to vent — provide a separate dry vent for each fixture trap. Historically, the earliest attempt was the horizontal crown vent, which was available for both S- and P-traps (Figure 2). However, because it was located beneath the sink rim, it had the problem of filling up with scum, debris, and rust, and would eventually fail. This brought about the first unbreakable rule for dry venting: You can't run a dry vent horizontally until

2. Why Crown Vents Fail

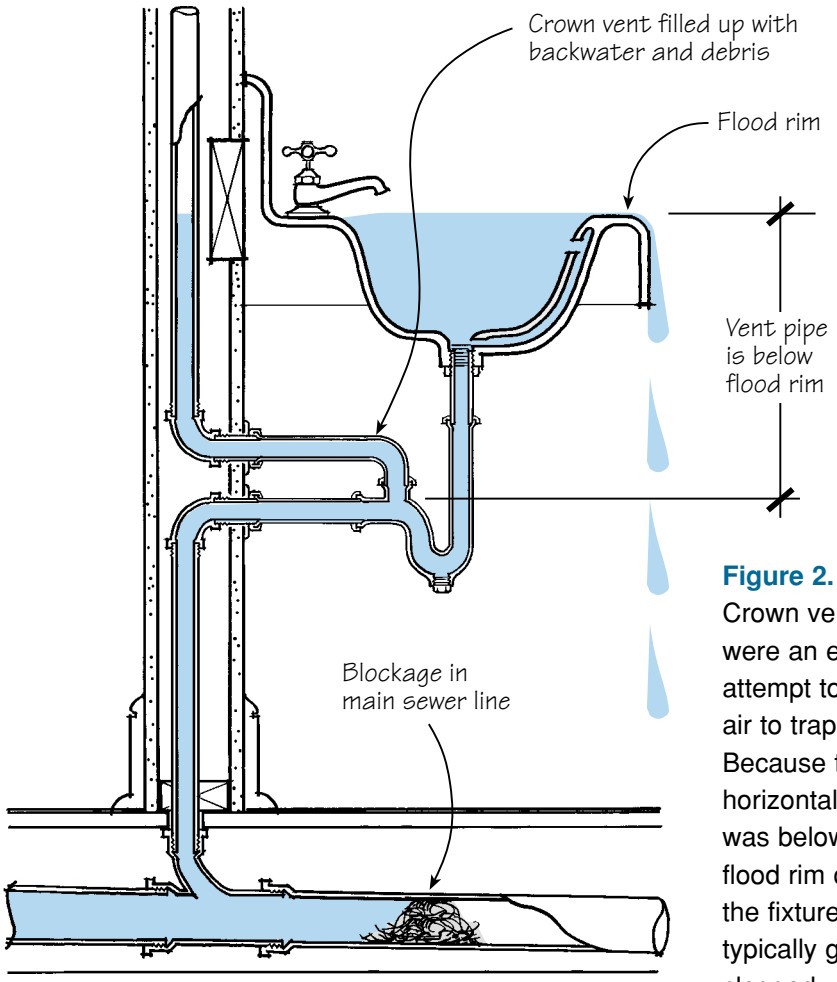


Figure 2. Crown vents were an early attempt to get air to traps. Because the horizontal leg was below the flood rim of the fixture, they typically got clogged with debris and rust.

Table A: Drainage Fixture Unit (dfu) Values for Various Plumbing Fixtures

Type of fixture or group of fixtures	Drainage fixture unit value
Automatic clothes washer standpipe	2
Bathroom group	6
Bathtub	2
Bidet	2
Dishwasher	2
Floor drains	2
Kitchen sink	2
Laundry tray	2
Lavatory	1
Mop basin	2
Shower	2
Water closet, private	4

3. Basic Back Vent

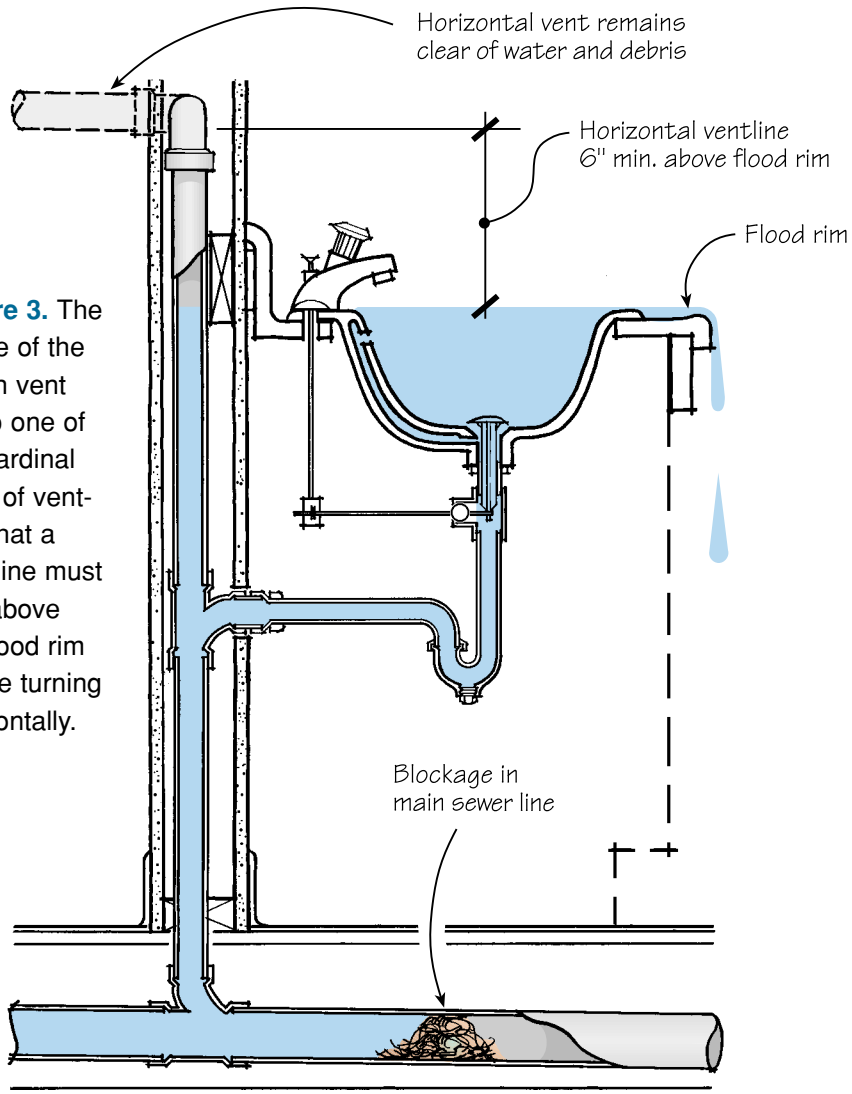


Figure 3. The failure of the crown vent led to one of the cardinal rules of venting: that a vent line must rise above the flood rim before turning horizontally.

the vertical feed is at least 6 inches above the flood rim of the fixture (Figure 3).

The next improvement was the back vent, where you take the drain water back via a single line and tee into a vertical pipe — down for the drain water and up for the vent. But this, too, presented a couple of problems. First, if you went into the vertical pipe immediately behind the trap, you basically had an S-trap again, and the draining water would pull the trap dry. Second, if the trap arm was too long, the tee might wind up below the level of the trap weir; eventually, negative pressure in the drain line would start a siphon, which would drain the trap.

These problems led to the next two rules of dry venting: You have to go horizontally for at least two pipe diameters before you tee into the vertical pipe, and you must limit the length of the trap arm (see Table B). This is why plumbers use a sanitary tee instead of a tee-wye combination, since the long sweep of the wye might place the pipe below the trap weir.

Horizontal vent runs. It's okay to run a back-vent horizontally as long as you follow the 6-inch rule, and as long as the run is sloped to allow any condensation that forms within the pipe to run back to the drain. No downward or upward U bends are allowed — keep it straight. The fittings should be installed to provide smooth, unrestricted air flow: This is why a sanitary tee in a vent connection is installed upside down.

Guidelines for Individual Vents

An individual vent must:

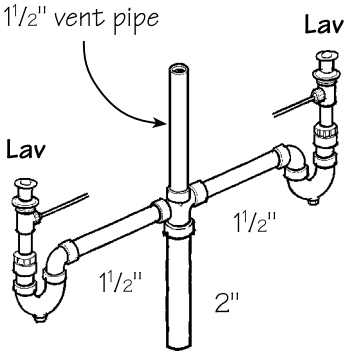
- be at least half the diameter of the drain served
- be a minimum 1 1/4 inches in diameter
- slope like a drain pipe
- rise at least 6 inches vertically above the flood rim before turning horizontal or connecting to vertical vent pipe
- Be increased by one size if its length exceeds 40 feet

Table B: Maximum Distance of Fixture Trap From Vent (Code Minimum)

Size of trap (inches)	Size of fixture drain (inches)	Slope (inch per foot)	Distance from trap (feet)
1 1/4	1 1/4	1/4	3 1/2
1 1/4	1 1/2	1/4	5
1 1/2	1 1/2	1/4	5
1 1/2	2	1/4	8
2	2	1/4	6
3	3	1/8	10
4	4	1/8	12

4. Common Vent Configurations
(Author's Recommended Sizing)

Back-to-Back Lavs



Lav Above, Bathtub Below

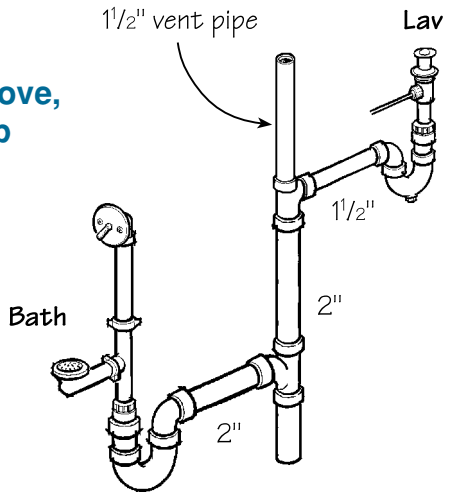


Figure 4. A common vent can handle two fixtures on the same floor level.

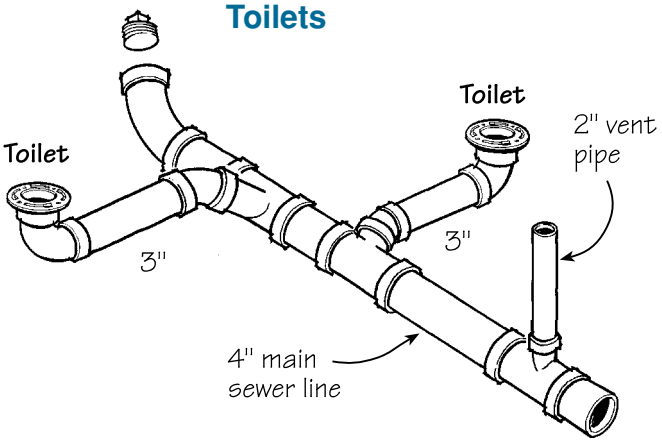
Common Vent Guidelines

- An individual vent can vent two fixtures (three lavs allowed) located on the same floor
- The vent pipe can come off at the interconnection of two fixtures or downstream
- Drains can connect at same level or at different levels
- See Table C for sizing

Table C: Common Vent Sizes for Fixtures at Different Levels
(Code Minimum)

Pipe size (inches)	Maximum discharge from upper fixture drain (dfu)
1½	1
2	4
3	6

Back-to-Back Toilets



Common Vents

Under the IPC, two fixtures can share the same individual vent as long as they are on the same floor. (An exception allows *three lavs* to share a common vent.) This "common" vent can be either dry or a combination of dry and wet (Figure 4).

The common vent connection can be made either at the same level, as when you have two bathroom lavs back to back on a wall, or at different levels, as you might have if a lav and shower shared the same vent. In the latter case, the vertical section of pipe that vents the shower is sized so that it can handle the waste for the upper fixture (the lav) as well as provide air to the lower fixture (see Table C). This means that the lower fixture is being wet-vented, even though the code refers to this as a common vent.

I normally use 1½-inch pipe for the dry part of the vent. It doesn't need to be large since it carries only air. To stay out of trouble, I use 2-inch pipe for the wet part, even though this is often larger than required (a 2-inch will even take two clothes washers back to back). But I like to stay on the safe side, since I'm the one who gets called in to unclog waste lines.

Keep in mind that you can't have a toilet as the upstream fixture, because the massive amount of water coming down the pipe might cut off the lower fixture's air and pull the trap dry. In this case you would have to run an individual vent for the bottom fixture. However, under the IPC, you are allowed to connect two back-to-back toilets to a horizontal drain line that also serves as a

5. Waste Stack Vent
(Author's Recommended Sizing)

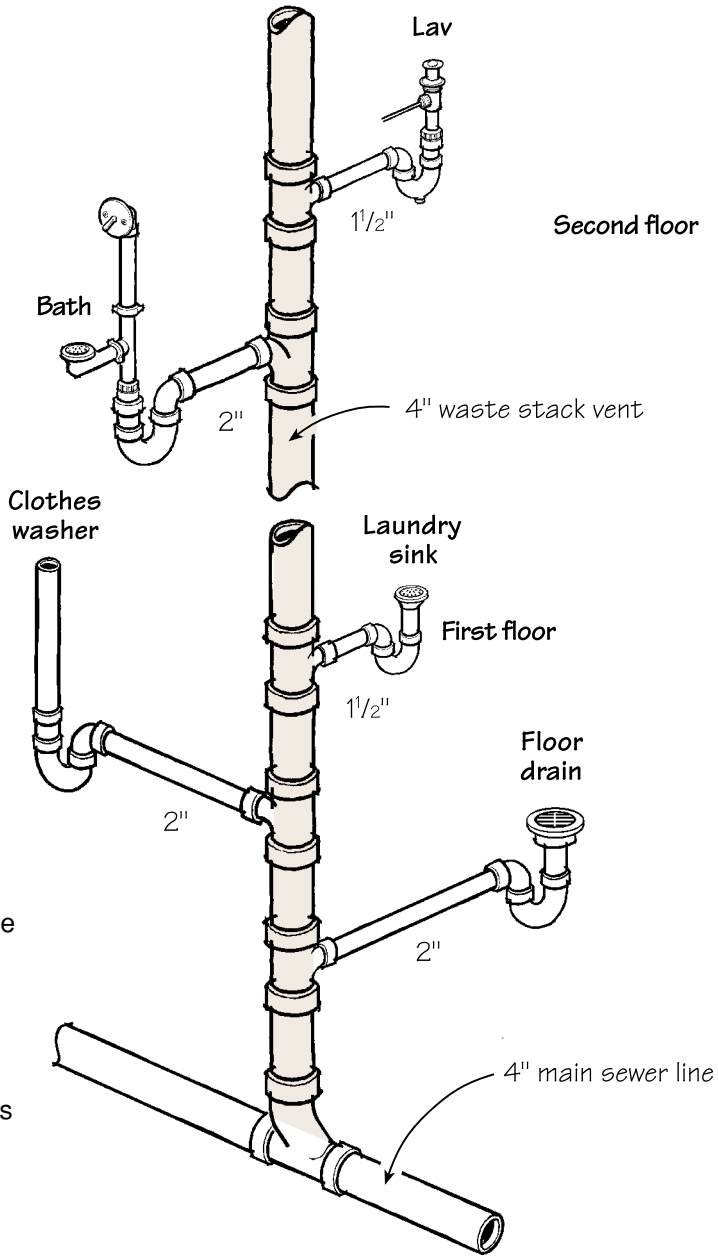


Figure 5. A waste stack vent can handle all fixtures except toilets and urinals, as long as each fixture connects individually.

common vent. Immediately downstream from the junction, one vertical dry vent can provide air for both toilets.

When putting two sinks back to back, be sure to use a special double side-outlet sanitary tee designed for such an installation. And remember that a double sink connected to a single trap is treated as one fixture, not two. (By the way, you aren't allowed to put commercial-style pump-assisted lavs — "blowout" fixtures — in a back-to-back configuration.)

Waste Stack Vent

In the old days we used to bring one large cast-iron drain line horizontally into the house right under the bath, make a bend, and then run straight to the roof for the vent. This was called the "soil stack." The only other vent in the system was the kitchen, because it was typically on the other side of the house. The entire bath group could discharge individually into the one large pipe as long as we kept the trap arms at the prescribed lengths. The heaviest discharge (the toilet) was at the bottom, the next heaviest (the tub) above that, with the lav at the top. The clothes washer might be in the basement dumping into a floor drain or out on the back 40 acres. The system worked great, but those were the good old days and they don't want us to do it anymore.

These days, a waste stack is not a soil stack — it's a graywater stack (Figure 5). You can still use a stack system, but you can't put a toilet in it. While individual fixtures can still drain separately into the stack, no horizontal drain containing a number of fixtures can. Like the toilet, this would place too much water at one

Waste Stack Vent Rules

- A vertical waste stack can handle the discharge of all fixtures except toilets & urinals
- The fixtures must connect individually to the waste stack
- No horizontal offsets are allowed
- The vent for a waste stack, which continues as an extension at the top, must be the same size as the waste stack
- See Table D for sizing

Table D: Waste Stack Vent Size
(Code Minimum)

Stack size (inches)	Maximum number of fixture units (dfu)	
	Total discharge from one floor	Total discharge for stack
1 1/2	1	2
2	2	4
3	No limit	24
4	No limit	50

6. Wet Vent Configurations
(Author's Recommended Sizing)

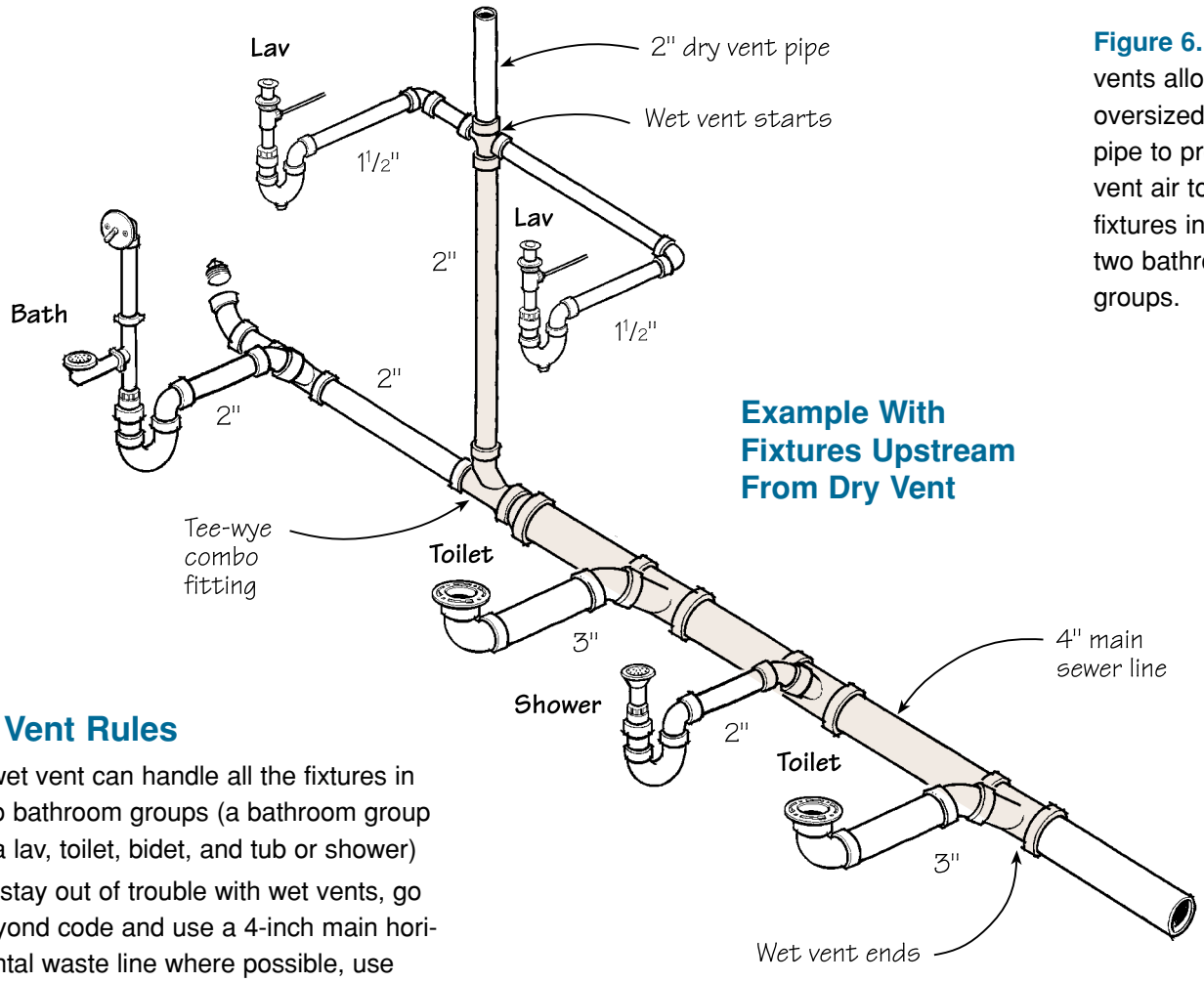


Figure 6. Wet vents allow an oversized drain pipe to provide vent air to all the fixtures in up to two bathroom groups.

Wet Vent Rules

- A wet vent can handle all the fixtures in two bathroom groups (a bathroom group is a lav, toilet, bidet, and tub or shower)
- To stay out of trouble with wet vents, go beyond code and use a 4-inch main horizontal waste line where possible, use minimum 2-inch pipe to individual fixtures, and use a minimum 2-inch dry vent
- See Table E for sizing

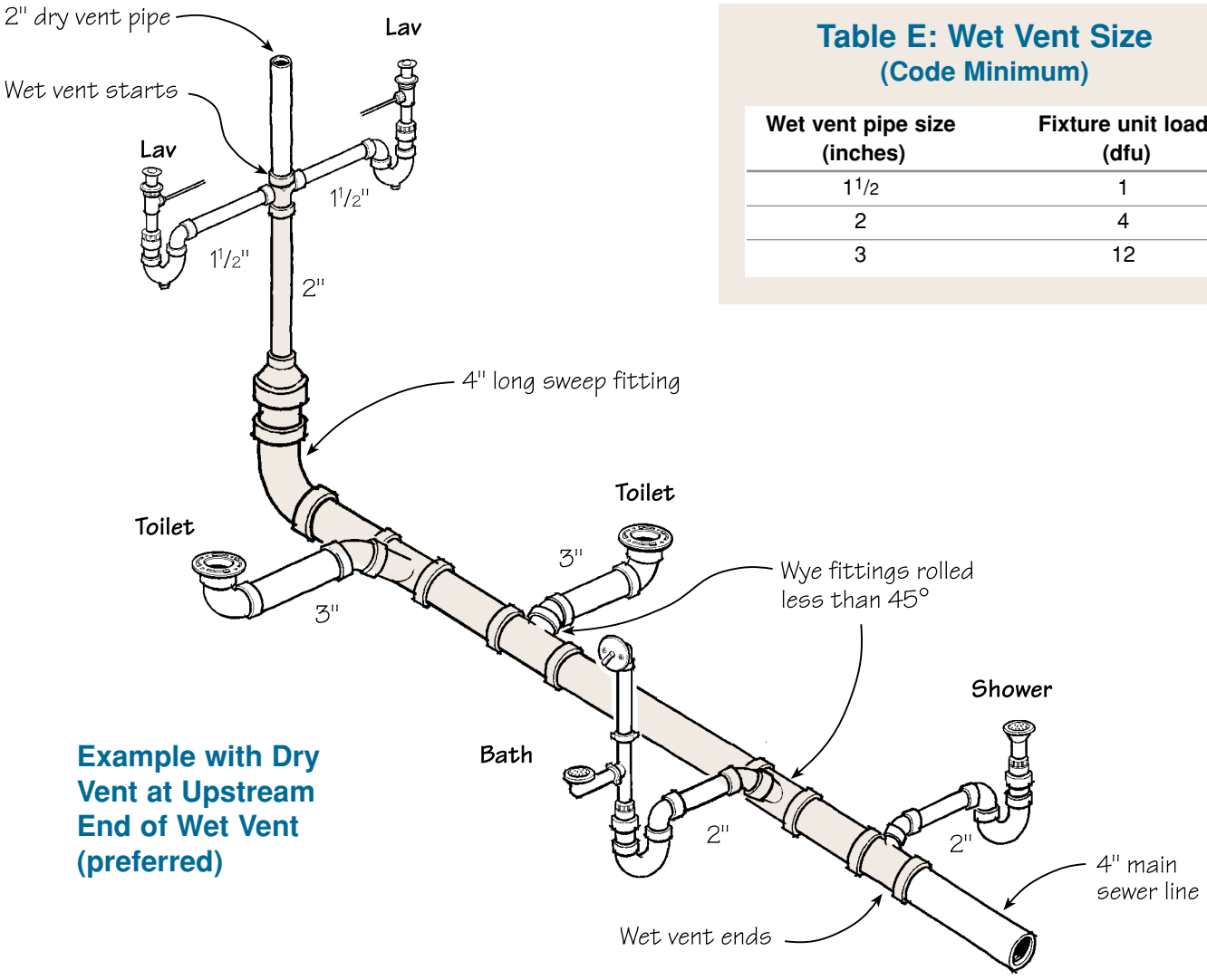
spot in the pipe, cutting off the vent air.

The alternative, if you want to use a stack, is to discharge whatever you want into the stack anywhere you want but vent every fixture individually — which is what many two-story houses come down to anyway.

Wet Vents

With a wet vent, one pipe does it all, at least for bathroom groups. A wet vent pulls vent air for a fixture through a pipe that also has wastewater going through it. You'll note that several of the other types of venting described here also use a wet vent approach. In this section of the article, we're discussing only what the code refers to as a wet vent.

You can wet vent a single branch of a bath group or the entire drainage system for up to two bath groups located on the same floor (Figure 6). Vent air enters the system through one or more dry vents. Both horizontal and vertical pipes (limited to one-story height) can be wet vented, though some codes (Uniform Plumbing Code, for example) do not allow horizontal wet venting.



Example with Dry Vent at Upstream End of Wet Vent (preferred)

Table E: Wet Vent Size
(Code Minimum)

Wet vent pipe size (inches)	Fixture unit load (dfu)
1 1/2	1
2	4
3	12

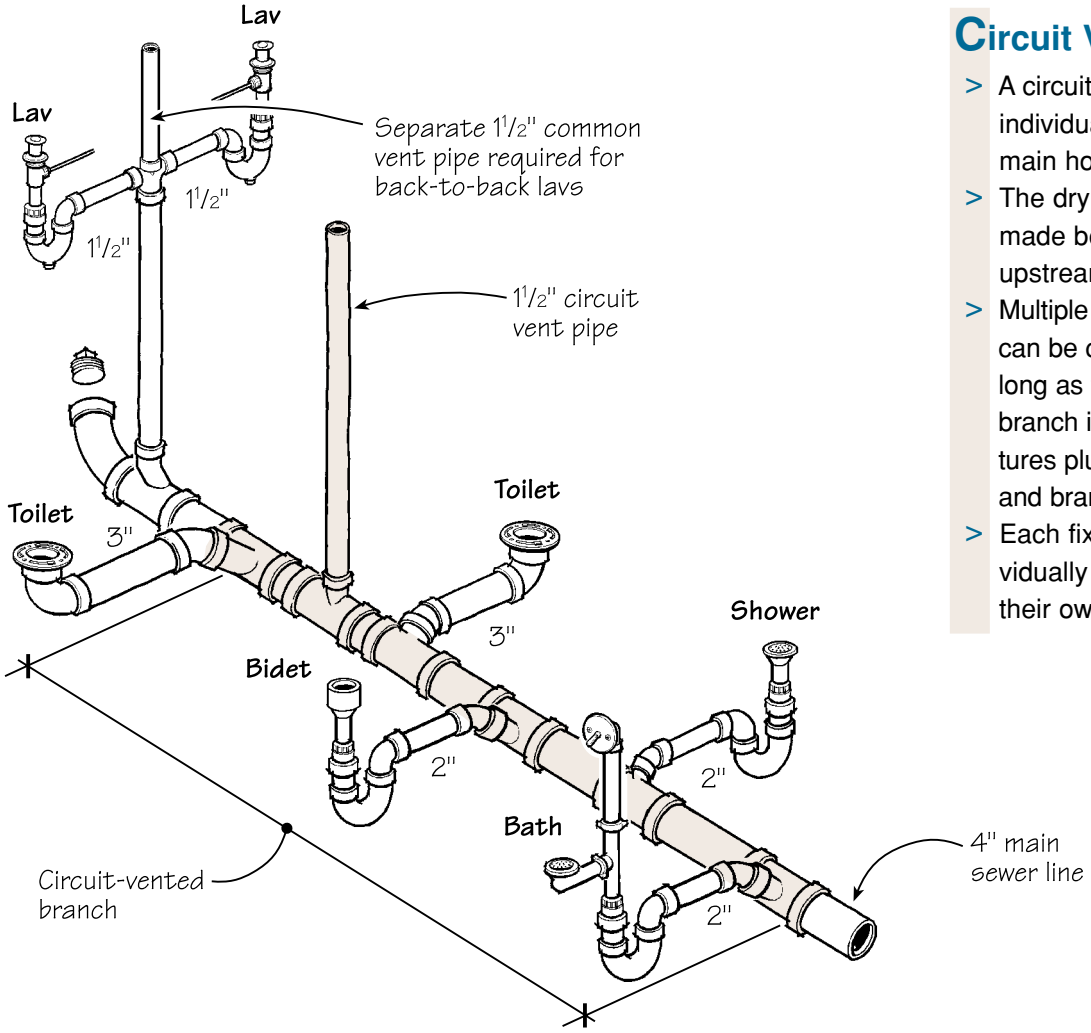
The cardinal rule is that all wet vent pipes must be increased in diameter by at least one size beyond what would normally be required for drainage alone. (This oversizing is common to all the venting methods that include a wet vent.) The larger pipe allows room for air movement over the water in the pipe (see Table E).

The dry vent should be at the upper end of the branch if possible — normally an extension of the lav pipe that continues through the roof. The diameter of the dry vent in some cases can be as little as 1 1/2 inches (if the main drain is 3 inches), but I always use a 2- or 3-inch pipe depending on the wall width, because I always try to use 4-inch pipe for the main horizontal drain. Fixtures other than the bath group fixtures can discharge into the oversized pipe, but they must have their own vent.

Circuit Vents

Similar to wet venting, circuit venting allows you to discharge up to eight fixtures into a drain line that has a single vent (Figure 7). The basic rules are

7. Circuit Vent Configurations
(Author's Recommended Sizing)



Example With Separately Vented Fixtures Above Circuit Vent

Circuit Vent Rules

- A circuit vent can handle up to 8 individual fixtures draining into a main horizontal waste line
- The dry vent connection must be made between the two most upstream fixtures in the group
- Multiple circuit-vented branches can be connected together, as long as the most downstream branch is sized to handle its fixtures plus all upstream fixtures and branches
- Each fixture must connect individually (back-to-back lavs need their own individual dry vent)

that the vent pipe must be installed between the two most upstream fixtures, and all the fixture trap arms must be within the code length limits. If an individual fixture is too far away it can still discharge into the pipe, but it must be individually vented. The vent pipe must be at least half the size of the drain line. The upstream fixture reference refers to fixtures that are frequently used under normal conditions — a floor drain would not be counted.

If you have more than eight fixtures, you can group the upper eight and individually vent the lower fixtures. If the uppermost fixture is beyond the trap arm limit, run an individual vent for that fixture and move the circuit vent system down to the next eight. Like a wet vent, for the system to work the drains must be large enough for air to circulate above the wastewater.

To stay out of trouble using a circuit vent system, use 4-inch pipe as the main drain even if 3-inch is allowed. And use 2-inch pipe to individual fixtures even if 1½-inch is allowed. This would typically mean your dry vent to the roof will be 2 to 3 inches.

Combination Drain and Vent

Yet another variation of wet venting, this is an oversized horizontal drain system that can serve sinks, lavs, washing machine standpipes, and floor drains (Figure 8). The only vertical pipes allowed are the drain lines from individual fixtures, and they must be limited to 8 feet total rise. This system allows only graywater — no toilets. As such, a combination drain and vent is typically a horizontal branch off the main drain line. Air is provided from a nearby dry vent or by connection to another horizontal drain that has a dry vent. Remember that in systems where one wet vented line connects to another, the vent pipe that serves the system must be sized for the total fixture load (see Table F).

To stay out of trouble with a combina-

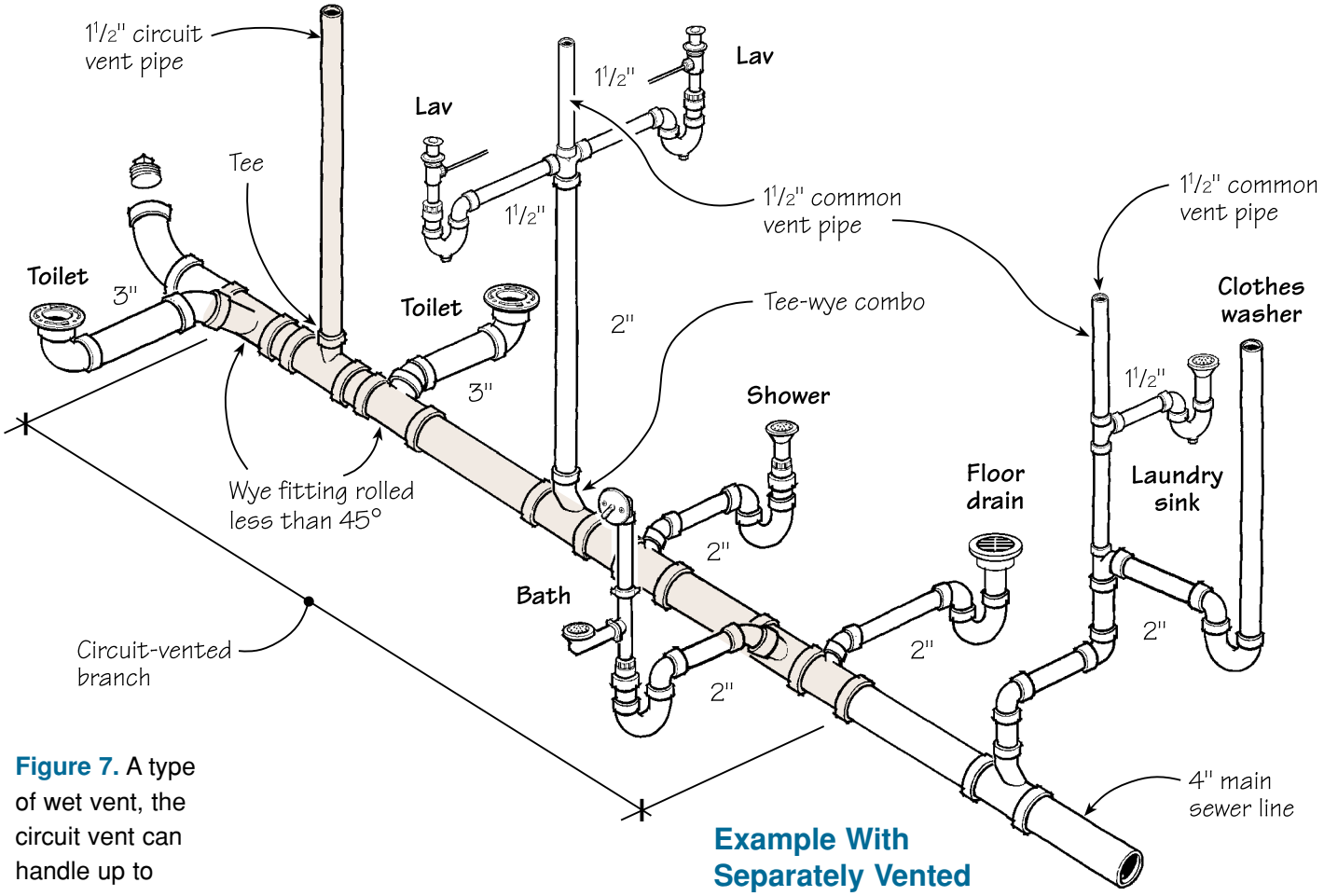


Figure 7. A type of wet vent, the circuit vent can handle up to eight fixtures.

Example With Separately Vented Fixtures Within and Below Circuit Vent

tion system, always use 4-inch pipe for the main horizontal line, decreasing to 3-inch only if you are picking up one or two small fixtures. The vertical pipe to the fixture (a sink or washing machine) should always be 2 to 3 inches — remember, it has to supply air up to the trap as well as allow for drainage. Since the main drain pipe is always oversized, the dry vent for the system may often be 2 or 3 inches.

Island Vents

Often, no matter what you try, there is just no way to get a vent in. For sinks in kitchen islands, I use one of three approaches.

The easiest solution is to install an automatic vent — a little unit about the size of a tin can that screws into the drain line several inches above the trap weir. These devices sense any negative pressure and allow air to come into the lines when needed. For some reason, most inspectors hate them. I have no idea why — they work very well. They do have their limits, however: You can't use one instead of a dry vent required to relieve both positive *and* negative pressure. The automatic vent senses only negative pressure.

Another solution that your inspector may allow is to increase the pipe size that the trap dumps into by one or two sizes and run a dry vent to the drain line as close by as possible (Figure 9). This essentially treats the island drain like a combination drain and vent. It's a good idea to oversize a kitchen sink drain anyway, because a standard 1½- inch drain frequently clogs up (this is my most common kitchen service call).

A third method, and one described in some codes, is to install a giant horseshoe piping system under the kitchen sink cabinet, where the vent line rises vertically to the bottom of the sink counter before turning horizontally then vertically back down to the drain line below. This creates a loop in the pipe that provides enough air to relieve

8. Combination Drain & Vent
(Author's Recommended Sizing)

Combination Drain & Vent Rules

- A combination drain and vent can serve floor drains, clothes washer standpipes, sinks and lavs
- A kitchen sink on a combination drain & vent cannot have a garbage disposal
- Toilets are not allowed on a combination drain and vent
- Minimum size is 2 inches
- See Table F for sizing
- Trap-to-vent maximum distances do not apply as long as Table F is followed

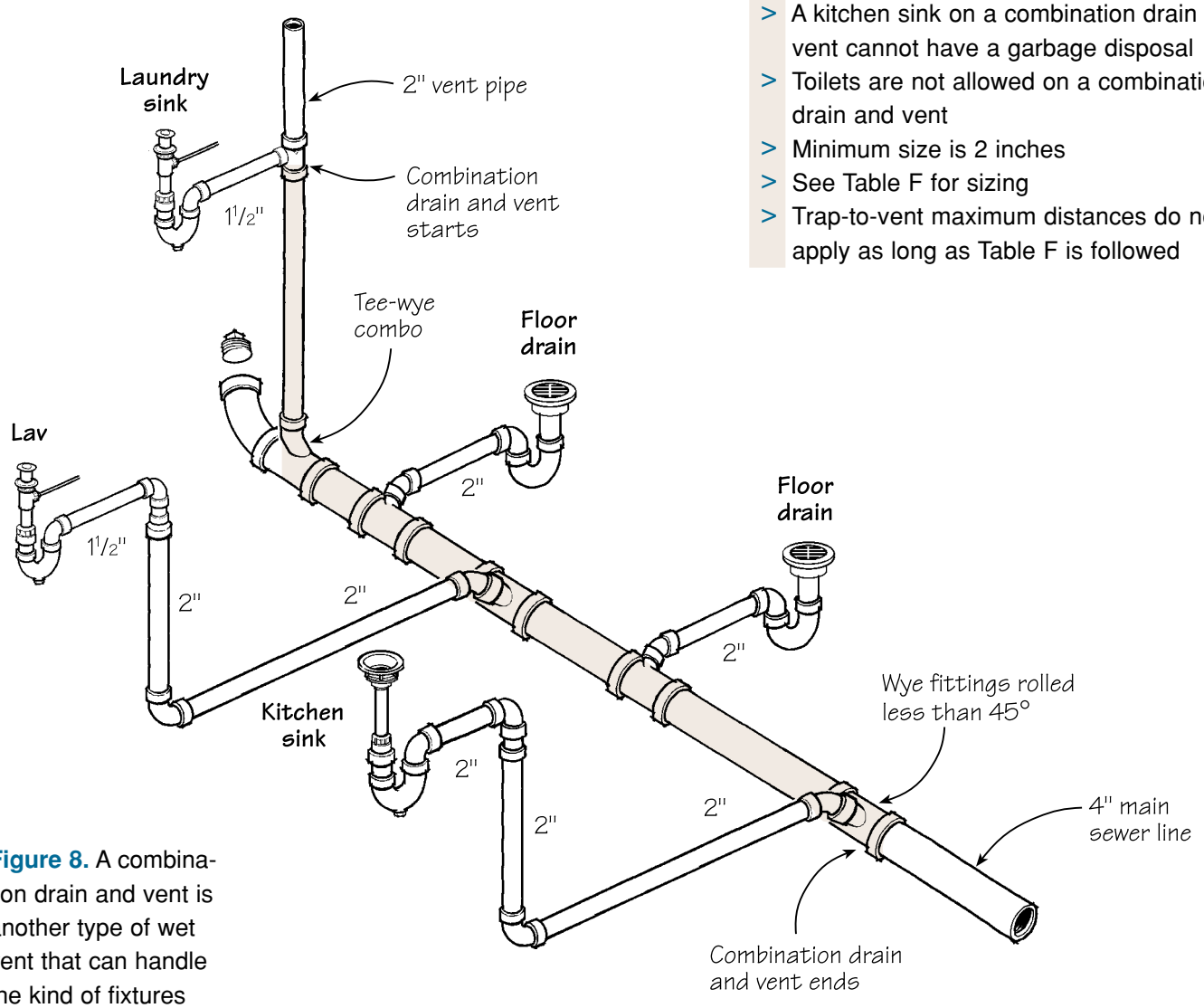
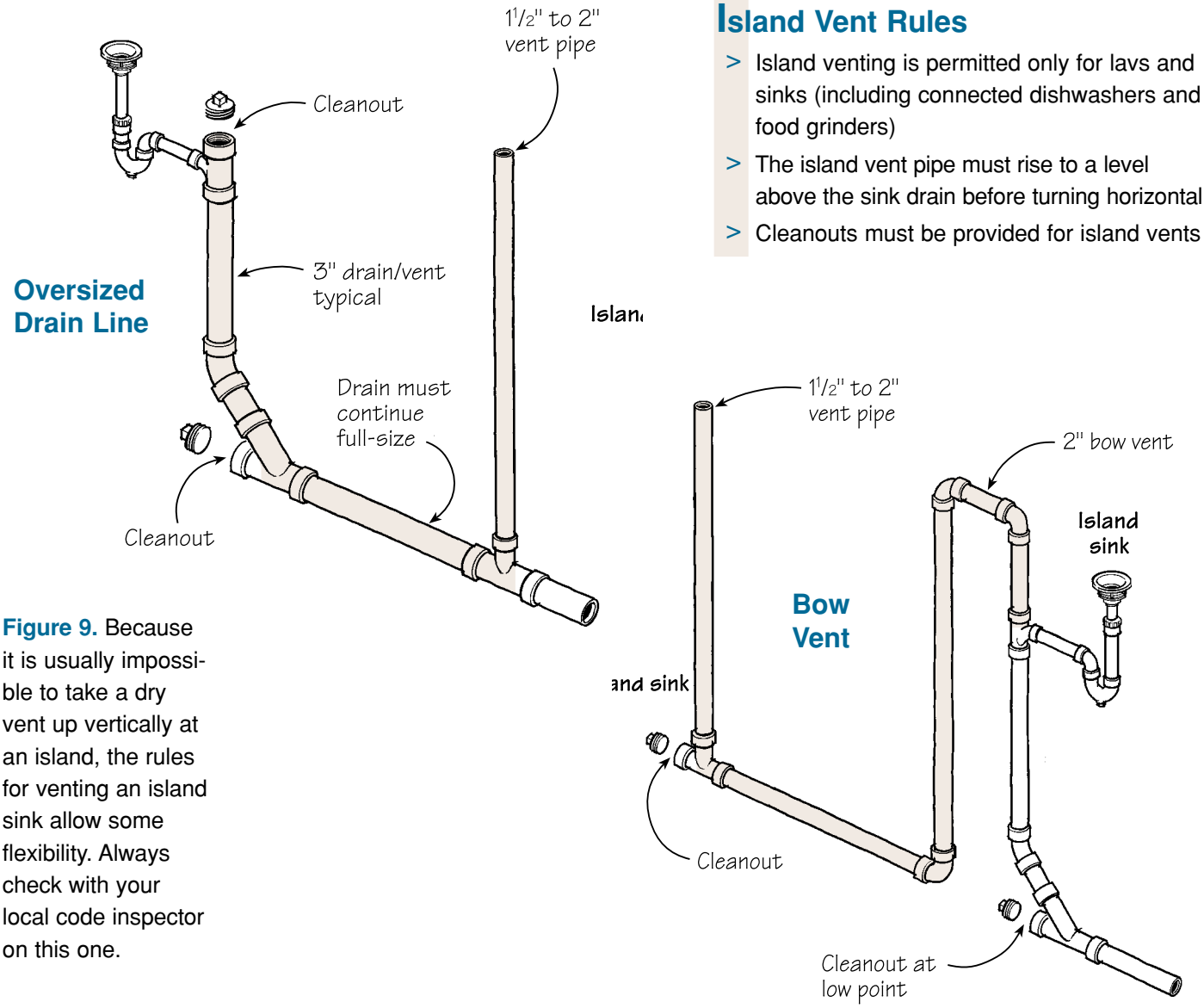


Figure 8. A combination drain and vent is another type of wet vent that can handle the kind of fixtures found in a laundry room: sink, lav, clothes washer standpipe, and floor drain.

Table F: Size of Combination Drain and Vent Pipe

Diameter pipe (inches)	Maximum number of fixture units (dfu)	
	Connecting to a horizontal branch or stack	Connecting to a building drain or building subdrain
2	3	4
3	12	31
4	20	50

9. Kitchen Island Venting
(Author's Recommended Sizing)



Island Vent Rules

- Island venting is permitted only for lavs and sinks (including connected dishwashers and food grinders)
- The island vent pipe must rise to a level above the sink drain before turning horizontal
- Cleanouts must be provided for island vents

Figure 9. Because it is usually impossible to take a dry vent up vertically at an island, the rules for venting an island sink allow some flexibility. Always check with your local code inspector on this one.

any pressure differences.

Most inspectors have a favorite way to deal with island vents, so the safest approach is to contact your inspector first. (For more on island vents, see "Venting Island Sinks," 2/97, and "The Down & Dirty on DWV," 11/91).

Vent Termination

The distance the vent extends above the roof varies by locale, depending on local snowfall. The minimum is 6 inches, while 1 to 3 feet is the norm. I often cut the pipe end at the same pitch of the roof to make it look nicer and sometimes paint the pipe the same color as the roof. You also have to keep the pipe end 10 feet away from any windows or skylights or anything else the vent gas might affect. In cold regions, where the vent is prone to frost up, the termination must be at least 3 inches in diameter.

Some codes permit the vent to exit the side of the house as opposed to the roof. This is sometimes done to keep the cost down during a renovation. If this is done, use a fitting at the end of the pipe to point it downward. Another good idea is to increase the size of the fitting by one size and put a screen over it to keep the birds out. A problem with going through the wall as opposed to the roof is that the gas will have less chance to disperse and any window under the pipe, even if it is 10 feet away, will probably pick up the odor.

Rex Cauldwell is a master plumber in Copper Hill, Va.