Vent Systems

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Flow of air is the primary consideration in the design of a venting system for the ventilation of the piping and protection of the fixture trap seals of a sanitary drainage system. Since air is of such primary importance, it is essential that the plumbing engineer be familiar with certain physical characteristics that are pertinent to its behavior in a plumbing system.

Density of any substance is its mass per unit volume. The density of air is its weight in pounds per cubic foot of volume. The density of air is affected by temperature, moisture content, and pressure. The density of "standard air" is taken at atmospheric pressure and 68.4°F. It is equal to 0.075 lbm/ft3. With a rise in temperature, the density of air decreases and with a lowering of temperature its density increases. The moisture content of air in the plumbing system has a negligible effect on its density and can be disregarded in all calculations. Pressure has an appreciable effect; the higher the pressure the greater the density, and the lower the pressure the less the density.

Specific Weight of a fluid is not an absolute property, but depends upon the local gravitational field (gravitational acceleration on earth is g=32.2 ft/sec2) and the properties of the fluid itself. Commonly called "density" when concerning gravitational force, the numerical value of specific weight (lbf/ft3) is equal to density (lbm/ft3).

Elasticity is the ability of a substance to assume its original characteristics after the removal of a force that has been applied. Air is a perfectly elastic substance. From the scientific definition of elasticity it becomes clear that a rubber band is really a very inelastic material. If a weight is suspended from a rubber band and left for a few hours, then the weight is removed, the rubber band will spring back, but definitely not to its original length. If a force is applied to air, the force can be applied for days or years, and when it is removed, the air will return exactly to its original condition.

Air is compressible. There is an increase in pressure when air is compressed. In the plumbing system, only an extremely small change in pressure can be tolerated. For a pressure of 1 in. of water column (0.036 psi), the volume of air will be compressed by 1⁄400 of its original volume. Assuming an original volume of 400 ft3 of air at atmospheric pressure and the application of a pressure of 1 in. of water column, the air will be compressed by 400 × 1⁄400 = 1 ft3. It is obvious that a comparatively small change in volume can very easily cause the accepted design limitation of ±1 in. of pressure to be exceeded with the consequent danger of destroying the trap seals. The vent piping must be designed to permit the air to flow freely without compression or expansion except for the small amount necessary to overcome friction.

STATIC HEAD

Static head is the pressure exerted at any point by the weight of the substance above that point. The pressure can be stated in feet of the substance, i.e., when the substance is water the static head is 100 ft of water, or if the substance is air, 100 ft of air. To convert from feet of head to pounds-force per square inch:

$$p = \gamma h/144 \quad \text{and} \quad h = 144p/\gamma \tag{8-1}$$

where p = Pressure, lbf./in^2
γ = Specific weight of substance, lbf/ft^3
h = Static head, ft

PNEUMATIC EFFECTS IN SANITARY SYSTEMS

As water flows in contact with air in vertical or horizontal piping, there is friction between the air and water. The frictional effect causes the air to be dragged along with the water and at practically the same velocity as the water. When the cross-sectional area of the water occupying the pipe is suddenly increased, such as at the hydraulic jump or where a branch discharges into the stack, the air passage is constricted. This constriction acts exactly the same as a stoppage or a blockage to the flow of air. This causes a buildup of pressure, the highest pressure occurring at the constriction and diminishing upstream. It is for this reason that excessive pressure usually develops at the lower floors of a building and at offsets of the stack. It is important to always be aware that protection from the entry of sewer gases is afforded by the 2-in. trap seal, and the design of plumbing systems must be such as to maintain pressure variations within ±1 in. column of water.

RATE OF FLOW FROM OUTLETS

The velocity at which air flows out of an outlet to the atmosphere (at the roof terminal of a stack) is due to the total pressure available in the vent pipe at the outlet. This pressure is the *flow pressure,* which is equal to the static pressure less the pressure lost in friction. The maximum rate of discharge in practice is expressed as:

$$q_D = c_D \, q_1 \tag{8-2}$$

where q_D = Actual quantity of discharge, gpm
q_1 = Ideal quantity of discharge, gpm
c_D = Coefficient of discharge

Utilizing the formula q = AV and substituting,

$$q_D = c_D \, (2.448 \, d_O{}^2 \, V_1) \tag{8-3}$$

where d_O = Outlet diameter, in.
V_1 = Ideal velocity, fps

Velocity is equal to $\sqrt{2gh}$, where g = acceleration due to gravity and h = height (or head) of air column.

$$q_D = c_D \, (2.448 \, d_O{}^2 \, \sqrt{2gh}) \tag{8-4}$$

$$= c_D \, (19.65 \, d_O{}^2 \, \sqrt{h}) \tag{8-5}$$

Using 0.67 as an acceptable coefficient of discharge, per Equation 6-1,

$$q_D = 13.17 \, d_O{}^2 \, h^{1/2}$$

STATIC PRESSURE OF AIR

The design criterion of maintaining pneumatic pressure fluctuations within ± l in. of water column is constantly stressed throughout this book. It should prove interesting to state this pressure in terms of an equivalent column of air. The formula for any substance is, per Equation 8-1:

$$P = \gamma h/144$$

then

$$P = \gamma_W h_W/144 = \gamma_A h_A/144 \tag{8-6}$$

where γ_W = Specific weight of water, lbf/ft^3
h_W = Static head of water, ft
γ_A = Specific weight of air, lbf/ft^3
h_A = Static head of air, ft

Transposing and using 1 in. of water column,

$$h_A = \frac{\gamma_W h_W}{\gamma_A} = \frac{(62.408)(1/12)}{0.07512 \text{ (at 70° F.)}}$$

$$h_A = 69.23 \text{ ft of air column}$$

A column of air 69.23 ft will exert the same pressure as a column of water 1 in. high. Stated another way, a static head of 1 in. of water will support a column of air 69.23 ft high.

The rate of discharge from a vent outlet can now be determined when the pressure at the outlet is 1 in. of water or 69.23 ft of air.

$$\begin{aligned} q_D &= 13.17\, d_O^2\, h^{1/2} \\ &= 13.17\, d_O^2\, (69.23)^{1/2} \\ &= (13.17)(8.32)\, d_O^2 \\ &= 109.57\, d_O^2 \end{aligned}$$

The gallons per minute (cubic feet per minute) discharge rate for various diameters of vent pipe at a flow pressure of 1 in. of water column is given in Table 8-1.

Table 8-1 Discharge Rates of Air (1 Inch Water Pressure)	
Outlet Diam, d_O inches	Air Discharge, q_D gpm (cfm)
2	438.3 (58.6)
2½	684.8 (91.5)
3	986.1 (131.8)
4	1753.0 (234.3)
5	2739.0 (366.1)

FRICTION HEAD LOSS

When air flows in a pipe there is a pressure loss which occurs due to the friction between the air and pipe wall. This loss of pressure can be expressed by the Darcy formula:

$$h = \frac{f L V^2}{D2g} \tag{8-7}$$

where h = friction head loss, ft. of air column
f = coefficient of friction
L = length of pipe, ft.
D = diameter of pipe, ft.
V = velocity of air, ft/sec
g = gravitational acceleration 32.2 ft./sec²

AIR FLOW IN STACKS

The complete venting of a sanitary drainage system is very complicated as evidenced by the variety of vents employed. There are so many variables that produce positive and negative pneumatic pressure fluctuations that it is not feasible to prepare tables of vent sizing for each particular design. Recognizing this, authorities base the formulation of venting tables for vent stacks and horizontal branches on the worst conditions that may reasonably be expected. To determine the maximum lengths and minimum diameters for vent stacks it would be valuable to review the conditions of flow in the drainage stack.

At maximum design flow, the water flows down the stack as a sheet of water occupying 7/24 of the cross-sectional area of the stack. The remaining 17/24 is occupied by a core of air. As the water falls down the stack, it exerts a frictional drag on the core of air and as this air is dragged down it must be replaced by an equivalent quantity of air so as not to develop negative pressures in excess of –1 in. of water. This is accomplished by extending the soil stack through the roof so that air may enter the stack to replenish the air being pulled down the stack. This is why stacks must be extended full size through the roof and also why soil stacks may not be reduced in size even though the load is less on the upper portions of the stack than it is at the lower portions. Any restriction in the size before terminating at the atmosphere would cause violent pressure fluctuations.

As the water flows down the stack and enters the horizontal drain there is a severe restriction to the flow of air as the hydraulic jump occurs. The air is compressed and pressure buildup may become very high. A vent stack is provided in this area of high pressure to relieve the pressure by providing an avenue for the flow of air. Obviously, the vent stack must be large enough to permit the maximum quantity of air dragged down the drainage stack to discharge through it and to the atmosphere without exceeding ±1 in. of water fluctuation The rate of air discharge that must be accommodated for various sizes of drainage stacks flowing at design capacity is tabulated in Table 8-2.

Table 8-2 Air Required by Attendant Vent Stacks (Drainage Stack Flowing 7/24 Full)		
Diameter of Drainage Stack, inches	Water Flow, gpm	Air Flow, gpm (cfm)
2	23.5	57.1 (7.6)
3	70	170.1 (22.7)
4	145	352.4 (47.1)
5	270	656.1 (87.7)
6	435	1057.1 (141.3)
8	920	2235.6 (298.9)
10	1650	4009.5 (536)
12	2650	6439.5 (860.8)

AIR FLOW IN HORIZONTAL DRAINS

It is assumed that the drainage branch flows half full at design conditions and the air in the upper half of the pipe is flowing at the same velocity and capacity. Table 8-3 tabulates these values for various slopes of drain.

Table 8-3 Rate of Air In Horizontal Drains		
Diameter of Drain, inches	Slope, inches per foot	Rate of Flow, gpm (cfm)
1 ½	¼	6.0 (.80)
2	¼	8.8 (1.2)
2½	¼	15.5 (2.1)
3	¼	25.5 (3.4)
4	⅛	38.0 (5.1)
5	⅛	69.0 (9.2)
6	⅛	112.0 (15)
8	⅛	240.0 (32.1)

PERMISSIBLE LENGTH OF VENT PIPE

The maximum length of vent piping, for any particular size with a pressure drop of 1 in. of water, is established by computing the pressure loss for various rates of flow in vents of various diameters. Combining Darcy's pipe friction formula (Equation 8-7) and the flow formula, and converting the terms of the equations to units generally used in plumbing:

$$h = \frac{f\,L\,V^2}{D2g}$$

(8-8)

$$q = 2.448\,d^2V$$

(8-9)

$$V = \frac{q}{2.448d^2}$$

Substituting V in the Darcy equation,

$$h = \frac{f\,Lq^2}{(d/12)(64.4)(2.448)^2(d)^4}$$

Solving for L,

(8-10)

$$L = \frac{h\,d^5}{0.013109\,f\,q^2} = \frac{2226\,d^5}{f\,q^2}$$

where L = Length of pipe, ft
d = Diameter of pipe, in.
f = Coefficient of friction
q = Quantity rate of flow, gpm

GRAVITY CIRCULATION

The principle of gravity circulation of air is utilized to keep the entire sanitary system free of foul odors and the growth of slime and fungi. The circulation is induced by the difference in head (pressure) between outdoor air and the air in the vent piping. This difference of head is due to the difference in temperature, and thus the difference in density, of each and the height of the air column in the vent piping. The cool air, being more dense, tends to displace the less dense air of the system and circulation of the air is induced. The formula is

$$H = 0.1925(\gamma_O - \gamma_1)\,H_S$$

where H = Natural draft pressure, in. of water
γ_O = Specific weight of outside air, lbf/ft³
γ_1 = Specific weight of air in pipe, lbf/ft³
H_S = Height of air column or stack, ft

Under conditions of natural draft, the rate of flow will be just great enough to overcome losses due to friction.

VENT STACKS

Every drainage stack should be extended full size through the roof. The pipe from the topmost drainage branch connection through the roof to atmosphere is called the "vent extension." The vent extension provides the air that is dragged down the stack and also provides means for the gravity circulation of air throughout the system. Vent extensions may be connected with the vent stack before extending through the roof or may be connected together with other vent extensions or vent stacks in a vent header and the header extended through the roof as a single pipe.

Every drainage stack should have an attendant vent stack. The purpose of installing a vent stack is to prevent the development of excessive pressures in the lower regions of the drainage stack by relieving the air as rapidly as it is carried down by the discharge of the drainage stack. The most effective location for the vent stack is below all drainage branch connections and preferably at the top of the horizontal drain immediately adjacent to the stack base fitting. It is at this location that pressure is at its maximum and the danger of closure due to fouling is at its minimum. Figure 8-1 illustrates acceptable methods of vent stack connections.

Figure 8-1   Various Vent Stack Connections
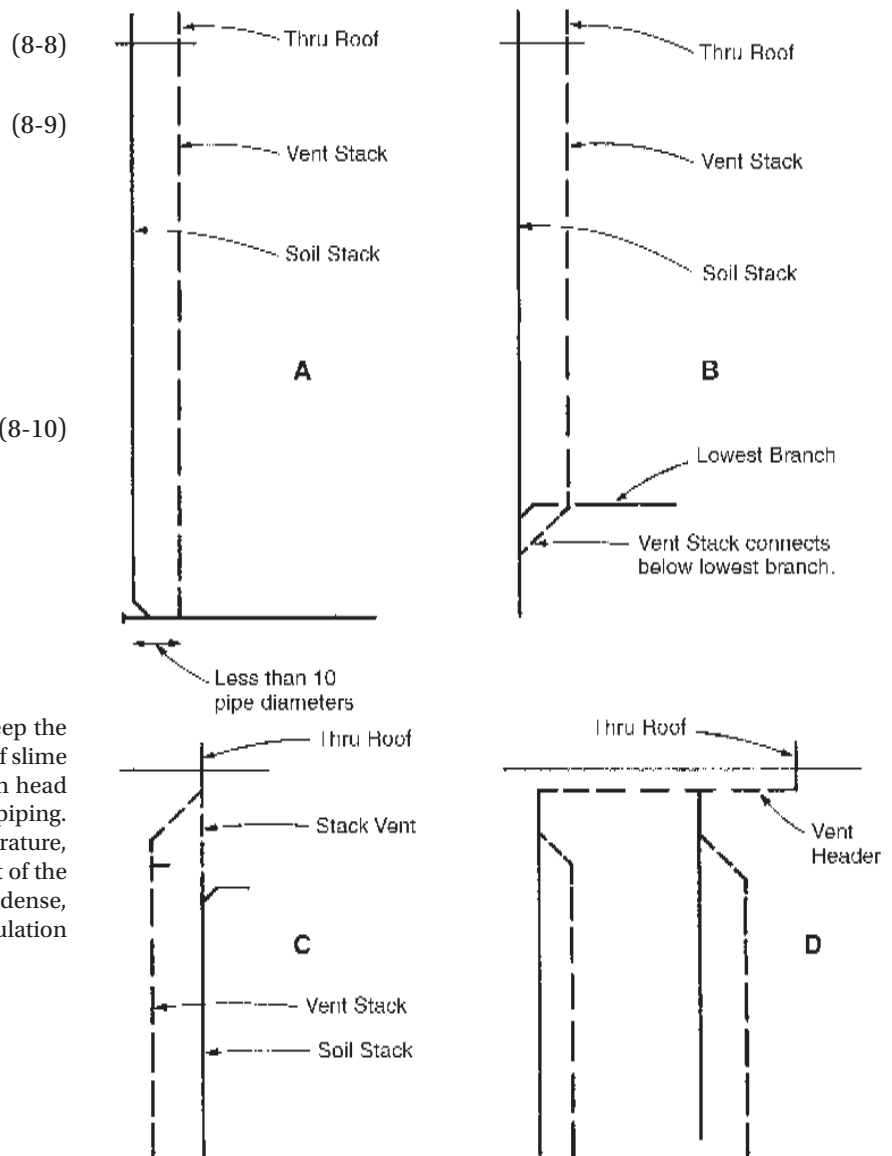
The vent stack should extend undiminished in size through the roof or connect with the vent extension of the drainage stack at least 6 in. above the overflow of the highest fixture or connect to a vent header.

VENT TERMINALS

Vent terminals should not be located within 10 ft of any door, window, or ventilation intake unless they are extended at least 2 ft above such openings. Terminals should be at least 6 in. above roof level and at least 5 ft above when the roof is used for other purposes. When it is impractical to extend the vent through the roof, it is permissible to terminate through a wall, but the terminal must turn down and be covered with a wire screen. The terminal should never be located beneath a building overhang.

FIXTURE TRAP VENTS

The water seal of all fixture traps should be protected against siphonage or blowout by the proper installation of a venting system. When drainage stacks are provided with an adequate supply of air at the terminal and an adequate vent stack is provided to relieve excess pressures at the base of the drainage stack, the only additional vent protection required to prevent water seal loss in fixture traps is that necessary to prevent self-siphonage when the fixture discharges and to relieve excessive pneumatic effects in the branch drains when other fixtures discharge into the branch. Some municipalities require that every fixture trap be individually vented, but most localities permit alternatemethods such as

1. Wet venting
2. Stack venting
3. Circuit and loop venting
4. Combination waste and vent venting

DISTANCE OF VENT FROM TRAP

The most comprehensive investigations of conditions under which fixture traps will be safe from self-siphonage have been conducted by the National Bureau of Standards in the United States and by the Building Research Station in England. The recommended maximum distances of a vent from the weir of the trap to the vent connection are tabulated in Table 8-4.
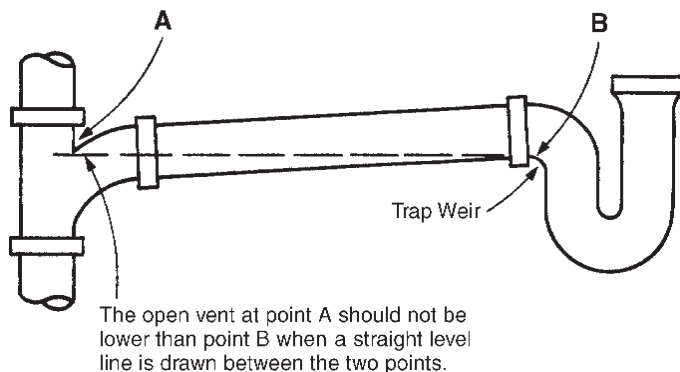
As illustrated in Figure 8-2, the vent pipe opening, except for water closets and similar fixtures, must never be below the weir of the fixture trap. A fixture drain that slopes more than one pipe diameter between vent opening and trap weir has a greater tendency to self-siphon the trap seal than a fixture drain installed at a slope of not more than one pipe diameter.

Table 8-4 Distance of Vent from Fixture Traps	
Size of Fixture Drain, inches	Maximum Distance of Vent to Trap, inches
1¼	30
1½	42
2	60
3	72
4	120

Self-Siphonage of Fixture Traps, National Bureau of Standards Building Materials and Structures Report BMS 126 (1951), prepared by John L. French and Herbert N. Eaton, is a very thorough study of self-siphonage Some of the conclusions drawn by French and Eaton as a result of their investigations are very illuminating and are quoted herewith:

1. Increasing the diameter of the outlet orifice of a lavatory from 1⅛ in. to 1¼ in. increases the trap seal loss greatly, frequently more than 100%, owing to the increased discharge rate.
2. Flat-bottomed fixtures cause smaller trap seal losses than do round fixtures, owing to the greater trail discharge from the former.

Figure 8-2 Vent Pipe Opening

The open vent at point A should not be lower than point B when a straight level line is drawn between the two points.

3. With a 1½-in. fixture trap and drain, an 18-in. by 20-in. lavatory gave greater trap-seal losses than did a 20-in. by 24-in. lavatory, presumably owing to the greater trail discharge of the latter. When a 1¼ in. trap and drain were used, no particular difference was noted in the trap seal losses caused by the two lavatories.
4. The elimination of the overflow in lavatories will increase the trap seal losses substantially.
5. The effect on trap seal losses of varying the vertical distance from the fixture to the trap from 6 in. to 12 in. appears to be negligible.
6. For a given rate of discharge from a lavatory, decreasing the diameter of the drain will increase trap seal losses.
7. An increase in slope or a decrease in diameter of the fixture drain will tend to cause increased losses due to self-siphonage, and these two dimensions are fully as important as the length of fixture drain in causing self-siphonage.
8. Trap seal losses are usually much greater when a long-turn stack fitting is used than when a short-turn or straight-tee fitting is used. No significant difference between the behavior of short-turn and straight-tee fittings was observed. Thus, since it is known that a long-turn fitting is more effective in introducing water from a horizontal branch into the stack than is either the short-turn or straight-tee fitting, the characteristics of these fittings are contradictory in these respects. The fitting that is most advantageous from the standpoint of introducing the water into the stack is the least advantageous from the standpoint of self-siphonage.
9. Trap seal losses are increased if the internal diameter of a P-trap is less than that of the fixture drain. Thus, if we are to prevent excessive trap seal losses for a P-trap due to self-siphonage, we should use a trap having a fairly large internal diameter. Furthermore, siphonage of the trap due to pressure reductions caused by the discharge of other fixtures on the system can be rendered less harmful by using a trap with a large depth of seal. While increasing the depth of seal may lead to greater trap seal losses, it also results in a greater remaining trap seal than if a trap with a shallow seal were used.
10. The test results on the self-siphonage of water closets have indicated that the unvented length of drain for these fixtures need not be limited because of self-siphonage.
11. Standardization of the dimensions of fixture traps and especially of lavatory traps, with regard to internal diameter and depth of trap seal is highly desirable. Minor restrictions on these dimensions can lead to substantially increased lengths of fixture drains.
12. Standardization of the hydraulic characteristics of fixtures is desirable, at least for lavatories, sinks, and combination fixtures. Substantially increased permissible unvented lengths of fixture drains can be obtained for a moderate decrease in the discharge rates of the fixtures.
13. Increase in depth of trap seal above the 2-in. minimum commonly permitted by codes will make it possible to increase appre-

ciably the maximum permissible unvented lengths of fixture drains.

These conclusions clearly illustrate various approaches in the effort to make plumbing systems less costly without affecting efficiency. The proper design of fixtures and fixture drain lines and limiting the maximum discharge rates of faucet-controlled fixtures could result in longer unvented lengths of drains.

VARIOUS METHODS OF FIXTURE TRAP VENTING

Figure 8-3 illustrates various fixture trap vents and their proper nomenclature. When venting one trap the vent is called an "individual" or "back vent." If fixtures are back to back or side by side and one vent is used for the two traps, the vent is a "common vent." Any connection from the vent stack is a "branch vent."

All vent piping should be graded to drain back to the drainage piping by gravity. The vent should be taken off above the centerline of the drainpipe and rise vertically or at an angle of not more than 45° from the vertical. The horizontal run of the vent should be at least 6 in. above the overflow level of the fixture. (See Figure 8-4.)

RELIEF VENTS

Pressures in the drainage and vent stacks of a multistory building are constantly fluctuating. The vent stack connection at the base of the drainage stack and the branch vent connections to the branch drains cannot always eliminate these fluctuations. It then becomes extremely important to balance pressures throughout the drainage stack by means of "relief vents" located at various intervals. The fluctuations in pressure may be caused by the simultaneous discharge of branches on various separated floors. Drainage stacks in buildings having more than ten branch intervals should be provided with a relief vent at each tenth interval, counting from the topmost branch downward. The lower end of the relief vent should connect to the drainage stack below the drainage branch connection and the upper end should connect to the vent stack at least 3 ft above the floor level. (See Figure 8-5.)

Relief vents are required where a drainage stack offsets at an angle of more than 45° to the vertical. Such offsets are subject to high pneumatic pressure increases and extreme surging flow conditions. The methods of installing relief vents are illustrated in Figure 8-6.

CONTINUOUS VENTING

A system of individual or common vents for every trap is called "continuous venting." Every fixture trap is provided with a vent. It is the most expensive system but provides positive protection of all trap seals.
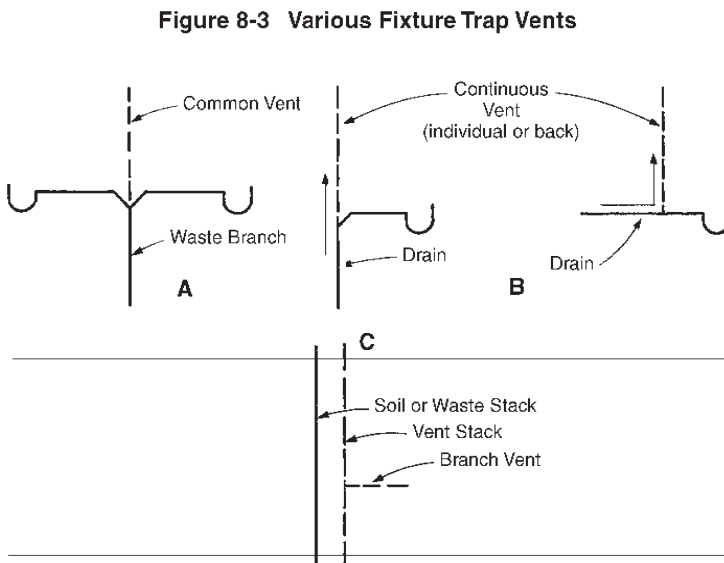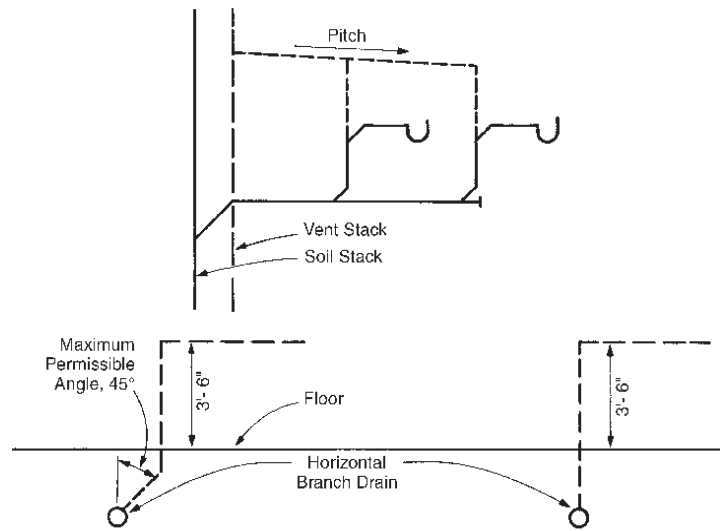
Figure 8-4 Horizontal Run of Vent

Figure 8-3 Various Fixture Trap Vents

WET VENTING

A "wet vent" is a vent that vents a particular fixture and at the same time serves as a waste to receive the discharge from other fixtures. The objective of using wet vents is to minimize the vent piping required by employing one pipe to serve two functions. There are three fundamental rules to follow when utilizing a wet vent:

At top floor:
1. No more than 1 FU is discharged into a 1½-in. wet vent nor more than 4 FU into a 2-in. wet vent.
2. Length of drain does not exceed maximum permissible distance between trap and vent.
3. Branch connects to the stack at the water closet connection level or below. (See Figure 8-7.)

At lower floors:

The rules are the same except that the water closets must be vented and the wet vent must be 2 in. minimum. Water closets below the top story need not be individually vented if a 2-in. wet vented waste pipe connects directly to the upper half of the horizontal water closet drain at an angle no greater than 45° from the angle of flow. (See Figure 8-8.)

"Stack venting" finds its general application in one-family homes and the top floor of multistory buildings. (See Figures 8-7 and 8-9.)

COMBINATION WASTE AND VENT VENTING

"Combination waste and vent venting" is used primarily for venting floor drains and laboratory and work tables. The drainage piping is oversized at least two sizes larger than required for draining purposes only and the drainage branch and stack should be provided with vent piping. This type of venting is employed when it is impractical to employ the other methods.

CIRCUIT AND LOOP VENTING

There has developed a tendency to call all "circuit venting" by the name applicable to a special installation of circuit venting. A circuit vent is a branch vent that serves two or more floor outlet fixtures, except blowout water closets, and extends from in front of the last fixture connection on the horizontal drain to the vent stack. A "loop vent" is the same, except that it is employed on the topmost floor serving fixtures and is connected to the vent extension of the drainage stack instead of to the vent stack. (See Figure 8-10.) When wall outlet fixtures are connected to the branch drain serving the floor outlet fixtures, the former must be provided with individual vents that can connect to the circuit vent or loop vent.

Figure 8-5 Venting for Stacks Having More Than 10 Branch Intervals

Figure 8-5 Venting for Stacks Having More Than 10 Branch Intervals
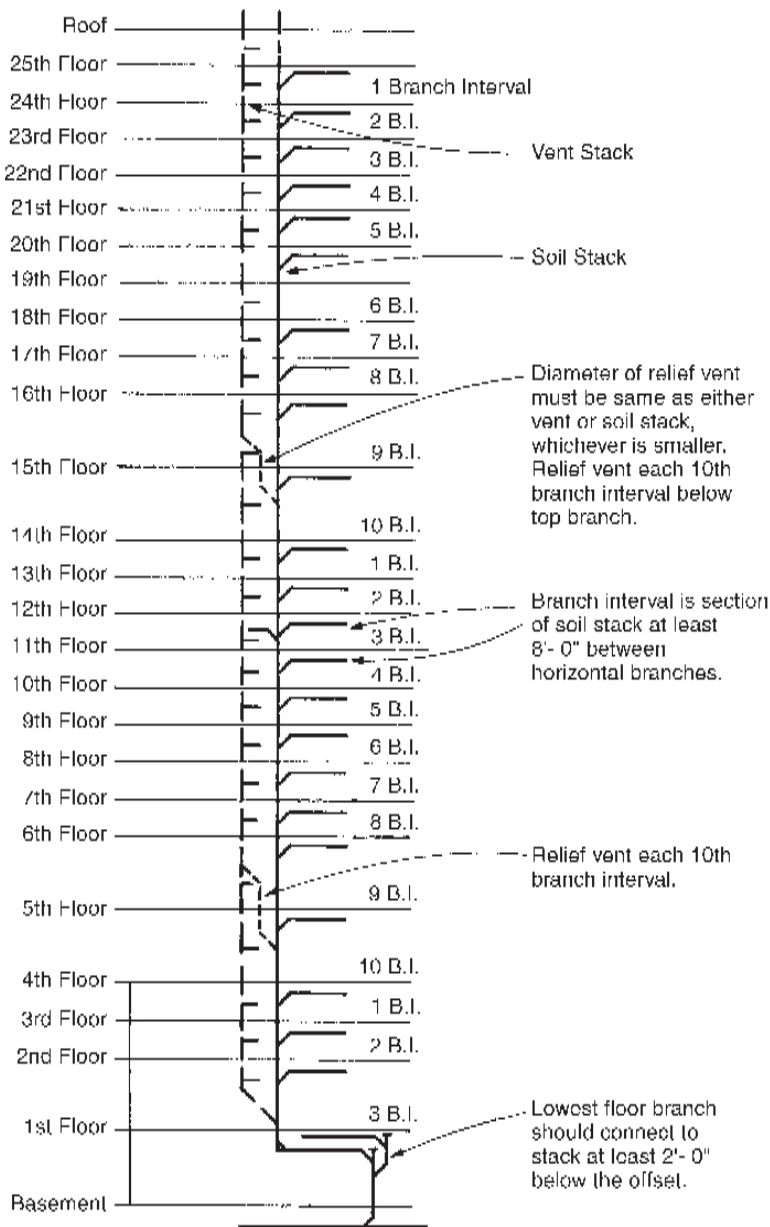
COMMON VENTS

Where two fixtures are connected to a vertical branch at the same level, a "common vent" may be employed. When one of the fixtures connects at a different level than the other, observe the following procedure. If fixture drains are the same size, increase the vertical drain one size. If fixture drains are of different sizes, connect the smaller above the larger connection and maintain the vertical size up to the top connection.

SUDS PRESSURE

The prevalent use of high-sudsing detergents in washing machines, dishwashers, laundry trays, and kitchen sinks has created serious problems in all residential buildings and especially in high-rise buildings. Until manufacturers are forced to market only detergents without sudsing characteristics, the plumbing engineer must understand and cope with the dangers created in the sanitary system by the presence of suds. (An interesting sidelight is that suds, in and of themselves, do not enhance the cleaning ability of soaps or detergents in any way.)

When the flow of wastes from upper floors contains detergents, the sudsingredients are vigorously mixed with the water and air in the stack as the waste flows down the stack and further mixing action occurs as other branch waste discharges meet this flow. These suds flow down the stack and settle in the lower sections drainage system and at any offsets greater than 45 degrees in the stack. Investigation has shown that when sudsing wastes are present, the sanitary and vent stacks are laden with suds and this condition was found to exist for extended periods of time.

Liquid wastes are heavier than suds and easily flow through the suds-loaded drainage piping without carrying the suds along with the flow. Everyone is aware of the difficulty of flushing the suds out of a sink. The water simply flows through the suds and out the drain, leaving the major portion of the suds behind. The same action occurs in the lower sections of the drainage system except for one important difference—air, as well as water, is now flowing in the piping. This air, which is carried down with the waste discharge, compresses the suds and forces them to move through any available path of relief. The relief path may be the building drain, any branches connected to the building drain, the vent stack, branch vents, individual vents or combinations of the foregoing. A path of relief may not always be available or could be cut off or restricted by the hydraulic jump, or a path may just be inadequate because of location or size. If one or more of these conditions exist, excessively high suds pressure can develop and blow the seals of traps with the accompanying appearance of suds in fixtures.

High suds pressure zones occur at every change in direction, vertically or horizontally, that is greater than 45°. Where vent stack base connections, relief vents, branch vents, or individual vents serve as the relief path for the high suds pressure, they are usually found to be inadequate in size with resultant suds conditions appearing at the fixtures. The vent pipe sizing tables in practically every code are calculated on the basis of air flow capacity and do not in any way provide for the more demanding flow of suds. Sizes that are based on these code tables are inadequate to accommodate suds flow and thus are incapable of providing adequate suds pressure relief.

Suds are much heavier than air and consequently do not flow with the same ease. They produce a much greater friction head loss for the same rate of flow. The density of old or regenerated suds varies from 2 lb/ft3 to a high of 19 lb/ft3, depending upon the detergent used. For equal rates of flow and pressure loss, the vent pipe diameter for suds relief flow must be from 20 to 80% greater than for air flow.

Whenever a soil or waste stack receives washing machines, dishwashers, laundry trays, kitchen sinks, or other fixtures where sudsing detergents are used, the drainage and vent piping for the lower-floor fixtures or for the fix tures above offsets must be arranged to avoid connection to any zone where suds pressure exists.

Suds pressure zones exist in the following areas:
1. At a soil or waste stack offset greater than 45°: 40 stack diameters upward and 10 stack diameters horizontally from the base fitting for the upper stack section. A pressure zone also exists 40 stack diameters upstream from the top fitting of the lower stack section.
2. At the base of a soil or waste stack: The suds pressure zone extends 40 stack diameters upward from the base fitting.
3. In the horizontal drain from the base of a stack: The suds pressure zone extends 10 stack diameters from the base fitting, and where an offset greater than 45° in the horizontal occurs, the pressure zones extend 40 stack diameters upstream and 10 diameters downstream from the offset fitting.
4. In a vent stack connected to a suds pressure zone: The suds pressure zone exists from the vent stack base connection upward to the level of the suds pressure zone in the soil or waste stack.

Figure 8-11 illustrates all the above zones.

VAPOR VENTS (LOCAL VENTS)

Years ago water closets and urinals were equipped with connections for venting the fixture to the outdoors to eliminate foul odors. Fixture design has been improved so that these vents are no longer required. The use of "vapor vents" is now applied to sterilizing equipment and bedpan washers. This application is also rapidly disappearing as new methods of condensing the foul vapors are being built into the equipment. When a vapor vent is used, it must be isolated from the sanitary venting system. The base of a vapor vent stack should terminate in a trap, to prevent the escape of vapors, and spill to a trapped, vented, and water-supplied receptacle. The stack should extend through the roof.

An individual vapor vent drip can be connected through an air gap to the inlet of the trap serving the fixture. Vapor vents for bedpan washers and bedpan sterilizers must not connect with the vapor vents of other fixtures.

Sizing of the vapor vent stack may be by empirical methods or the rational approach may be used. The minimum size of the stack should be 1¼ in.

EJECTOR AND SUMP VENTS

Ejectors, other than the pneumatic type, operate at atmospheric pressure and receive drainage discharge under gravity flow conditions. An ejector is installed when the level of fixture discharge is below the level of the public sewer. It is convenient to view an ejector system as being exactly similar to the gravity sanitary system and all of the requirements for the proper design of the sanitary system are applicable. Thus, the air required to be conveyed by the vent piping is the same as the maximum rate at which sewage enters or is pumped out of the receiver.

The ejector vent can be determined by reference to Equation 8-10:

$$L = 2226 \, (d^5/fq^2)$$

and using Table 8-1, which gives air discharge in gpm for various pipe diameters. It has been found in practice that 3 in. is adequate except for extremely large installations.

FROST CLOSURE

Where the danger of frost closure of vent terminals is present, the minimum size of the vent stack or vent extension through the roof should be 3 in. When a vent stack must be increased in size going through the roof, the increase should be made inside the building at least 1 ft below the roof.

The National Bureau of Standards has investigated the problem of frost closure both theoretically and experimentally. It was demonstrated that a 3-in. vent terminal froze up solidly at –30°F only over an extended period of time. Closure occurs at the rate of 1½ in. for every 24 hr. that the temperature remains at –30°F.

It can be seen that frost closure presents a real problem only in the far northern regions. The problem is serious in Canada, and they have devised various methods of overcoming it:

1. Vent terminal to extend only 1 in. or 2 in. above the roof. The more pipe exposed to the atmosphere, the greater the problem. Snow covering the vent terminal has proven to cause no trouble. The snow is porous enough for the passage of air and melts rather rapidly at the outlet.
2. Enlargement of the stack below the roof. The increased diameter decreases the chance of complete closure and the stream of air tends to flow through the enlarged portion without touching the walls of the enlarged pipe.
3. Install cap flashing at the terminal and counterflashing to leave an air space from the heated building.

Frost closure depends upon the: (1) outside temperature, (2) temperature and humidity of inside air, (3) wind velocity, (4) length of exposed pipe, (5) diameter of exposed pipe, and (6) velocity of air flow. There is very little danger of frost closure unless the outside

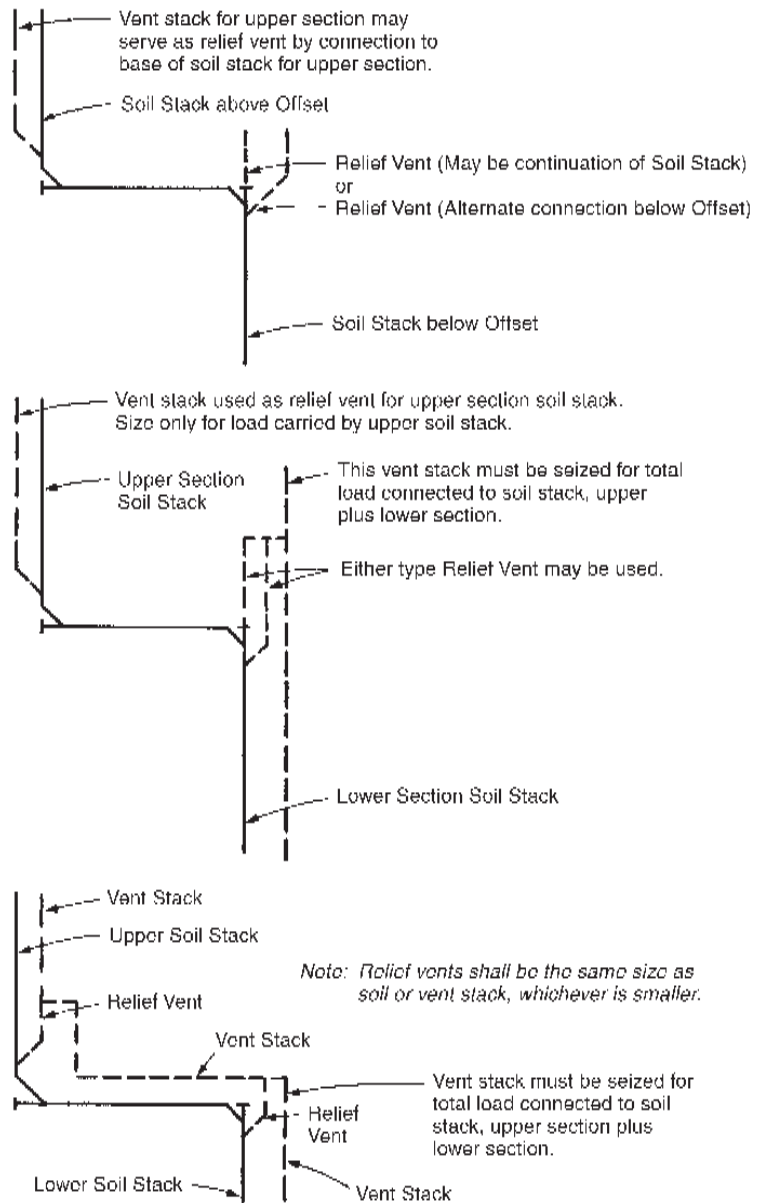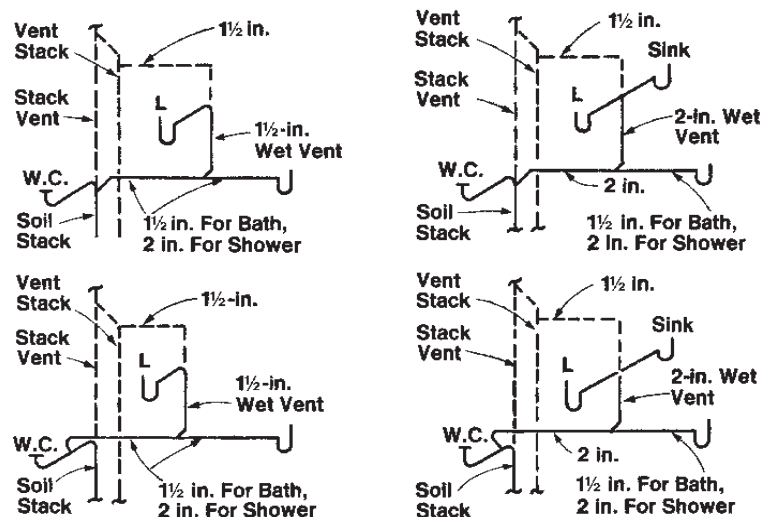Figure 8-6 Venting at Stack Offsets

Figure 8-7 Wet Venting at Top Floor

temperature falls below –10°F and remains there for several days. It has been found that if frost closure does occur, siphonage of traps is reduced or prevented by connecting the drainage and vent stacks together before extending through the roof. An analysis of air flow under these conditions will convince the plumbing engineer of its validity, as it can be seen that air forced into the vent stack at its base will be introduced into the soil stack at the top connection.

TESTS OF PLUMBING SYSTEMS

The complete storm and sanitary system should be subjected to a water test and proven watertight upon completion of the rough piping instal-lation and prior to covering or concealment. The test pressure should be a minimum of a 10-ft column of water except for the topmost 10 ft of pipe. The test pressure should never exceed a maximum of a 100-ft column of water. Any greater pressure will cause the test plugs used to seal temporarily open piping in the system to blow. If the system is higher than 100 ft, test tees may be installed at appropriate heights so as to test the building in sections. Very rarely in practice are more than seven stories tested at one time.

If it is not possible to perform a water test, an air test is acceptable. The air test shall be made by attaching an air compressor testing apparatus to any suitable opening, and, after closing all other inlets and outlets to the system, forcing air into the system until there is a uniform gage pressure of 5 psi (34.5 kPa) or a pressure sufficient to balance a column of mercury 10 in. (254 mm) in height. The pressure shall be held with-out introduction of additional air for a period of at least 15 min.

Upon completion of the sanitary system and after all fixtures are installed with traps filled with water, the system should be subjected to an additional test and proved gastight.

An alternate test is the smoke test. The smoke test is performed by introducing pungent, thick smoke produced by smoke bombs or smoke machines. When smoke appears at the roof terminals, each terminal is sealed and a smoke pressure of 1-in. column of water is maintained to prove the system gastight. This test is not practical and is seldom used.

Another alternate test is the peppermint vapor test. At least 2 oz. of oil of peppermint are introduced into each roof terminal and vaporized by immediately pouring 10 qt of boiling water down the stack. The ter-minals are promptly sealed. Oil of peppermint and any person coming in contact or handling the oil must be excluded from the interior of the building for the duration of the test. Leakages will be detected by the peppermint odor at the source. However, it is very difficult to pinpoint the leak by this method. This test is not practical and is seldom used.
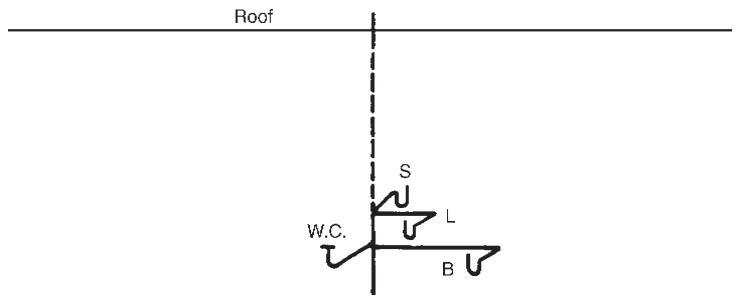

Figure 8-9 Stack Vented Unit
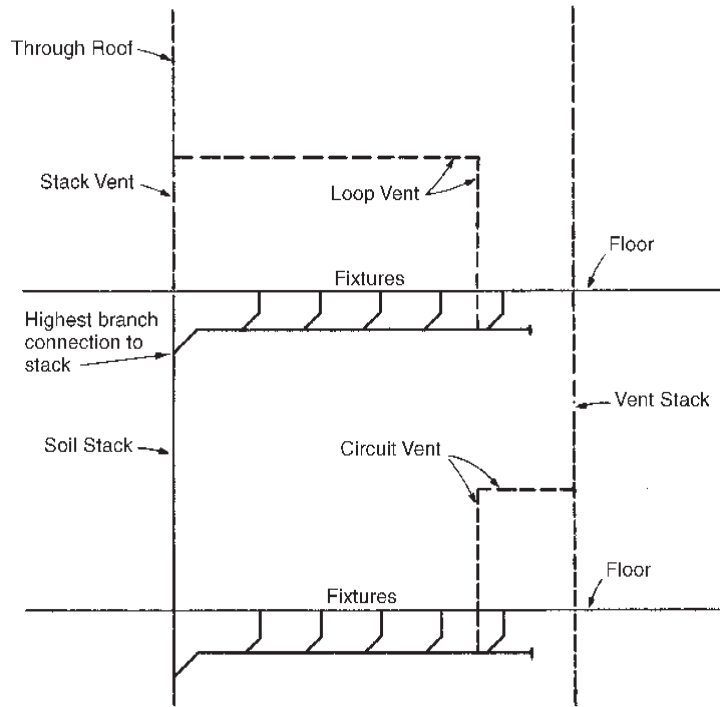

Figure 8-10 Circuit and Loop Venting

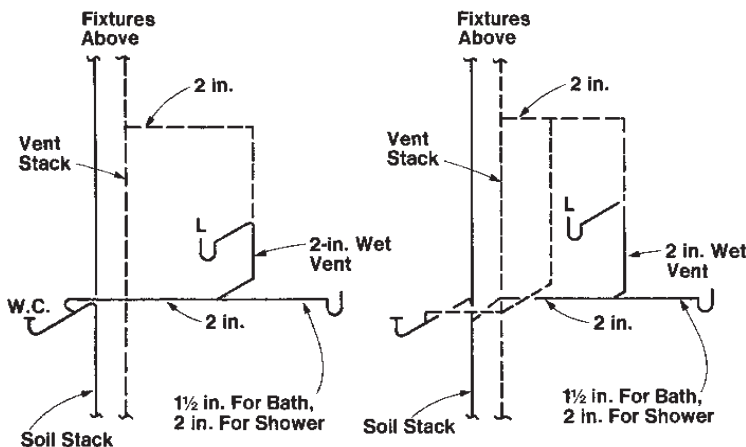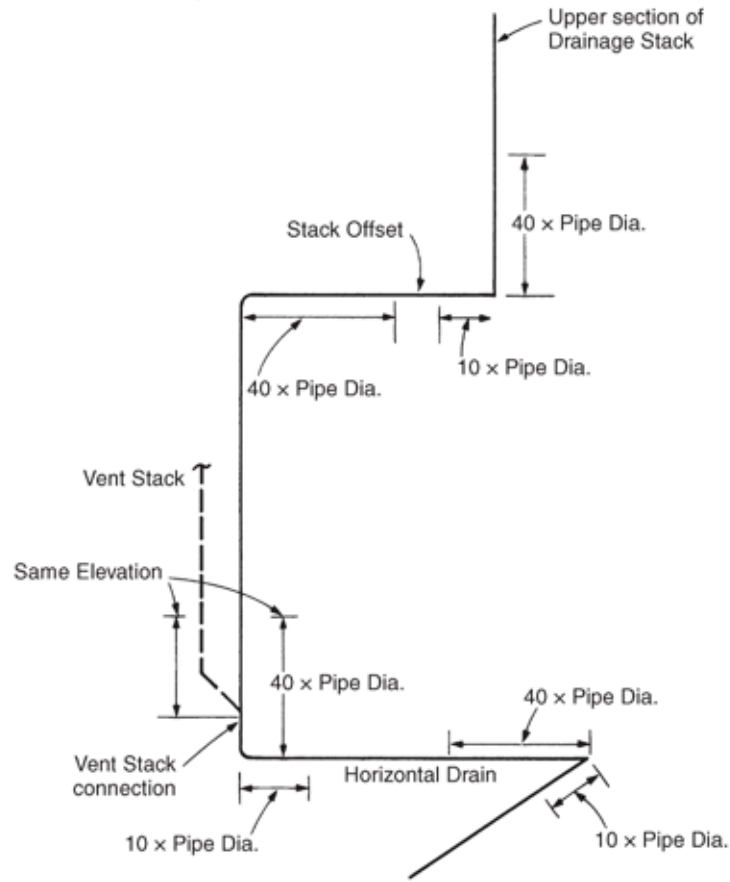Figure 8-8 Wet Venting Below Top Floor

Figure 8-11 Suds Pressure Zones

Upper section of Drainage Stack

Stack Offset

40 × Pipe Dia.

40 × Pipe Dia.

10 × Pipe Dia.

Vent Stack

Same Elevation

40 × Pipe Dia.

40 × Pipe Dia.

Vent Stack connection

Horizontal Drain

10 × Pipe Dia.

10 × Pipe Dia.

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CE Questions — "Vent Systems" (CEU 189)

Circle the correct answers below.

1. _____ is the pressure exerted at any point by the weight of the substance above that point.
   a. specific weight
   b. static head
   c. density
   d. flow pressure

2. At a flow pressure of 1 inch of water column, what is the air discharge rate of a 3-inch vent pipe?
   a. 58.6 cfm
   b. 91.5 cfm
   c. 131.8 cfm
   d. 234.3 cfm

3. The Darcy formula expresses what?
   a. friction head loss
   b. static pressure of air
   c. rate of flow
   d. none of the above

4. What is the rate of air flow in a 4-inch horizontal drain at a slope of 1/8 inch per foot?
   a. 15.5 gpm
   b. 25.5 gpm
   c. 38.0 gpm
   d. 69.0 gpm

5. The pipe from the topmost drainage branch connection through the roof to the atmosphere is called the _____.
   a. vent terminal
   b. vent extension
   c. trap vent
   d. vent stack

6. What is the recommended maximum distance of a 2-inch fixture drain trap to the vent connection?
   a. 30 inches
   b. 42 inches
   c. 60 inches
   d. 72 inches

7. A _____ is required where a drainage stack offsets at an angle of more than 45 degrees to the vertical.
   a. branch vent
   b. back vent
   c. wet vent
   d. relief vent

8. A _____ vents a particular fixture and at the same time serves as a waste to receive the discharge from other fixtures.
   a. branch vent
   b. back vent
   c. wet vent
   d. relief vent

9. A _____ is used on the topmost floor serving fixtures and is connected to the vent extension of the drainage stack
   a. common vent
   b. circuit vent
   c. combination waste and vent
   d. loop vent

10. Where frost closure is possible, the vent extension through the roof should be _____ minimum.
    a. 1 inch
    b. 2 inches
    c. 3 inches
    d. 4 inches

11. During a water test, the test pressure should never exceed _____.
    a. 10 feet of water column
    b. 20 feet of water column
    c. 50 feet of water column
    d. 100 feet of water column

12. Which of the following tests is seldom used?
    a. smoke test
    b. air test
    c. peppermint vapor test
    d. both a and c