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Where the Siphon and Siphonage Make Sanitary Plumbing Fixtures Insanitary & How Cross-Connections Can Be Avoided

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Perhaps the most difficult task in the matter of cross connections is teaching the skeptical and indifferent the how and why of siphons and siphonage. The siphon in its various forms, and siphonage, has more uses and functions in plumbing practice than any other apparatus. As a force or energy, it is employed in many types of fixtures, apparatus and construction. In order to study the subject of plumbing fixtures, acting as cross connections, we must have a clear understanding on the subject of siphons and siphonage, recognize them where they are built into a plumbing fixture, or made up in the connection of a plumbing fixture to a water supply distributing system. The sanitary engineer, architect, hospital superintendent, plumber and manufacturer of plumbing materials must be able to recognize a siphon in laces where they are liable to cause or be responsible for the contamination or pollution by making possible the return of waste matter or sewage from a plumbing fixture to a water supply distributing system.

Definition of Siphons - *A pipe to tube bent to form two branches or legs of unequal effective length, by which a liquid can be transferred to a lower level, over an intermediate elevation, by the pressure of the atmosphere in forcing the liquid up the shorter leg of the pipe immersed in it, while the excess of weight of the liquid in the longer leg (when once filled) causes a continuous flow. The flow takes place only when the discharging extremity is lower than the liquid surface, and when no part of the pipe is higher above the surface than the same liquid will rise by atmospheric pressure [about thirty-three (33) feet for water, thirty (3) inches for mercury near sea level].*

While the above definition is perhaps scientifically correct, it does not graphically convey the idea wanted. It is hard for the non-technical mind to comprehend how liquid can be made to run uphill. They cannot visualize that when the discharging extremity (outlet end) is lower than the water level in the water closet, bath tub, lavatory, tank or other plumbing fixtures, liquid can be lifted to a height above the fixture.

It must be understood that many plumbing fixtures have a submerged water supply inlet. A submerged inlet is connected below or beneath the top of the fixture. By the top of the fixture, we mean the point where the water will overflow on the floor. It must always be remembered that in the event of waste pipe stoppage, the waste overflow of a bath tub or lavatory is also affected by the stoppage. When a fixture stops up we must think in the terms of the overflow point where the waste or water will discharge on the floor.

What is needed is something more in the nature of explanation accompanied by illustrations so the form and shape of apparatus called the siphon can be seen. The simple form of such apparatus may be found in Figure No. 1.

Simple siphon, Figure No. 1 is nothing more or less than a pipe bent to form two legs, one longer than the other. The legs are of unequal effective length. The primary principle of a siphon of any kind is legs of unequal length. If both branches or legs were the same length, it would not be a siphon. In order to make a siphon, or produce siphonage, we must have a short branch or short leg (1), and a long branch or long leg (2).

A water supply distributing system in a building with its underground street main, service to the building, main, riser, branches and individual fixture connections and fixtures invariably form a siphon.

The connection to the fixture forms the short leg (1) and its vertical riser which supplies the water to each floor or elevation forms the long leg (2). Engineers, architects, plumbers and manufacturers must keep this distinction well in mind when considering the subject of cross connections. The short leg (1) of a siphon owing to its peculiar construction is not always so easy to perceive as in the simple siphon illustrated in Figure No. 1. Submerging the short leg (1) into or below the water level in the bucket will not produce siphonage or make a siphon. The water would not run out of the bucket through the bent tube. The long leg (2) when once filled with water produces the force that lifts the water from the vessel into the short leg (1) up over the vend into the long leg (2). The water will continue to flow until it reaches the level of the mouth (3) of the short leg (1). Air will pass into the pipe at this point and break the siphon. Observe that in flowing from the pail through the siphon, the water is carried some distance above the level of the water (4) in the pail.

A siphon will raise water to a higher level than its source before discharging it but will never discharge water at a higher level than the source.

In other words, the long leg (2) of a siphon must be turned down, and the outlet must be at a lower level (5) than the source of water (4) in the pail or the siphon will not work.

Using a short piece of rubber hose, any person can siphon liquid from a higher to a lower level. Fill a bucket or pail full of water, put one end of the hose in water, draw the air out the long end, and lower it below the bottom of the vessel and the water will continue to flow through the tube until the bucket is empty. Atmospheric pressure causes the water to flow through the siphon once it has been started. The pressure of the atmosphere is bearing down on the surface of the water in the vessel with an intensity of 14.7 pounds per square inch at sea level. This 14.7 pounds per square inch produces an upward pressure through the mouth (3) of the short leg (1) and drives the water into the short leg (1).

How high will a siphon raise water above its source or above the plumbing fixture?

A column of water 2.3 feet high exerts a pressure of one (1) pound per square inch; therefore the maximum theoretical height to which water may be lifted by a vacuum is equal to 2.3 times 14.7 or 33.8 feet. A perfect vacuum is not attainable and in actual practice 25 feet is considered the maximum practical working distance.

Figure No. 2 illustrates the approximate height water can be raised by siphonage. The motive force of raising the water is due to the difference in length of the two columns of water.

In Figure No. 2 there is a distance of twenty-five (25) feet between the surface of water in tank and the top of the siphon. The long leg (2) is thirty-five (35) feet in length. Thirty-five (35) feet in length in the long leg (2) will counterbalance the twenty-five (25) feet of lift in the short leg (1), leaving a difference at the beginning of the operation between the long leg (2) and the short leg (1) of a column of water ten (10) feet higher. The unequal weight of water would cause the thirty-five (35) feet of water to run out the long leg (2), creating a vacuum in the down leg. Instead of forming a vacuum the pressure of air on the surface of the water (4) forces the water in to fill the space and will continue to flow until the vessel is empty or air is sucked into the mouth (3) of the short leg (1).

In order that our readers may keep in mind the principle involved, we are showing figure No. 3. The difference is that the illustration shows plumbing fixtures with submerged water supply inlets instead of buckets or pails.

To be able to recognize a cross connection formed by a plumbing fixture and its connection to a water supply distributing system we must be able to evolve a bucket or a pail into a plumbing fixture with a submerged or underrim water supply connection. Any plumbing fixture with a submerged or underrim water supply connection usually forms the pail or the bucket on the short leg (1) of the siphon. a water main in the street, the service and the riser forms the long leg (2).

We have described how the short leg (1) of a siphon involves itself forming a plumbing fixture but what means or method or what are the possibilities of establishing the long leg (2)?

(1) The breaking of a water main in the street.
(2) Shutting off the water in the street mains for repairs or emergencies.
(3) Fluctuation in the pressure of the municipal supply. Peak load periods often provide dribble flow and no water in the higher elevation on the upper floor of taller buildings.
(4) Pumps connected direct to city water mains supplying equalization tanks in tall buildings. Where two such pumps are operated, the buildings fed by a gravity flow between them are automatically robbed of water pressure. These pumps hog all of the water that comes into the main and the risers in each of the gravity-fed buildings are the long legs (2) which produce siphonage.
(5) Shutting off of the water supply distributing system in the basement for emergency or other causes.
(6) Shutting off the water at the foot of a riser in the event of fixture stoppage.

Some engineers, architects and manufacturers hold to the theory that a pipe from a fixture rising vertically to the ceiling above the floor level where the fixture is located will prevent siphonage. The vertical arm from each fixture would increase the cost of installation without adding to its efficiency or protecting against cross connections.

The overhead water supply distributing system in Figure No. 4 in which water enters a riser and feeds down offers protection only when the vertical rise of pipe from the individual fixture is greater than the atmospheric pressure on the water level in the plumbing fixture. A down feed riser serving water closets, lavatories and drinking fountains on the third, second and first floor is siphon in itself G-2. The leg (2) from the third to the second, to the first will take the waste from any fixture with a submerged water supply inlet and discharge it at a lower level. It should also be remembered that the supply riser H-2 from the overhead or down feed system often go to make up the long leg (2) of the siphon and the fixture branch forming the short leg (1) thereby creating a simple siphon.

The opening of a valve or faucet on a lower floor and the rushing of the water out of the long leg (2) picks up the waste water in the fixture and passes it back through the valve or faucet through the fixture branch K-1 into the down leg H (2) of the water supply distributing system, forming a cross connection. Vacuum breakers at the points indicated on Figure No. 4 would be necessary to make this system safe.

In Figure No. 5 A and B illustrate two water closets connected to the water supply pipe in the same manner. The difference is that A is foolproof against the possibility of contamination or pollution, while B will permit the return of excrement, urine or waste water to the water supply distributing system

The Venturi method or air intake located in the flush valve or between the valve and the closet and above the closet is always open to the atmosphere. The intake openings must have sufficient area to supply air in quantities to prevent a partial vacuum and eliminate siphonage. It will be noted that Figure No. 5 reproduces the simple siphon illustrated in Figure No. 1.

There are thousands of installations similar to B. Emphasis should be placed upon the fact that it is not the closet or the valve but a combination of the two that creates the insanitary condition. The problem is how can this type of installation be made foolproof? By what economical means or methods can the type of installation in B be made safe and sanitary? The problem is to prevent the flowing back or return of water, excrement, urine or wastes from a plumbing fixture into the water supply distributing system by siphonage. Two methods may be employed to correct the type of installation shown in B. The use of either method may be employed without replacing the existing bowl and valve.

(1) Install air break in flush pipe above topof the closet bowl.. Air intake openings must be at least one (1) inch above top of the closet bowl.

(2) Install automatic air intake valve or vacuum valve on the fixture branch at V.

Number 1 method is the most economical for water closet installation. No. 2 method may also be employed in connection with risers, fixture branches, bath tubs and on all fixtures having an underrim or submerged supply inlet.

The point where safe water ends and sewage begins is sometimes very finely drawn. Plumbing fixtures are the terminals of the water supply distributing system, the source of sewage and the beginning of the sewerage system. Excrement, urine, body and domestic wastes from plumbing fixtures is not safe for human consumption. No person would knowingly drink waste water from a water closet, urinal, bed pan sterilizer, instrument sterilizer, lavatory or bath tub. There is no question, however, that many of us have and will continue to do so until this evil has been eliminated. Where the water enters the fixture through overrim nozzle or spout with several inches between the top of the fixture and spout or nozzle as in Figure No. 6 there is no danger of any waste water finding its way back into the water supply distributing system.

There are few, if any, plumbing fixtures that do not at some time become clogged. Stoppage may be due to accident, carelessness, abuse or other causes. It may be the building sewer, building drain, the branch or the trap of the plumbing fixture that becomes clogged. The stoppage may be due to back pressure because the main sewer in the street is overloaded. There always will be stoppages in plumbing fixtures and drainage systems.

The point is that if the water supply inlet is below the top of the fixture the wastes of the fixture may be returned to the water supply distributing system either by siphonage or gravity. We have already pointed out that the overrim supply effectively prevented any possibility of the return of sewage or waste from a fixture to a distributing water supply system, Figure No. 6.

We find, however, that it is impracticable to use the overrim method of water supply in serving many types and kinds of plumbing fixtures. The integral supply is the only practical and efficient method of connecting a water supply to various types of plumbing fixtures. The plumbing fixture with the underrim or submerged water supply inlet should not be disqualified or condemned as such. However, it is the combination of this type of fixture with the water supply connection that makes a cross-connection possible.

Two methods of installation to prevent cross-connections are shown in Figures No. 4 and 5.

Many of the well designed bath tubs, lavatories, sinks and closet tanks have overrim nozzles and spouts or raised ball valves. All others of the underrim integral supply, bell supply, bottom supply, side supply similar to Figure No. 7 come under the classification of plumbing fixtures that make cross-connections possible.

There are many hospital instrument sterilizers, utensil sterilizers, water sterilizers, bed pan sterilizers, integral supply lavatories, water closets and drinking fountains illustrated by Figures No. 7A, 8 and 9 that do not require the energy of siphonage but will return sewage and wastes by gravity.

In this type of fixture and connection, siphonage in the water supply line or stoppage in the waste pipe of the fixture are not always factors. The excrement, urine or waste in the fixture will flow back into the water supply distributing system by gravity. the dirty water from the rinsing tub and glass washer used in connection with the back bar of soda fountains are also included in this classification as illustrated in Figure 10 A. The contents of utensil sterilizers illustrated in Figure No. 11 will return to the water supply system by gravity. Figure No. 10 B, illustrates a system of piping that may be used to correct existing installations shown in Figure No. 10 A and in Figure No. 11.

Health regulations require drinking fountains and individual drinking cups to prevent human contact but overlook a more dangerous source of possible infection. Any fixture, fitting, apparatus, device or connection similar to those illustrated in Figures No. 7A, 8, 9, 10, and 11, should be prohibited.

Anyone who believes that the conditions have been exaggerated or who is indifferent to the possibility of pollution or contamination of a water supply can easily satisfy himself or herself by making a few simple tests. Make your own tests. Use harmless blue or green food dye to color water in the fixture. Fifteen minutes of any persons time is sure to convince him that immediate steps should be taken to prevent future installation and to recognize that there is need of effectively correcting existing installation.