WATER SUPPLY AND PLUMBING CROSS-CONNECTIONS

HAZARDS IN HOUSEHOLD AND COMMUNITY SYSTEMS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

U. S. ENVIRONMENTAL PROTECTION AGENCY

Statement From Chairman, Joint Committee on Backflow Preventers of the American Water Works Association and the Conference of State Sanitary Engineers

January 11, 1963.

DIVISION OF ENVIRONMENTAL
ENGINEERING AND FOOD PROTECTION,
U.S. Public Health Service,
Washington 25, D.C.

GENTLEMEN: I greatly appreciate the opportunity in getting a preview of your cross-connection control manual. I believe this step is a long one forward in the battle against unprotected cross-connections. In my opinion, the manual will certainly be of great use to all who are concerned with this problem, either as a health department official, as a water purveyor, or as a water user. It is well written and clearly sets forth the dangers and problems involved in the efforts to keep water distribution systems free from health hazards. It will be of definite help to those water purveyors who are waging this battle in their own community.

Sincerely,

RAY L. DERBY,
Chairman, Joint Committee on
Backflow Preventers, 8210–J.

WATER SUPPLY AND PLUMBING CROSS-CONNECTIONS

HAZARDS IN HOUSEHOLD AND COMMUNITY SUPPLY SYSTEMS

A MANUAL OF RECOMMENDED CONTROL PRACTICES, INCLUDING A RECOMMENDED ORDINANCE

U. S. ENVIRONMENTAL PROTECTION AGENCY
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Water Supply Programs Division

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FOREWORD

Plumbing cross-connections, which connect potable water supply with nonpotable supply, are a public health problem. There are numerous and well-documented cases where such connections have been responsible for contaminated drinking water, and have resulted in spread of disease. The problem is a dynamic one, because piping systems are continually being installed, altered, or extended.

Control of cross-connections is possible, but only through knowledge and vigilance. Education is essential, for many of those who are experienced in piping installation, fail to recognize cross-connection possibilities and dangers. All municipalities with public water supplies should have cross-connection control programs. Those responsible for institutional or semipublic water supplies also should be familiar with the dangers, and should exercise careful surveillance.

WATER SUPPLY AND PLUMBING CROSS-CONNECTIONS, has been designed and produced as a tool for health officials, water works personnel, plumbers and many others. It is the result of many years experience in this field and may be used in educational, administrative and technical ways in conducting cross-connection control programs. It was produced under the direction of Mr. Floyd B. Taylor. The writer of the text and designer of illustrations was Mr. Marvin T. Skodje, Professor of Sanitary Engineering at North Dakota State University who is a Public Health Service reserve officer. Chapter II, Public Health Significance of Cross Connections, appeared in *Modern Sanitation and Building Maintenance*, Vol. 14 No. 7 (July 1962). Permission to reprint has been given by the publication.

The manual has been reviewed by members of the Joint Committee on Backflow Preventers of the American Water Works Association and the Conference of State Sanitary Engineers.

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Chapter 1. PURPOSE AND SCOPE

Public health officials have long been concerned about cross-connections and backflow connections in plumbing systems and in public, drinking water supply distribution systems. Such cross-connections, which make possible the contamination of potable water, are ever-present dangers. One example of what can happen occurred in Chicago in 1933. As later proved, old, defective and improperly designed plumbing fixtures and plumbing permitted the contamination of drinking water. As a result, 1,409 people came down with amoebic dysentery. There were 98 deaths. This epidemic and others resulting from contamination introduced into public water supply through improper plumbing, made clear the responsibility of public health officials and water purveyors for exercising control over public water distribution systems and all plumbing systems connected to them. This responsibility includes advising and instructing plumbing installers in the recognition and elimination of cross-connections.

Cross-connections and backflow connections are the links through which it is possible for contaminating materials to enter a potable water supply. The probability of contamination of drinking water through a cross-connection occurring within a single plumbing system may seem remote, but considering the multitude of similar systems the probability is great. The only proper precaution is to eliminate all possible links or channels whereby such pollution may occur.

Why do such cross-connections exist?

One reason is that a connection is made by a plumbing installer without an awareness of the danger. He does not realize that waterflow may occur in a reverse direction, or even uphill. A second reason why such connections are made is the simple one of convenience, combined with a false reliance on a valve or other mechanical device as an adequate protection. Valves may fail or be carelessly left open.

To combat the dangers of cross-connections and backflow connections, education in the dangers of them is needed. First, installers of plumbing must know that hydraulic and pollutional factors may combine to produce a sanitary hazard if a cross-connection is present. Second, they must realize that there are available reliable and simple standard backflow prevention devices and methods which may be substituted for the convenient but dangerous direct connection. And third, it should be made clear to all that the hazards resulting from direct connections greatly outweigh the "convenience" gained.

This manual has been designed for use as an instructional guide. It does not describe all the cross-connections possible in piping systems. It does attempt to reduce the subject to a statement of the principles involved and to make it clear to the reader that such installations are potentially dangerous. The primary purpose is to define, describe, and illustrate typical cross-connections and to suggest simple methods and devices by which they may be eliminated without interfering with the functions of plumbing or water supply distribution systems.

Chapter 2.—PUBLIC HEALTH SIGNIFICANCE OF CROSS CONNECTIONS

According to the official investigation of the 1933 Chicago epidemic of amoebic dysentery, ". . . old and generally defective plumbing and cross-connections potentially permitting backsiphonage from fixtures such as bathtubs and toilets" . . . were to blame for contamination of drinking water supply.

The event and its sad result—the death of 98 persons—dramatized the concern which public health officials feel about the dangers of cross-connections. Because such plumbing defects are so frequent, and the opportunity for contaminants to invade drinking water through cross-connections so general, it is practically a certainty that similar tragedies will occur again unless more cities take preventive action.

Enteric infections caused by drinking water that has become contaminated through cross-connections, may occur in almost any city, on any day. How do these events happen?

Reversal of Pressure

A cross-connection is a link or channel between pipes carrying polluted water and pipes carrying drinking water. The contaminant enters the potable water system when pressure from the polluted source exceeds pressure on the drinking water. The action may be called backsiphonage, or backflow. Essentially it is simply a reversal of hydraulic pressure produced by a variety of circumstances.

It might be assumed that steps for detecting and eliminating cross-connections would be elementary and obvious. Actually, cross-connections may appear in many subtle forms and in unsuspected places. Reversal of pressure in the water may be freakish and unpredictable.

Published histories of massive enteric infections caused by cross-connections abound. While the following cases have their natural appeal as historical literature, they are listed here mainly to illustrate the serious consequences of cross-connections, their ubiquity, their frequency, and their peculiarity.

Brucellosis at the Faucet

In 1938, 80 students at a large midwestern university reported remittent fevers, malaise, headache, and anemia. Their symptoms led to a diagnosis of undulant fever (brucellosis). Curiously, only those students who had been working in the cultivation of bacteria in one of the laboratories were affected. The mystery was how the brucella cultures in the laboratory could have been transmitted to the students. Finally, a hose was found connected to a faucet in the laboratory. The other end of the hose was submerged in water containing brucella. A temporary reversal of pressure, possibly the consequence of a demand for water in another part of the system, had drawn the water teeming with brucella into the drinking supply. Of the 80 students affected, 1 died.

Sewage in the Water Main

In Newton, Kans., in 1942, one of the town's two water supply mains had been taken out of service on September 2, 7, and 8. A house service connection to this main supplied three frost-proof hydrants and two frost-proof toilets. It was assumed, from subsequent events, that some unknown person or persons tried to obtain water from a hydrant connected to the main out of service. When no water flowed, the anonymous agents departed, leaving the valve open. On September 10, it was discovered that a neighboring toilet sewer was clogged and that sewage had overflowed into the hydrant box. It was learned that for 2 days, all the sewage from the toilets of 10 families had been permitted to flow into the water main. When the main was put back into service, there was no attempt to sterilize it. More than 2,500 persons in all parts of the town suffered enteric disorders as a result. Stool cultures and pathological findings from two autopsies diagnosed the illness as bacillary dysentery. In addition to the widespread illness in the town, it is believed that the infection was carried aboard a number of troop trains which were watered in Newton at that time.

Pressure Drop

In 1942, a casting plant in Pittsburgh employing 500 persons undertook to install new water connections. During installation, the city water supply was shut off. It is believed that a drop in pressure in the drinking water lines of the plant permitted river water to pass through a valved connection to the drinking water. Twelve hours after the first new connection to the city water was installed, many of the employees suffered mild intestinal disorders. Two weeks later, after another shutdown to make a second connection from the plant system to the city water, there was a second oubreak of intestinal disturbances among the employees.

Defective Valve

Aboard a vessel in a West Coast shipyard in 1943, a valve on the main line, connecting the drinking water to the fire water supply, was found to be defective and the cause of an outbreak of gastroenteritis. The pumping of contaminated harbor water through the fire waterlines aboard the vessel had forced bacteria into the drinking supply through a cross connection. As a result, 1,179 men became ill.

Arsenic in Reverse

A California laborer had been using an aspirator, attached to a garden hose, to spray a driveway with weed killer containing arsenic. Sometime while he was at the job, the water pressure reversed. Taking no notice of the incident, the man disconnected the hose and, feeling thirsty, drank from the bib of the hose connection at the house. Arsenic in the waterline killed him.

Peak Demands

At a large aviation plant on the West Coast, officials learned that the difference between a 3-inch water main and an 8-inch main was a high rate of absenteeism. When it was discovered that 25 to 40 percent of the employees were suffering from gastroenteritis, the plumbing system was suspected. Investigators found that there was such a demand on the 3-inch main at peak periods that the outflow produced enough of a vacuum to allow waste water to be backsiphoned through cross-connections into the drinking water system. After an 8-inch main was installed, the high rate of infection subsided.

The Vacuum Breaker

In April 1944, after an outbreak of gastroenteritis in an Oklahoma school, it was found that none of the flushometer valve toilets with submerged inlets were provided with vacuum breakers, which prevent atmospheric pressure from forcing waste water into the supply lines. Each night, to conserve water and eliminate the possibility that rooms might be flooded if a leak should develop, the custodian turned off the valve of the main supply line. As the pressure in the supply lines was cut off, atmospheric pressure on the toilet bowls moved the waste water up into the drinking supply. Most of the people affected were those who drank from faucets on the first floor of the school; there were progressively fewer cases on the second and third floors, as the atmospheric pressure moved less of the waste water to those heights.

Wrong Valve

At a school in Milford, Nebr., the fire lines and hydrants were separate from the domestic water supply, although the two systems connected through a valve at the pumphouse. The source of water for the fire system was the river. In January 1947, following a fire, someone negligently opened the connecting valve at the pumphouse, and river water entered the domestic water supply. About 150 people came down with gastroenteritis.

Ten-Percent Polio Incidence

In 1932 during a 5-week period, more than 10 percent of the 347 children in Huskerville, near Lincoln, Nebr. contracted polio. A study of the water supply revealed that the afflicted children lived in areas where flush valve water closets lacked vacuum breakers. A time relationship was found also in places where extreme fluctuations of pressure in the water mains might have permitted waste water to be forced into the drinking supply.

Dysentery at Sea

In 1952 a large ocean-going vessel set sail from its berth with every indication that things were shipshape. A day or so later and 300 miles out, over a thousand cases of dysentery developed among those on board. Contaminated water was blamed for the episode and the evidence indicated that while tied up at its moorings, the ship's fresh water tanks had been contaminated. A cross-connection was the most likely explanation.

A Drink of Chromates

Chromates are one of the chemicals for which the Public Health Service Drinking Water Standards of 1962 prescribe the very low amount of 0.05 parts per million as the limit which can be tolerated in a drinking water supply. In 1958 an employee using a drinking water fountain in a large city library noticed that the water stream issuing from the spout was yellowish, and the matter was called to the attention of the building engineer. Upon investigation, it was found that the chilled water pipe system supplying the fountains, was directly connected to another chilled water system in which heavy dosages of chromates were used for corrosion control. Someone forgot to close the valve!

Harbor Water Threatens Vessel Crews

About 2 p.m. on June 29, 1960, on a large pier installation in an eastern port harbor, a worker noticed evidence of salt in the potable water supply. Investigation showed that salt water from the harbor had been pumped into the pier's potable water pipes. The fire systems of three vessels anchored nearby had been connected to the fresh water piping system and high fire-pump pressures apparently did the rest. One measurement of chlorides at a "fresh" water outlet showed 6,425 parts per million. Only prompt and vigorous action by a sanitary engineer is believed to have prevented widespread illness.

Antifreeze

Usually service stations supply antifreeze for automotive equipment, not for people to drink. The reverse was true during October of 1961 when there occurred one of the most bizarre backsiphonage episodes on record. In a midwestern city, ethylene glycol antifreeze was being pumped from a large storage tank to an antifreeze distribution system. This system was cross-connected to the city water supply lines and it was estimated that over 100 gallons of 60 percent ethylene glycol were pumped into the water mains. Samples from the water pipes showed the presence of from 1.5 to 2.0 percent ethylene glycol or up to 20,000 ppm of this toxic chemical agent. A homeowner reported a bitter taste and reddish color to the water department. Radio announcements, a shutdown of the water supply to the area affected and repeated flushings were required to cope with the situation.

Outbreak Fells Shipyard Workers

The time was 7:00 a.m. on September 28, 1962, at a large eastern shipyard. Beginning then and throughout the day some 700 men reported ill with gastroenteritis. All had drunk water from the yard area where they worked and one water sample showed coliforms in excess of 240 per 100 milliliters. Investigators concluded that a temporary cross connection had been made between the potable water lines and pipes containing river water for fire fighting purposes. They stated that, ". . . such an episode may occur again if steps are not taken to insure that such ill-considered cross connections cannot be made by accident."

* * * * *

The foregoing incidents illustrate why public health officials earnestly caution builders, plumbers, maintenance men, and city planners on the correct design and installation of plumbing facilities. Even more important than the new installations are the many established systems which deserve review and correction.

Chapter 3. THEORY OF BACKFLOW AND BACKSIPHONAGE

A CROSS-CONNECTION[1] is the link or channel connecting a source of pollution with a potable water supply. The polluting substance, in most cases a liquid, tends to enter the potable supply if the net force acting upon the liquid, acts in the direction of the potable supply. TWO factors are therefore essential for backflow. FIRST there must be a LINK between the two systems. SECOND, the resultant FORCE must act TOWARD the potable supply.

Detecting and eliminating cross-connections may be difficult. First, the link between the source of pollution and the potable supply may be much more subtle than a solid pipe connection. Second, the factors which might produce a reversal of the normal direction of flow may appear extremely remote or even impossible.

An understanding of the principles of backflow and backsiphonage, requires an understanding of terms frequently used. FORCE, unless completely resisted, will produce motion. The direction of the motion is always the same as that of the force. A force may occur in several forms, but the form of prime concern in backflow is that of PRESSURE. Pressure normally refers to a force per unit area, such as pounds per square inch. WEIGHT is a special type of force resulting from the action of gravity which produces a pressure towards the center of the earth. The pressure is commonly expressed in pounds per square inch (psi) and may be referred to an "absolute" scale (psia) where the "zero" represents absolute vacuum, or to a "gage" scale (psig) where the "zero" represents the atmospheric pressure. ATMOSPHERIC PRESURE is that pressure exerted by the weight of the atmosphere above the earth. At sea level it is approximately 14.7 pounds per square inch absolute. The term VACUUM refers to a negative gage pressure, or that amount of absolute, negative, differential pressure existing between a contained fluid and the surrounding atmosphere. The maximum complete vacuum which can be created at sea level is about 14.7 psi. Since it is nearly impossible to produce a complete vacuum, the term vacuum used herein will be assumed to include all degrees of partial vacuum. The pressures exerted by a fluid while at "rest" will be referred to as STATIC PRESSURE.

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[1] See formal definition in the glossary of the appendix.

BACKSIPHONAGE[1] is siphon action in an undesirable or reverse direction. It is caused by the force of atmospheric pressure exerted against a pollutant liquid forcing it towards a potable water supply system which is under a negative pressure, or vacuum. BACKFLOW, although literally meaning any type of reversed flow, will hereafter generally refer to the flow produced by the differential pressure existing between two systems both of which are at pressures greater than atmospheric (i.e., where negative pressures are not present). Backsiphonage is usually less understood than this type of backflow.

SIPHON THEORY. For an understanding of the nature of pressure force and its relationship to height, consider the pressure exerted on the base of a cubic foot of water at sea level. (See figure 1.) The average weight of a cubic foot of water is 62.4 pounds per cubic foot. The pressure exerted upon the square foot area, is therefore, 62.4 pounds gage pressure. The base may be subdivided into 144 square inches with each subdivision being subjected to a pressure of 0.433 pounds.

Suppose another cubic foot of water were placed directly on top of the first. (See figure 2.) The pressure on the top surface of the first cube which was originally atmospheric, or 0 psig, would now be 0.433 psig as a result of the superimposed cubic foot of water. The pressure

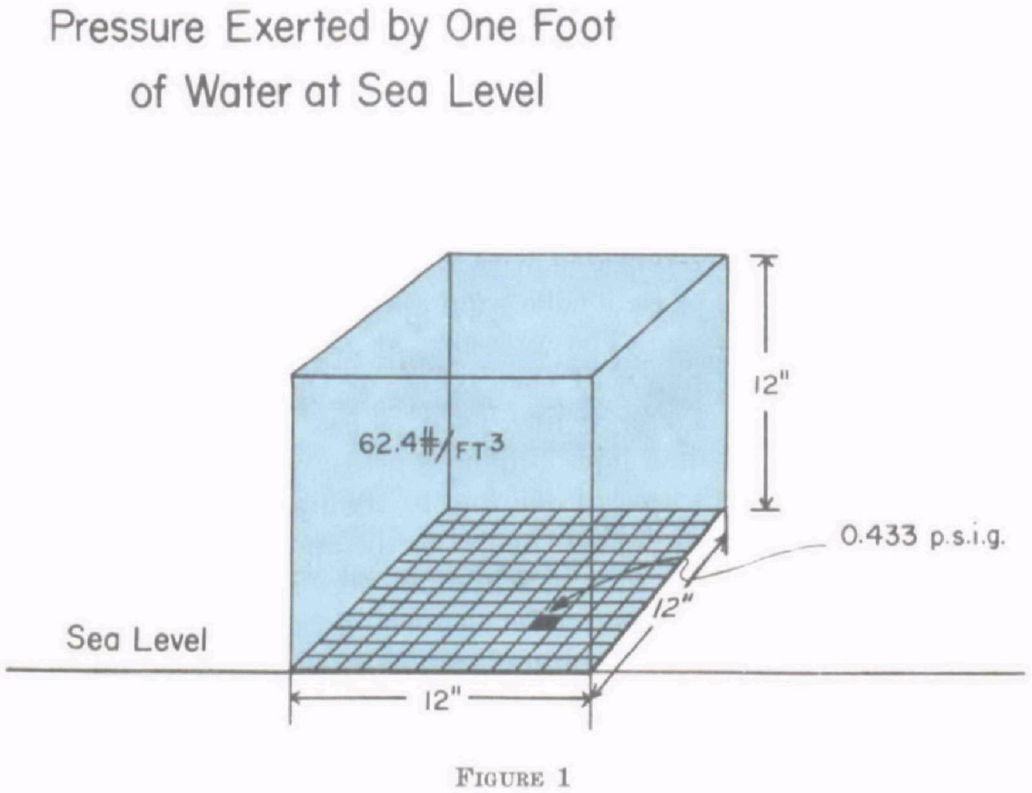


FIGURE 1

[1] See formal definition in the glossary of the appendix.

at the base of the first cube would also be increased by the same amount to 0.866 psig, or two times the original pressure.

Pressure Exerted by Two Feet of Water at Sea Level

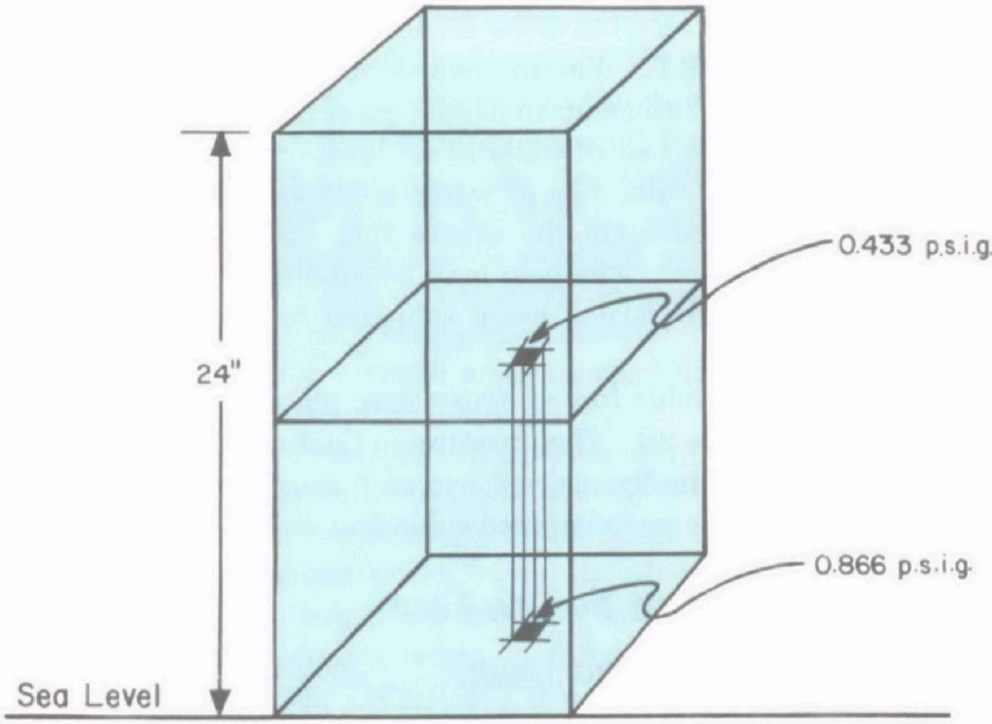


FIGURE 2

If this process were repeated with a third cubic foot of water, the pressures at the base of each cube would be 1.299 psig, 0.866 psig, and 0.433 psig respectively. The pressure at any point in a fluid is dependent upon the depth of that point, or the level of that point above a horizontal reference line, such as sea level. Each foot of elevation change within a liquid changes pressure by an amount equal to the weight per unit area of one foot of the liquid. For water this value is 0.433 pound per square inch. If the static water pressure at a faucet on the top floor of a building 100 feet high was equal to 20 psig, the pressure at the water service would be approximately 63.3 psig. If the pressure at the water service was changed suddenly to 33.3 psig, the water pressure at the upper tap would reduce to a negative pressure of −10 psig, or the water in the piping system would drop to a lower level.

Another illustration, figure 3, depicts, "absolute" pressure on the surface of a liquid at sea level. An open tube is inserted vertically into the liquid so that the atmospheric pressure acts equally on the surface of the liquid within the tube and on the outside of the tube. The atmospheric pressure is considered to be 14.7 psia.

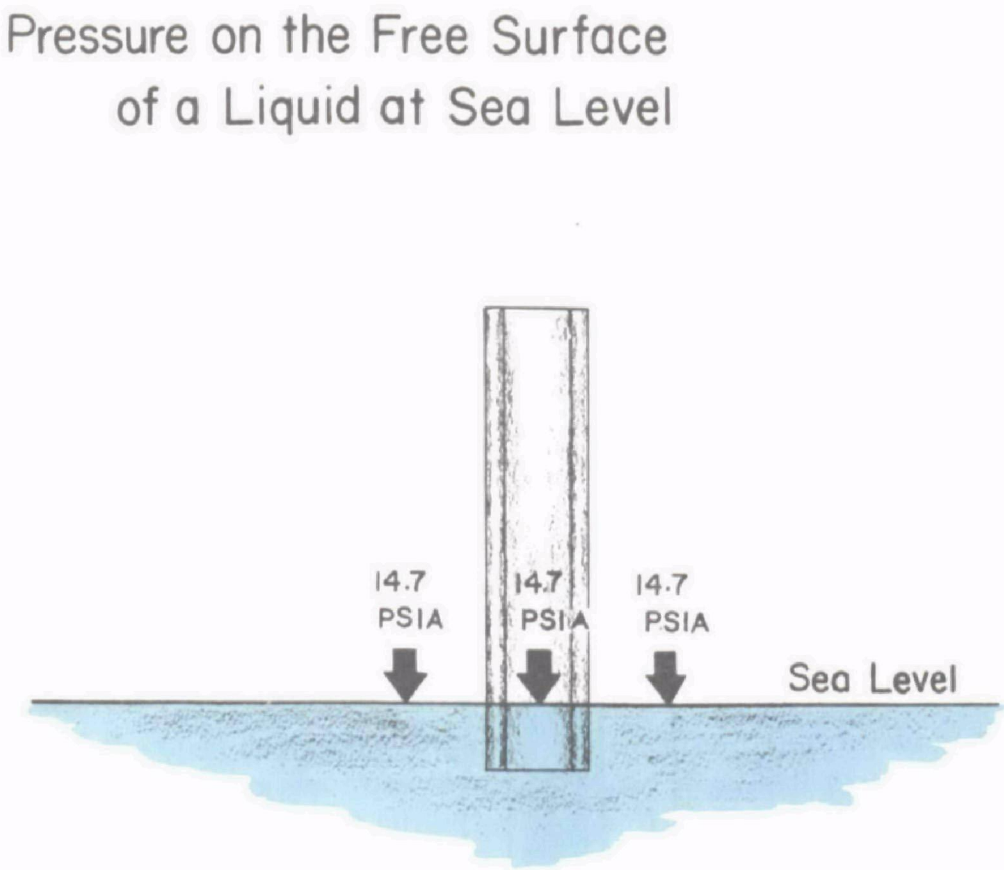


FIGURE 3

If the tube is tightly capped and a vacuum pump is used to evacuate the air from the sealed tube, a total vacuum or a pressure of absolute zero is created within the tube. Because the pressure at any point in a static fluid is dependent upon the height of that point above a reference line, such as sea level, it follows that the pressure within the tube at sea level must still be 14.7 psia. This is equivalent to the pressure at the base of a column of water 33.9 feet high and with the column open at the base, water would rise to fill the column to a depth of 33.9 feet.

Another way of illustrating the rise of water up the tube is to demonstrate that the weight of the atmosphere at sea level exactly balances the weight of 34 feet of water as shown in figure 5.

In the column of water in figure 4 the absolute pressure within the tube at a height of 11.5 feet is equal to 9.7 psia. This represents a

Effect of Evacuating Air from a Column

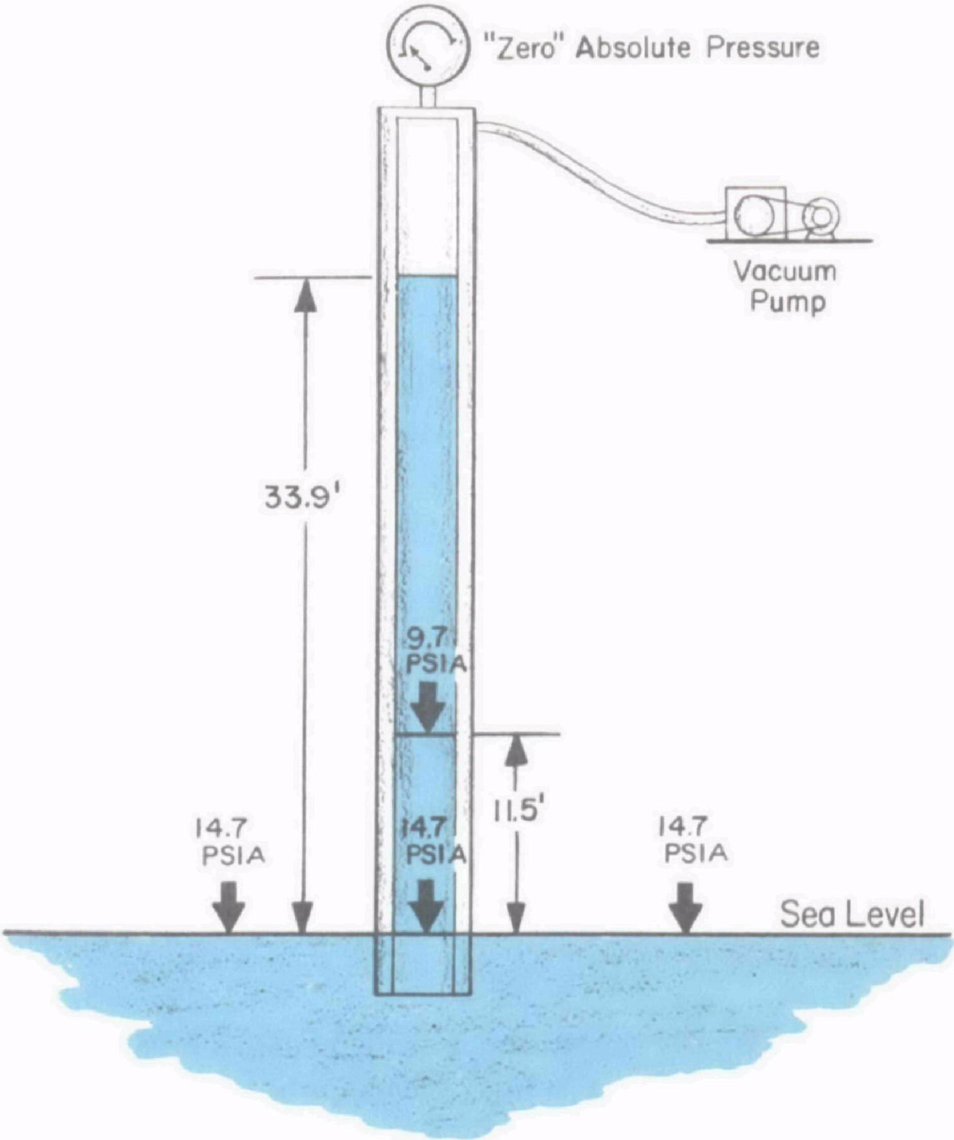


FIGURE 4

pressure of 5 pounds per square inch below atmospheric pressure, or a vacuum of 5 psi.

In the cases cited, the liquid was at rest and not in motion and the pressures exerted therefore are static pressures. The pressures exerted by fluids in motion are called DYNAMIC PRESSURES. It is not feasible to include in this manual a discussion of the more complicated relationships and laws for calculating the pressure at a point within a moving liquid. It will suffice to say that the fluid will move in a direction tending to produce a stable or static state.

Effect of Evacuating Air from a Column

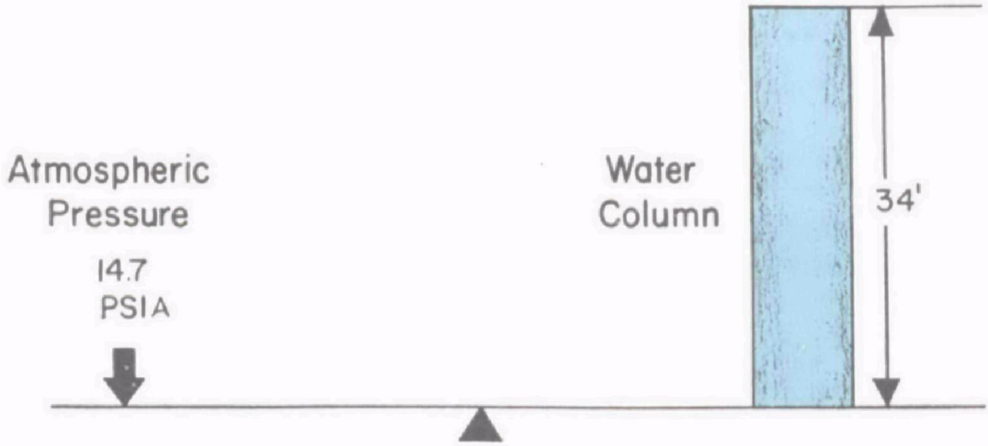


FIGURE 5

The following diagram (figure 6) is of an inverted "U" tube which has been filled with water and placed in two open containers at sea level.

If the open containers are placed so that the liquid levels in each container are at the same height, a static state will exist; and the vacuum at any level in either leg of the "U" tube may be calculated as before.

The equilibrium condition is altered by raising one of the containers so that the liquid level in one container is 5 feet above the level of the other. (See figure 7.) Since both containers are open to the atmosphere, the pressure on the liquid surfaces in each container will still remain at about 14.7 psia. However, a static condition cannot exist in this instance, since under static conditions the same pressure will exist in a continuous liquid only if the two points are at the same elevation above sea level. The fluid will, therefore, move toward a static state (i.e., where the free surfaces in each container are at the same level).

One method of determining the flow within the tube may be demonstrated if it is assumed that a static state exists, momentarily, within the system and the degree of vacuum that exists at a point in the left tube from the height of the point above the free surface in the left container is calculated. The degree of vacuum which would exist in this static state at the corresponding level in the right tube above the

Pressure Relationships at Different Elevations in a Continuous Fluid System

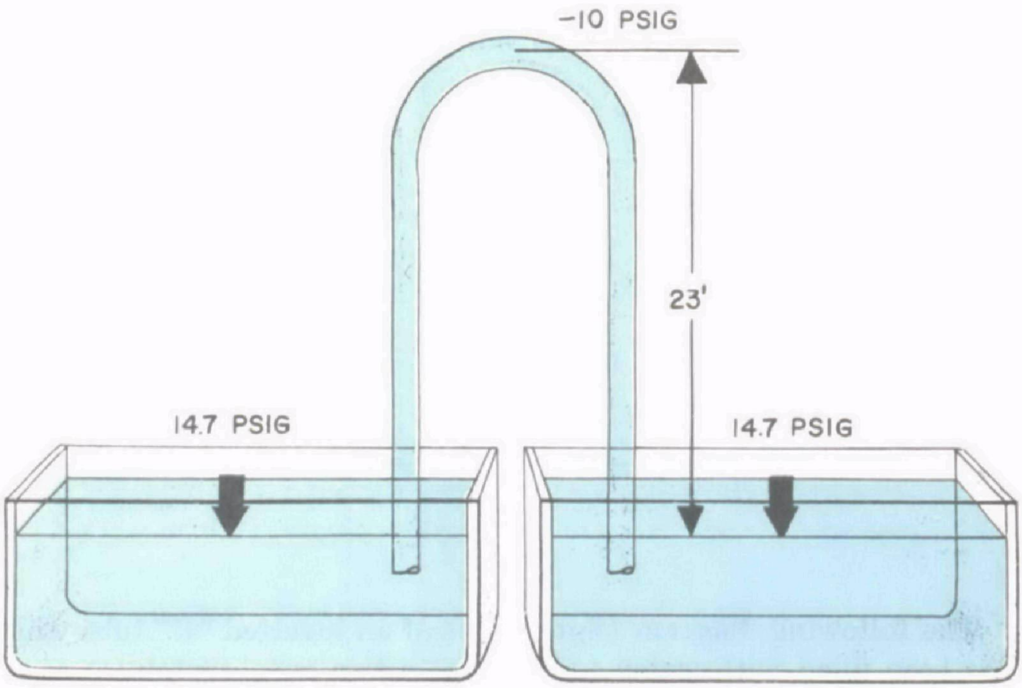


FIGURE 6

free surface in the right container may also be worked out, and if so, it would be observed that the degree of vacuum at this point, and at all levels of the left tube, would be greater than at corresponding levels in the right tube. Since the flow of fluid is from the higher pressure to the lower pressure, the flow would be from the right tube to the left tube. This arrangement will be recognized as a siphon.

Naturally, water flows *downhill;* but with the aid of a siphon it may also flow *over* the hill with the additional help of the atmospheric pressure. The crest of the siphon, however, cannot, ideally, be higher than 34 feet above the upper liquid surface since the atmosphere cannot support a column of water greater in height than 34 feet.

Figure 8 illustrates how this siphon principle can be hazardous in a plumbing system. Atmospheric pressure acts at the open faucet and also at the water closet which is located at a higher elevation. If the supply valve is closed, the degree of vacuum in the line supplying the faucet is greater at all levels than the vacuum in the supply line to the water closet. Flow will occur, therefore, through siphonage, from the water closet to the open faucet.

Pressure Relationships at Different Elevations in a Continuous Fluid System

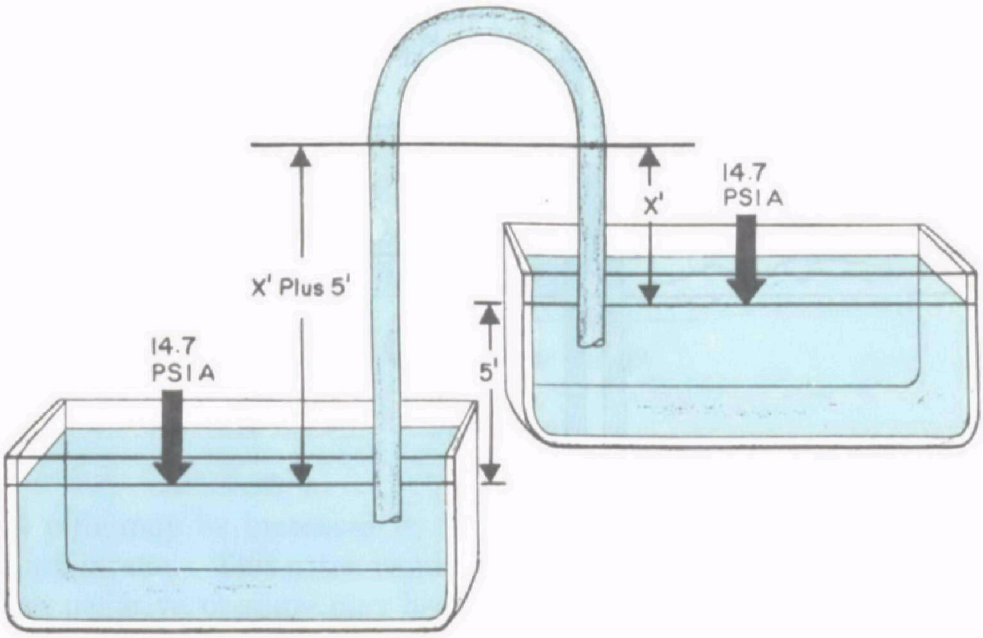


FIGURE 7

The siphon actions cited have been produced by reduced pressures or vacuum resulting from a difference in the water levels at two separated points within a continuous fluid system. It should also be noted that reduced pressure may also be created within a fluid system as a result of dynamic pressures. One of the basic principles of fluids as well as of other forms of matter is the principle of conservation of energy. Based upon this principle, it may be shown that as a fluid accelerates, as shown in figure 9, the pressure is reduced. As water flows through a constriction such as a converging section of pipe, the speed of the water is increased; but as a result, the pressure is reduced. Under possible circumstances, negative pressures may be developed in a pipe. The simple aspirator is based upon this principle. If this point of reduced pressure is linked to a source of pollution, backsiphonage of the pollutant can occur.

One of the common occurrences of dynamically reduced pipe pressures is found on the suction side of a pump. In many cases similar to the one illustrated in figure 10, the line supplying the booster pump is undersized or does not have sufficient pressure to deliver water at the rate at which the pump normally operates. The rate of flow in

Siphon Action in a Plumbing System

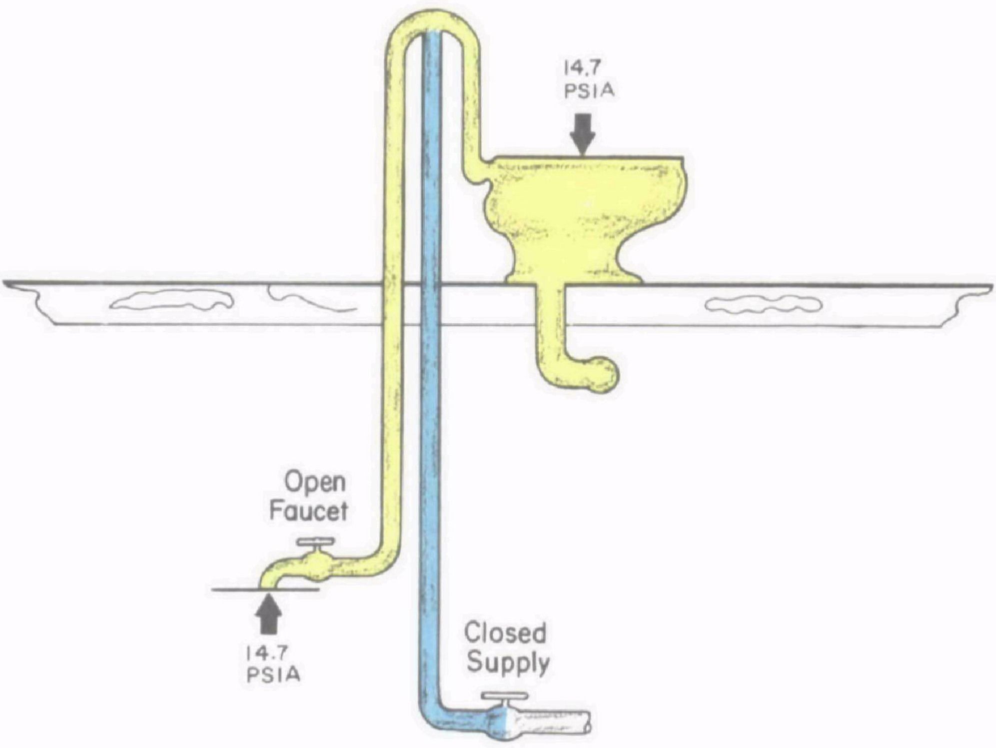


FIGURE 8

Negative Pressures Created by Constricted Flow

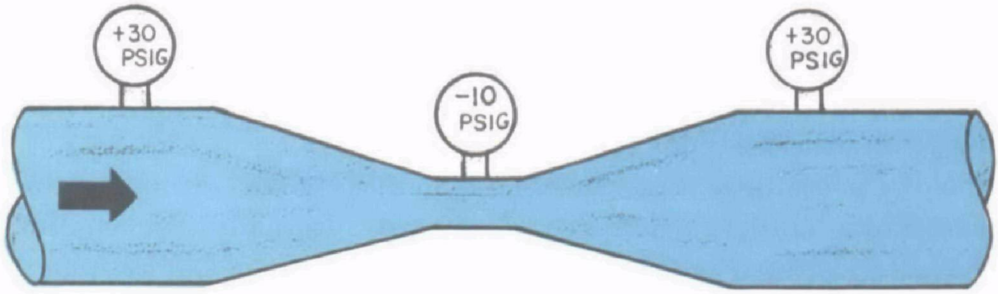


FIGURE 9

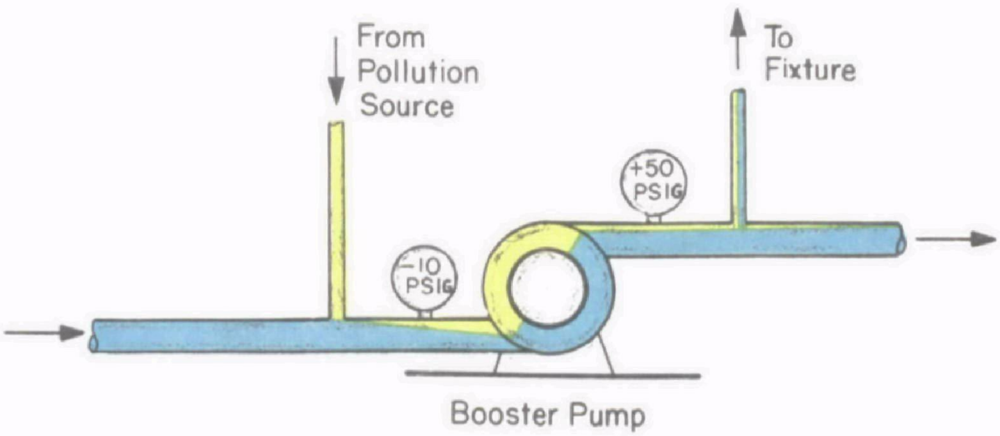


FIGURE 10

the pipe may be increased by a further reduction in pressure at the pump intake. This often results in the creation of negative pressures. This negative pressure may become low enough in some cases to cause vaporization of the water in the line. Actually, in the illustration shown, flow from the source of pollution would occur when pressure on the suction side of the pump was less than pressure of the pollution source but this is BACKFLOW which will be discussed below.

The preceding discussion has described some of the means by which negative pressures may be created and which frequently occur to produce backsiphonage. In addition to the negative pressure or reversed force which is necessary to cause backsiphonage and backflow, there must also be the cross-connection or connecting link between the potable water supply and the source of pollution. Two basic types of connections may be created in piping systems. These are the SOLID PIPE with valved connection and the SUBMERGED INLET. Figures 11 and 12 illustrate solid connections. This type of connection is often installed where it is necessary to supply an auxiliary piping system from the potable source. It is a direct connection of one pipe to another pipe or receptacle.

Solid pipe connections are often made to continuous or intermittent waste lines where it is assumed that the flow will be in one direction only. An example of this would be used cooling water from a water jacket or condenser as shown in figure 12. This type of connection is usually detectable but creating a concern on the part of the installer about the possibility of reversed flow is often more difficult. Upon

Valved Connection Between Potable Water and Non-Potable Fluid

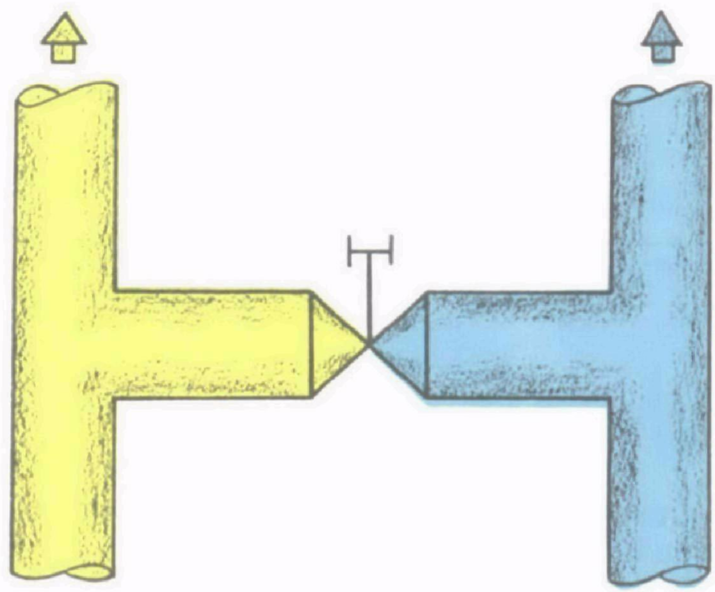


Figure 11

questioning, however, many installers will agree that the solid connection was made because the sewer is occasionally subjected to back pressure.

Submerged inlets are found on many common plumbing fixtures and are sometimes necessary features of the fixtures if they are to function properly. Examples of this type of design are siphon-jet urinals or water closets, flushing rim slop sinks and dental cuspidors. Old style bathtubs and lavatories had supply inlets below the flood level rims but modern sanitary design has minimized or eliminated this hazard in new fixtures. Chemical and industrial process vats sometimes have submerged inlets where the water pressure is used as an aid in diffusion, dispersion, and agitation of the vat contents. Even though the supply pipe may come from the floor above the vat, backsiphonage can occur as it has been shown that the siphon action can raise a liquid such as water almost 34 feet. Some submerged inlets difficult to control are those which are not apparent until a significant

Valved Connection Between Potable Water and Sanitary Sewer

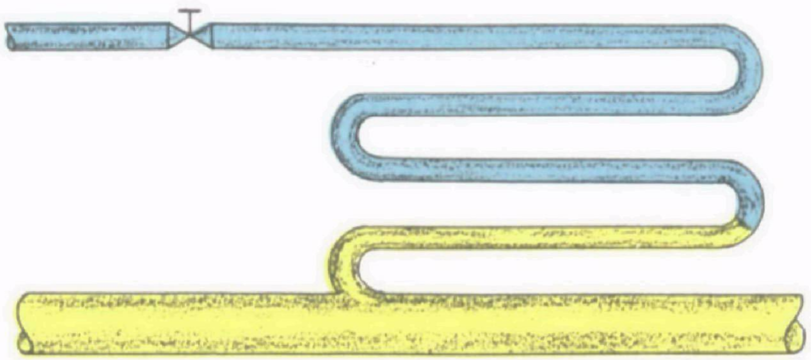


Figure 12

change in water level occurs or where a supply may be conveniently extended below the liquid surface by means of a hose or auxiliary piping. A submerged inlet may be created in numerous ways, and its detection in some of these subtle forms may be difficult.

The illustrations included in part B of the appendix are intended to describe typical examples of backsiphonage, showing in each case the nature of the link or cross-connection, and the cause of the negative pressure.

BACKFLOW.[1] Backflow, as described in this manual, refers to reversed flow due to back pressure other than siphonic action. Any interconnected fluid systems in which the pressure of one exceeds the pressure of the other may have flow from one to the other as a result of the pressure differential. The flow will occur from the zone of higher pressure to the zone of lower pressure. This type of backflow is of concern in buildings where two or more piping systems are maintained. The potable water supply is usually under pressure directly from the city water main. Occasionally, a booster pump is used. The auxiliary system is often pressurized by a centrifugal pump, although back pressure may be caused by gas or steam pressure from a boiler. A differential pressure may occur when pressure in the

[1] See formal definition in the glossary of the appendix.

potable system is reduced, by some means, to a pressure lower than that in the system to which the potable water is connected.

The most positive method of avoiding this type of backflow is the total or complete separation of the two systems. Other methods used involve the installation of mechanical devices. All methods require routine inspection and maintenance.

Dual piping systems are often installed for extra protection in the event of an emergency or possible mechanical failure of one of the systems. Fire protection systems are an example. Another example is the use of dual water connections to boilers. These installations are sometimes interconnected thus creating a health hazard.

The illustrations in part C of the appendix depict installations where backflow under pressure can occur, describing the cross-connection and the cause of the reversed flow.

Chapter 4.—METHODS AND DEVICES FOR THE PREVENTION OF BACKFLOW AND BACK-SIPHONAGE

The control of fire necessitates the removal of one of the three requirements for combustion, namely, fuel, oxygen, or heat. The control of backflow requires the removal of one of the two essential factors, namely, the physical link, or the cause of the reversed pressure gradient (i.e., the pressure reduction in the reversed direction). The removal of the link, or cross-connection, is a positive means of preventing backflow. However, the proper operation of some fixtures, such as the siphon-yet water closet, requires the link in the form of a submerged inlet. There are NO cases where the cross-connection CANNOT be removed or corrected, and the solution which will provide adequate safety to health should be chosen.

AIR GAP SEPARATION. The only absolute means of eliminating the physical link is through the use of the vertical air gap, as illustrated by figure 13 (Page 22). Air gaps should be used wherever possible, and where used must not be bypassed.

The supply inlet to the fixture should be terminated above the flood level rim of the fixture by a distance equal to at least two times the effective opening[1] of the fixture. There should be no provision for extending the fixture outlet below the flood level rim. If the end of the supply pipe is threaded or serrated to permit the connection of a hose, a properly installed vacuum breaker should also be provided.

Some minimum air gaps for internally used plumbing fixtures are shown in the following table excerpted from the National Plumbing Code ASA A40.8–1955.

Minimum airgaps for internally used plumbing fixtures

Fixture	Minimum airgap	
	When not affected by near wall [1] (inches)	When affected by near wall [2] (inches)
Lavatories and other fixtures with effective openings not greater than ½-in. diameter	1.0	1.50
Sink, laundry trays, goose-neck bath faucets and other fixtures with effective openings not greater than ¾-in. diameter	1.5	2.25
Over rim bath fillers and other fixtures with effective openings not greater than 1-in. diameter	2.0	3.0
Drinking water fountains—single orifice 7/16 (0.437) in. diameter or multiple orifices having total area of 0.150 sq. in. (area of circle 7/16-in. diameter)	1.0	1.50
Effective openings greater than 1 in.	(3)	(4)

[1] Side walls, ribs, or similar obstructions do not affect airgaps when spaced from inside edge of spout opening a distance greater than 3 times the diameter of the effective opening for a single wall, or a distance greater than 4 times the diameter of the effective opening for 2 intersecting walls.

[2] Vertical walls, ribs, or similar obstructions extending from the water surface to or above the horizontal plane of the spout opening require a greater airgap when spaced closer to the nearest inside edge of spout opening than specified in note 1 above. The effect of 3 or more such vertical walls or ribs has not been determined. In such cases, the airgap shall be measured from the top of the wall.

[3] 2 times diameter of effective opening.

[4] 3 times diameter of effective opening.

[1] See glossary in appendix.

Air Gap on Lavatory

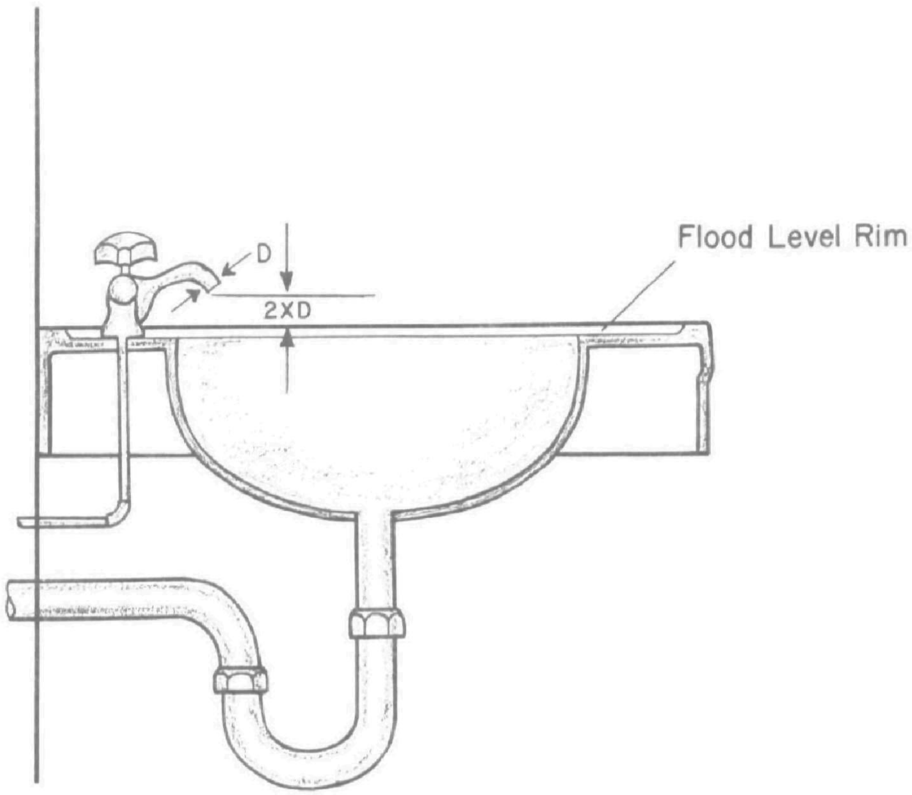


FIGURE 13

If an air gap separation is provided at each fixture, complete protection will be provided within the building as well as to the municipal supply. The separation may also be made at one point where the water service enters the building. However, this protects only the municipal water supply system. Where the air gap separation is made at the building water service entrance, a single surge tank is often used. The single surge tank, which is illustrated in figure 14, consists of a reservoir and pump combination with the potable water supply to the reservoir delivered through an air gap. The surge tank is used often in installations where water is needed in industrial processes. The potable water piping system supplies the lavatory fixtures and drinking fountains while the pumped system may provide water for industrial processes. Many dual piping systems are not adequately identified by a color code. A color code system is recommended to help prevent the possibility of the two systems becoming inadvertently interconnected.

When color marking is used, a green color should be used for potable waterlines and a yellow color for nonpotable waterlines. As painting long stretches of pipe may be costly and difficult, color bands, 3 inches wide may be applied at intervals which should not exceed 25 feet. The pipes should also be banded on both sides of points where they pass through walls or ceilings.

SURGE TANKS. The surge tank may be used to serve single fixtures or equipment units, or entire house systems. The size of each unit is determined by the water demand rate which it is to accommodate. The rate of flow into the receiving reservoir of the simple surge tank shown in figure 14 is governed by the float valve. The booster pump draws suction from the reservoir, or surge tank, and discharges directly to the distribution system under pressure. When the discharge of the booster pump is to serve points where water will be withdrawn for domestic use, the surge tanks should be properly covered to prevent contamination.

Surge Tank and Booster Pump

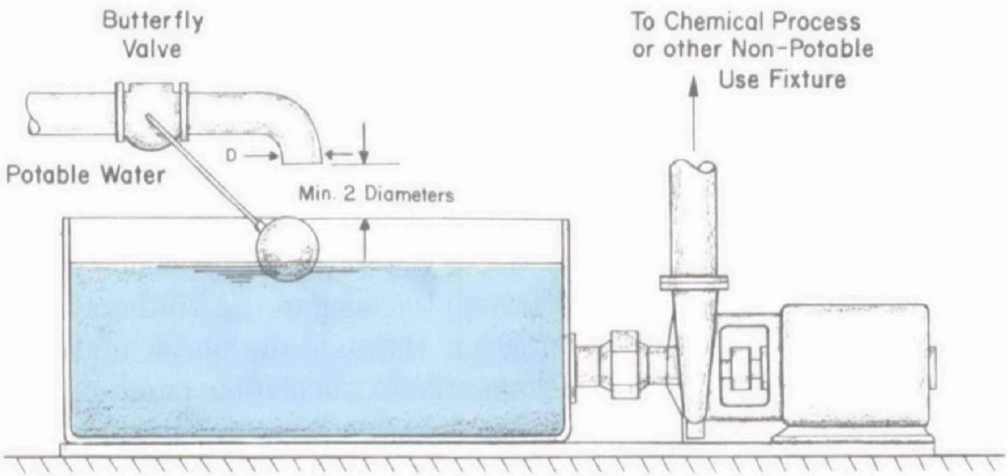


FIGURE 14

An elaboration on the simple surge tank is the combination surge tank and hydropneumatic tank shown in figure 15. The addition of the hydropneumatic tank provides additional pressurized storage permitting the use of a slightly smaller capacity booster pump in systems where the demand rate of the system is not uniform. The use of an air compressor also permits longer intervals between cycles of pump operation.

BOOSTER SYSTEMS. Booster pumps are often required in high buildings. Frequently these booster pumps are connected directly to the city water main or water service under which conditions

Hydro-Pneumatic
Booster System

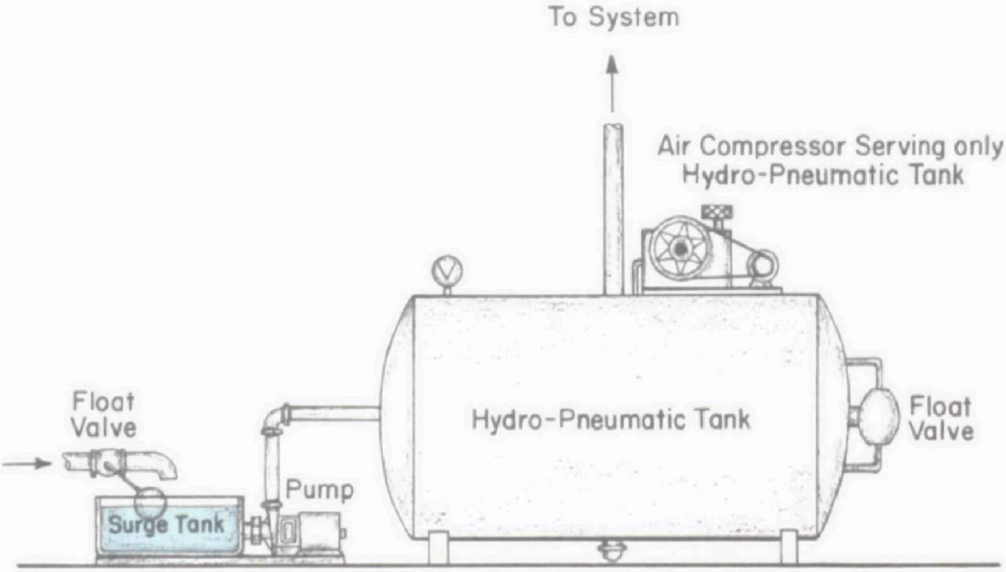


FIGURE 15

there is always the possibility of creating a negative pressure in the water main, as shown in figure 28 of appendix B. A simple surge tank could be used to protect the city main in such cases. Its disadvantage is that all or most of the city water pressure which otherwise might be available, is lost through the air gap. Also there is the hazard of introducing contamination through the surge tank. A pressure limiting switch can be connected to the booster pump suction to prevent the pump from creating negative pressures in the main, but operators find it convenient to shunt around such a switch if there is any interruption in service. Figure 16 illustrates a positive method of negative pressure control, which at the same time permits the direct use of city pressure when the pressure is adequate.

When the city pressure is sufficient, the booster pump is operated with full city pressure applied to the intake side of the pump. An altitude, or pressure reducing valve, is installed below the reservoir to minimize the required reservoir height. If the pressure in the water main drops below the pressure differential of the pressure-reducing valve, air is drawn in through the pressure-reducing valve, air binding the pump and causing it to stop. If air binding the pump is undesirable, a low-water level pump shutoff switch may be added to the unit.

House Booster System

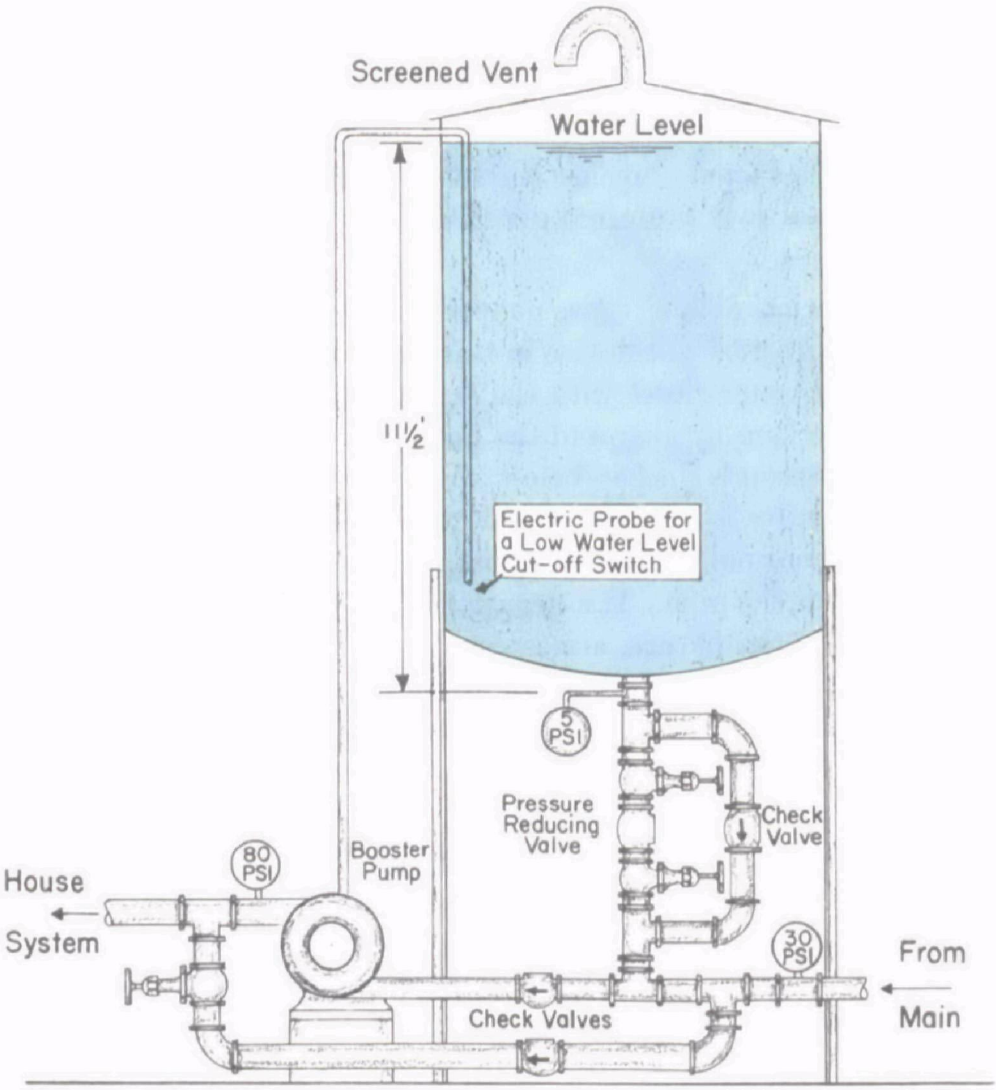


FIGURE 16

VACUUM BREAKERS. A fundamental factor in backsiphonage, as outlined in chapter 3, is vacuum or negative pressure. If atmospheric pressure is admitted to a piping system between a source of pollution and the origin of the vacuum, backsiphonage will be prevented. This is the function of a vacuum breaker. Because a vacuum may be created at numerous places in a piping system, a vacuum breaker must be located as near as possible to the fixture from which contamination is anticipated. The position of a vacuum breaker must be sufficiently above the fixture flood level rim so that flooding or submergence of the vacuum breaker or backpressure cannot occur.

Two types of vacuum breakers have been developed. One is designed to be installed on the pressurized distribution system. This device is called a pressure type vacuum breaker, as it is designed to be operable even after having remained under hydrostatic pressure for extended periods of time. The other is called the non-pressure-type vacuum breaker. The nonpressure type vacuum breaker must always be installed on the atmospheric side of the fixture valve. The installation of a vacuum breaker on the atmospheric side of the last control valve is always preferred over the use of a pressure type vacuum breaker.

The operation of one type, nonpressure, vacuum breaker is illustrated in figure 17. The device in this instance is installed on a flushometer valve water closet with the flushometer valve located directly above the vacuum breaker and the flood level rim of the water closet located at least six inches below the vacuum breaker. When the flushometer valve is operated, the flow of water is downward and the disc is in the normal, vertically seated position, preventing water from spilling out of the pipe. If a negative pressure should develop on the supply line to the fixture, atmospheric pressure would be exerted on the disc and within the supply line above the flood level rim, thus preventing backsiphonage from the water closet. This action is illustrated by views 2 & 3. The vacuum breaker IS NOT designed to provide protection against backflow resulting from BACKPRESSURE and should not be installed where backpressure may occur.

Figure 18 shows another nonpressure type vacuum breaker installation. The serrated outlet laboratory sink supply might easily be extended by a hose to a point below the flood level rim of the laboratory sink thus producing a cross-connection. The vacuum breaker installation on the atmospheric side of the control valve and between the cross-connection and the control valve effectively protects the piping system against backsiphonage. Figures 22 & 23 show other types.

The pressure type vacuum breaker operates on the reverse principle of the non-pressure type in that the moving parts do not complete a full cycle of operation each time the fixture or supply line is used. The principle of operation is shown in figure 19. The device is designed to open permitting the admission of air to satisfy the vacuum when a negative head occurs in the supply line. It does not provide protection in the case of backflow resulting from backpressure. Such devices have limited application as a positive protection against backflow and should be used only on specific authorization of the administrative authority having jurisdiction.

Operation of a Vacuum Breaker

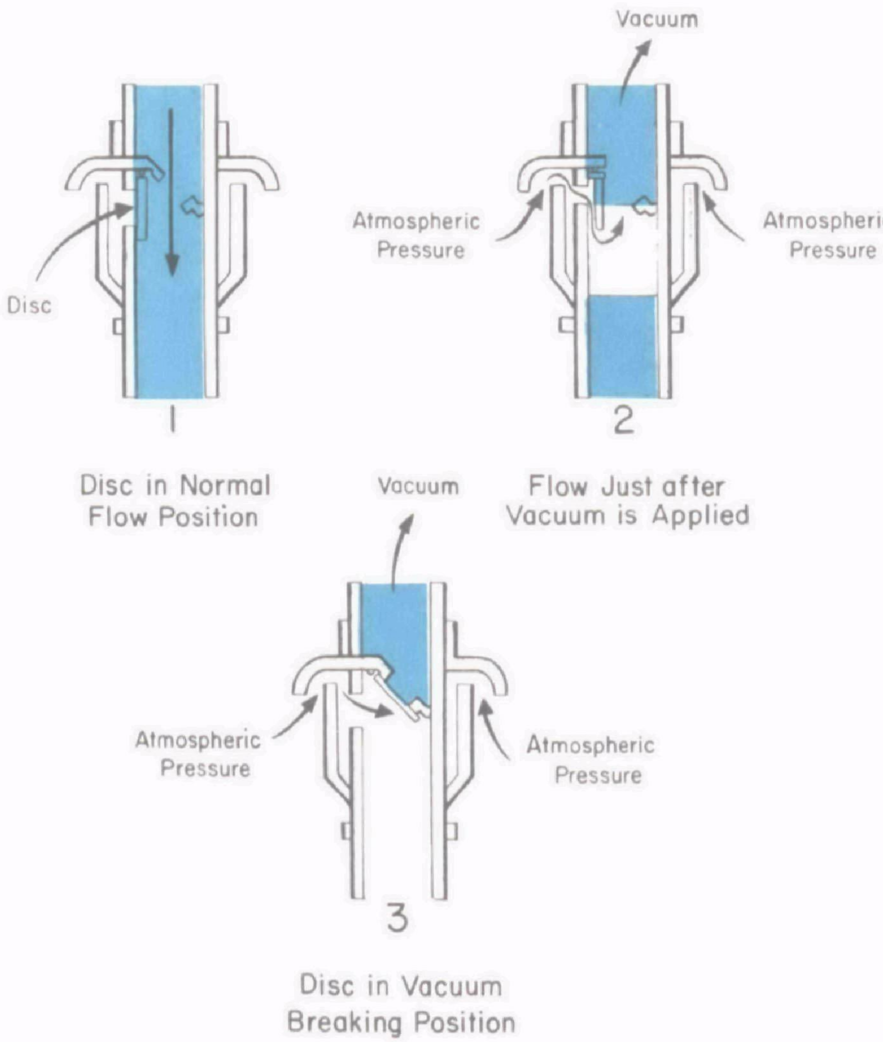


FIGURE 17

REDUCED PRESSURE PRINCIPLE BACKFLOW PREVENTER. The pressure and nonpressure type vacuum breakers are designed to prevent backsiphonage only and cannot be installed where backpressures are likely to occur. In situations where it would be extremely difficult to provide a physical break between two systems and where backpressures can be expected, a reduced pressure principle, backflow preventer can be used. This device consists of two, hydraulically or mechanically loaded, pressure reducing, check valves with a pressure regulated relief valve located between the two check valves as shown by figure 20.

Flow from the left enters the central chamber against the pressure exerted by the loaded check valve number 1. The supply pressure is reduced thereupon by a predetermined amount. The pressure in the

Typical Non-Pressure Type
Vacuum Breaker Installation

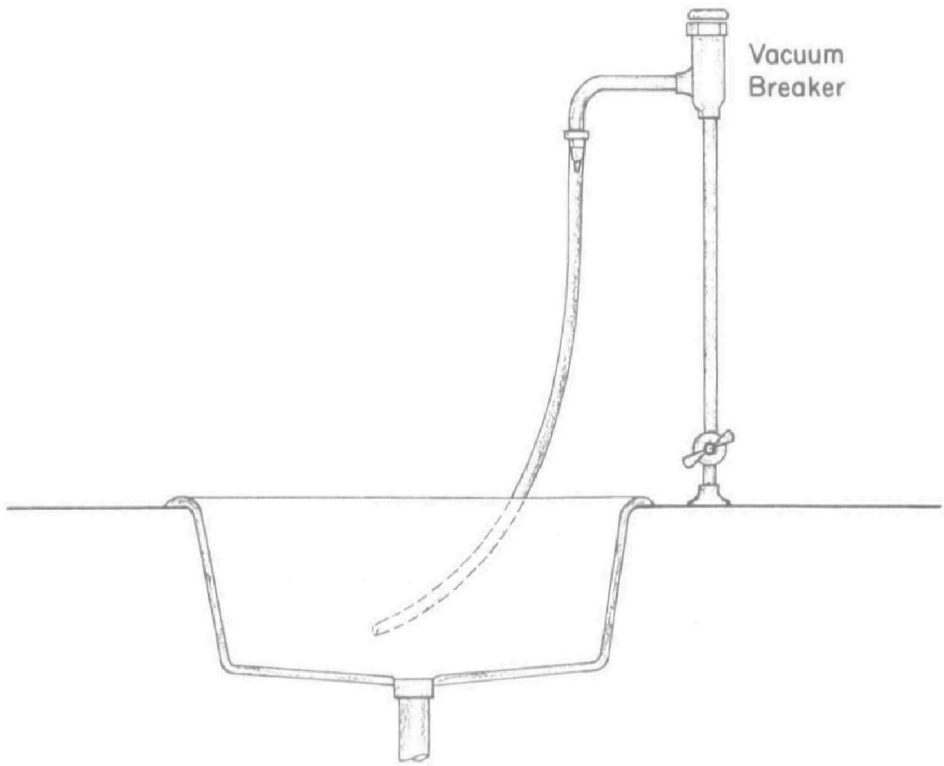


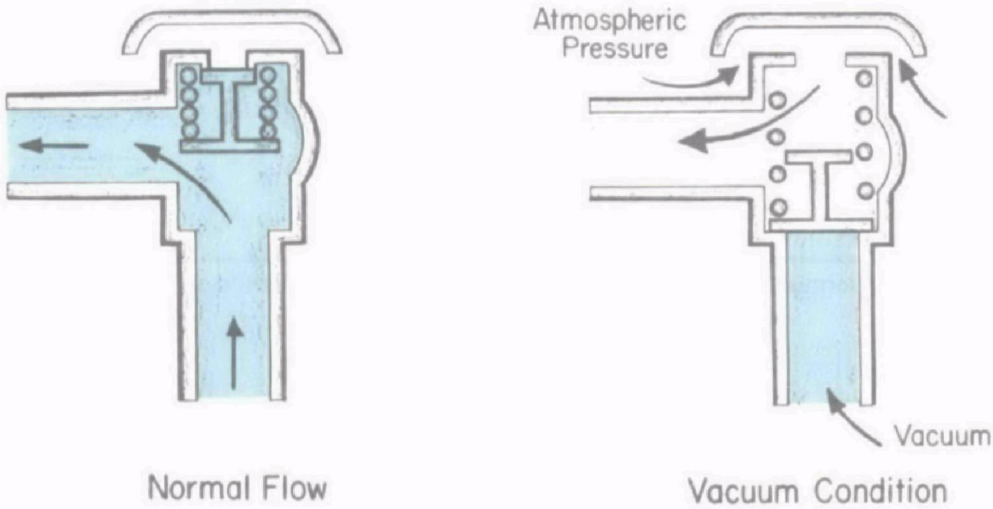
FIGURE 18

central chamber is maintained lower than the incoming supply pressure through the operation of the relief valve number 3, which discharges to the atmosphere whenever the central chamber pressure approaches within a few pounds of the inlet pressure. Check valve number 2 is lightly loaded to open with a pressure drop of 1 psi in the direction of flow and is independent of the pressure required to open the relief valve. In the event that the pressure increases downstream from the device, tending to reverse the direction of flow, check valve number 2 closes, preventing backflow. Because all valves may leak as a result of wear or obstruction, the protection provided by the check valves is not considered sufficient. If some obstruction prevents check valve number 2 from closing tightly, the leakage back into the central chamber would increase the pressure in this zone, the relief valve would open, and flow would be discharged to the atmosphere.

When the supply pressure drops to the minimum differential required to operate the relief valve, the pressure in the central chamber should be atmospheric. If the inlet pressure should become less than atmospheric pressure, relief valve number 3 should remain fully open to the atmosphere to discharge any water which may be

Pressure-Type Vacuum Breaker

(Not Applicable Where
Back-Pressure May Occur)



NOTE: This shows the principle of operation. Other types have a sliding spool which closes the air inlet when there is forward flow.

FIGURE 19

caused to backflow as a result of backpressure and leakage of check valve number 2.

Malfunctioning of one or both of the check valves or relief valve should always be indicated by a discharge of water from the relief port. This factor is an important advantage over earlier backflow devices. The pressure loss through the device may be expected to average between 10 and 20 pounds per square inch within the normal range of operation, depending upon the size and flow rate of the device.

DOUBLE CHECK VALVE ASSEMBLY AND OTHER METHODS. Other methods and devices have been promoted for the separation of auxiliary systems or for the prevention of backflow. Among these are the single check valve, the plain double check valve assembly, the double check valve-double gate valve assembly, the swivel connection, and the barometric loop.

The single check valve offers no visual or mechanical means of determining malfunctioning, and since all mechanical devices are

Reduced Pressure Zone Backflow Preventer
(Principle of Operation)

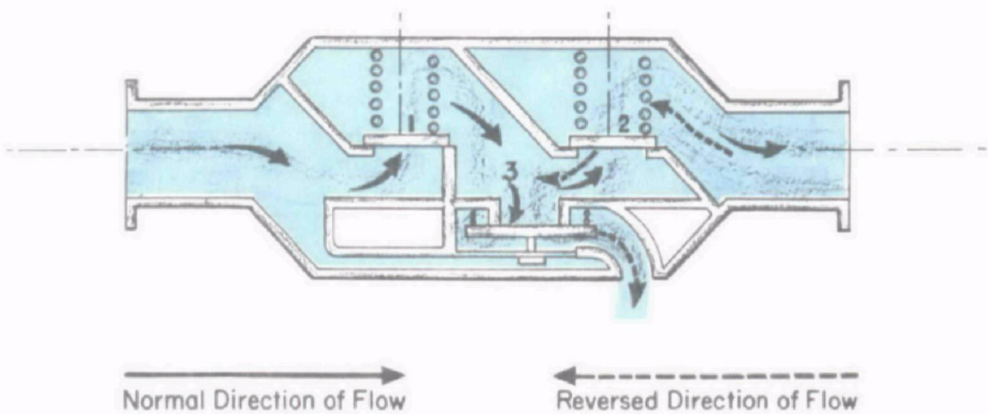


FIGURE 20

Swing Connection

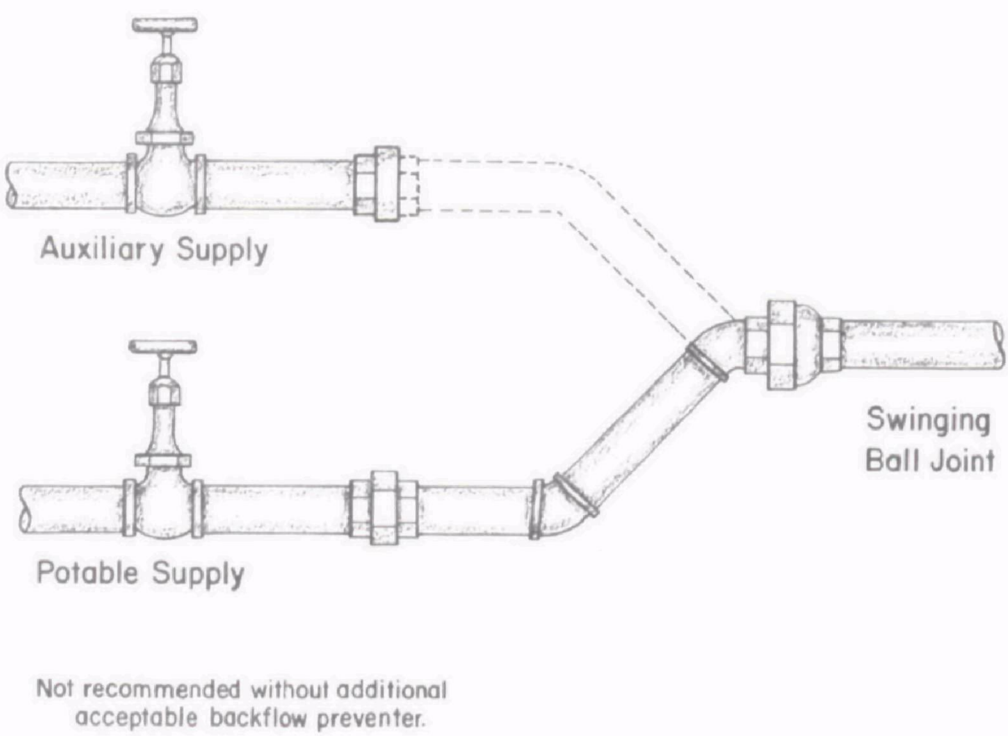


FIGURE 21

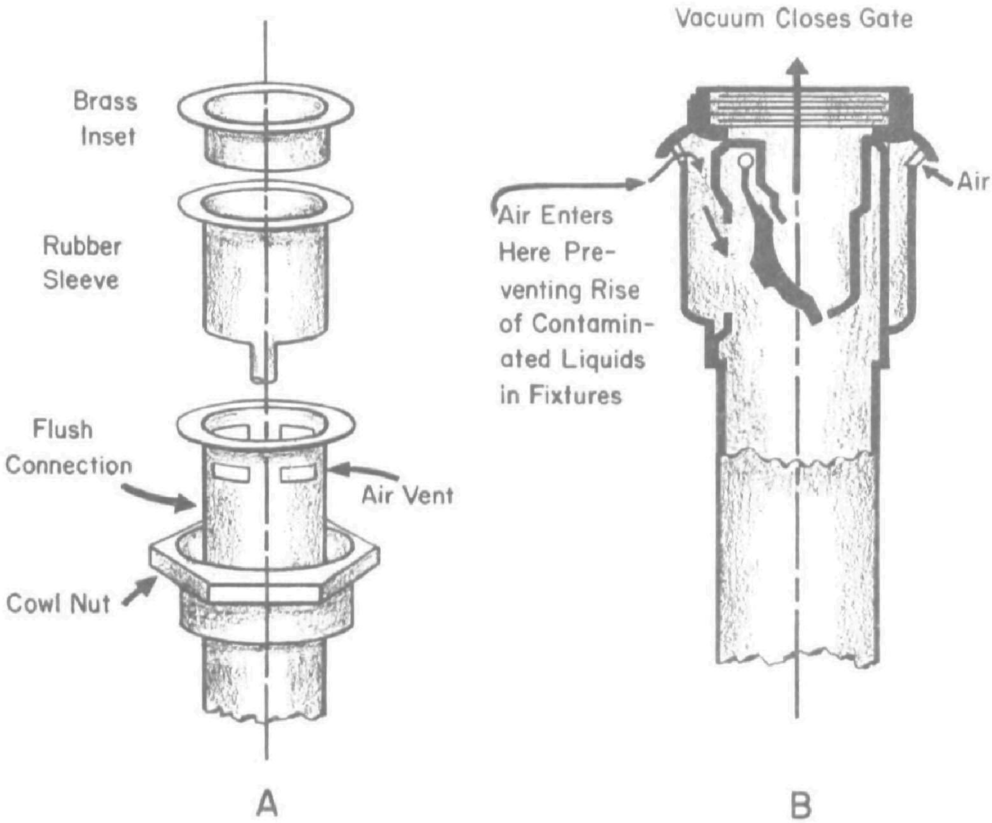


FIGURE 22

subject to wear and interference resulting from deposits and other factors, the single check valve is not considered an adequate backflow preventer. Double check valve assemblies in series, including those with spacers and manual bleed valves, have similar disadvantages. The advantage offered by the manual bleed valve is usually negated by the human element which may cause the valve to remain closed.

The double check-double gate valve assembly, shown in Figure 26, is a very useful and, when properly maintained, reliable means of backflow protection for intermediate degrees of hazard. Frequently referred to as the Factory-Mutual assembly, this device had been in service at some plants since the early 1900's. As in the case of other backflow preventers, the double check-double gate valve assembly should be inspected at regular intervals. Some health authorities have established programs of annual inspection.

The double check-double gate system has the advantage of a low head loss. With the gate valves wide open the two checks, when in open position, offer little resistance to flow.

Vacuum Breaker Arrangement for Outside Hose Hydrant

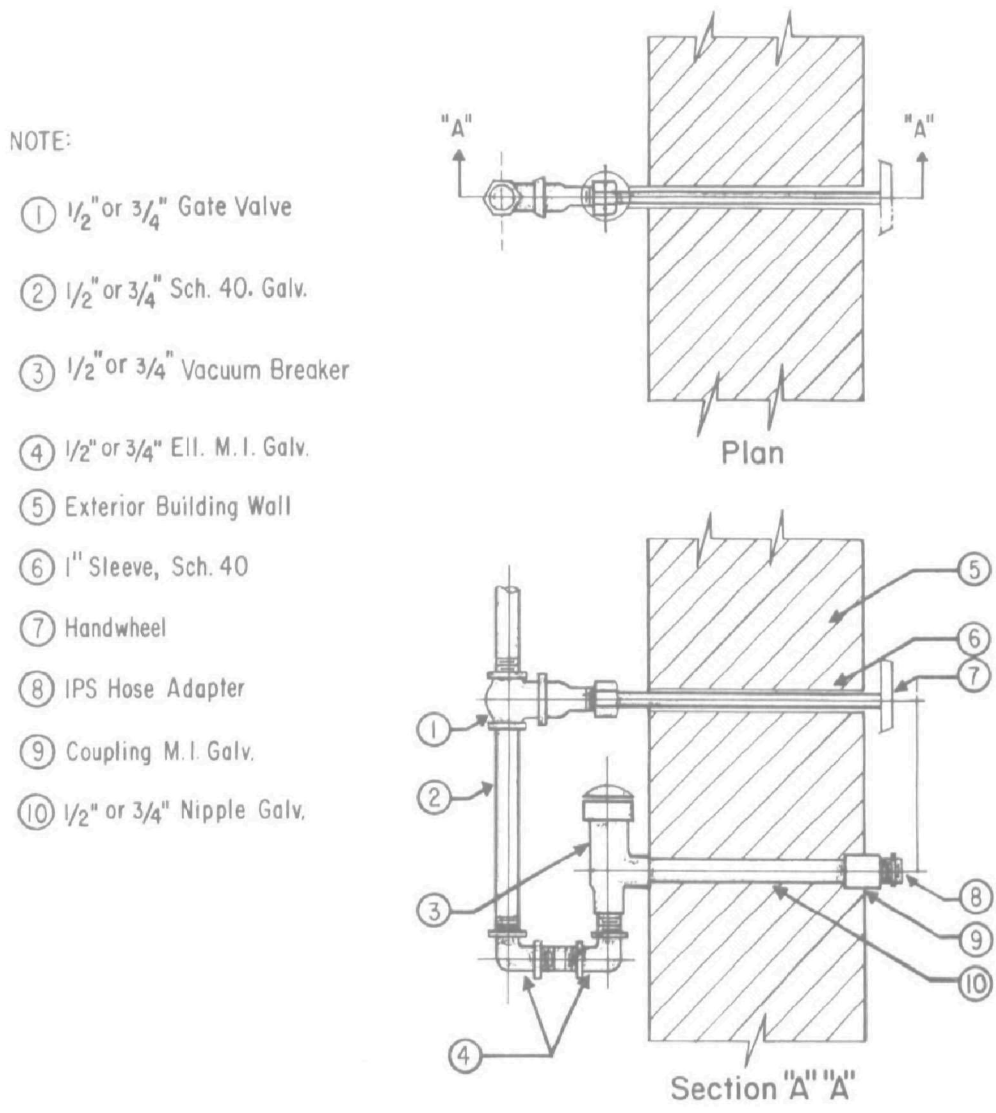


FIGURE 23

Double check-double gate assemblies should be well designed and constructed. The valves should be all bronze or, for larger sizes, galvanized gray iron. The trim should be of bronze, or other corrosion resistant material. Springs should be bronze, stainless steel, or spring steel covered with a coat of vinyl plastic. Valve discs should be of composition material with low water absorption properties. Test cocks should be provided.

The swivel connection shown in figure 21 does not offer adequate protection against backflow between the two systems which it interconnects. It should not be used to connect a hazardous system to a potable system without the inclusion of an acceptable means of backflow prevention.

Fire System Make-up Tank
for a Dual Water System

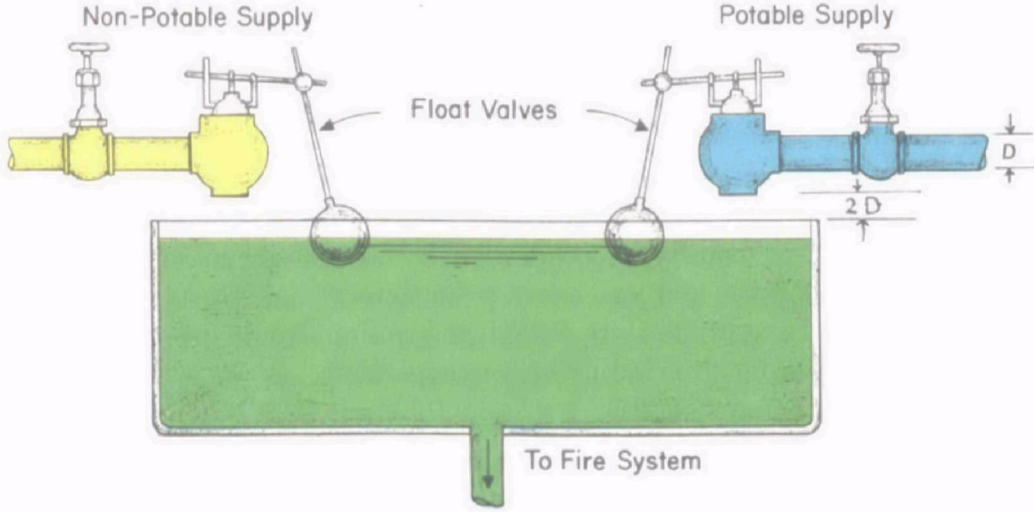


FIGURE 24

The barometric loop consists of a vertical loop of pipe extending at least 35 feet above the highest fixture. The principle is that a complete vacuum cannot raise water to an elevation greater than 33.9 feet. The device, however, does not provide protection against backflow due to backpressure and the installation of a pipe loop of this height is usually difficult and expensive. As a result it is not widely used.

The air gap method may be used to permit the use of an alternate source of water for a fire system or for some other distribution system not requiring a potable water. This method, as shown in figure 24, provides the reliability of having two separate sources of water and at the same time adequately protecting the potable supply against backflow from the nonpotable system.

Chapter 5. TESTING PROCEDURES FOR BACKFLOW PREVENTERS

VACUUM BREAKER, ATMOSPHERIC. Normal failure of an atmospheric type vacuum breaker is the result of a rupture of the rubber membrane in devices using the rubber check valve, or the result of damage or failure of the disc in the disc type devices. This type of failure is usually accompanied by an excessive weeping or leakage of the device and can readily be determined through visual examination. In addition to visual inspection, some of the units should be disassembled periodically for inspection.

REDUCED PRESSURE PRINCIPLE BACKFLOW PREVENTER. The reduced pressure principle backflow installation should include a tight closing gate valve at each end of the device.

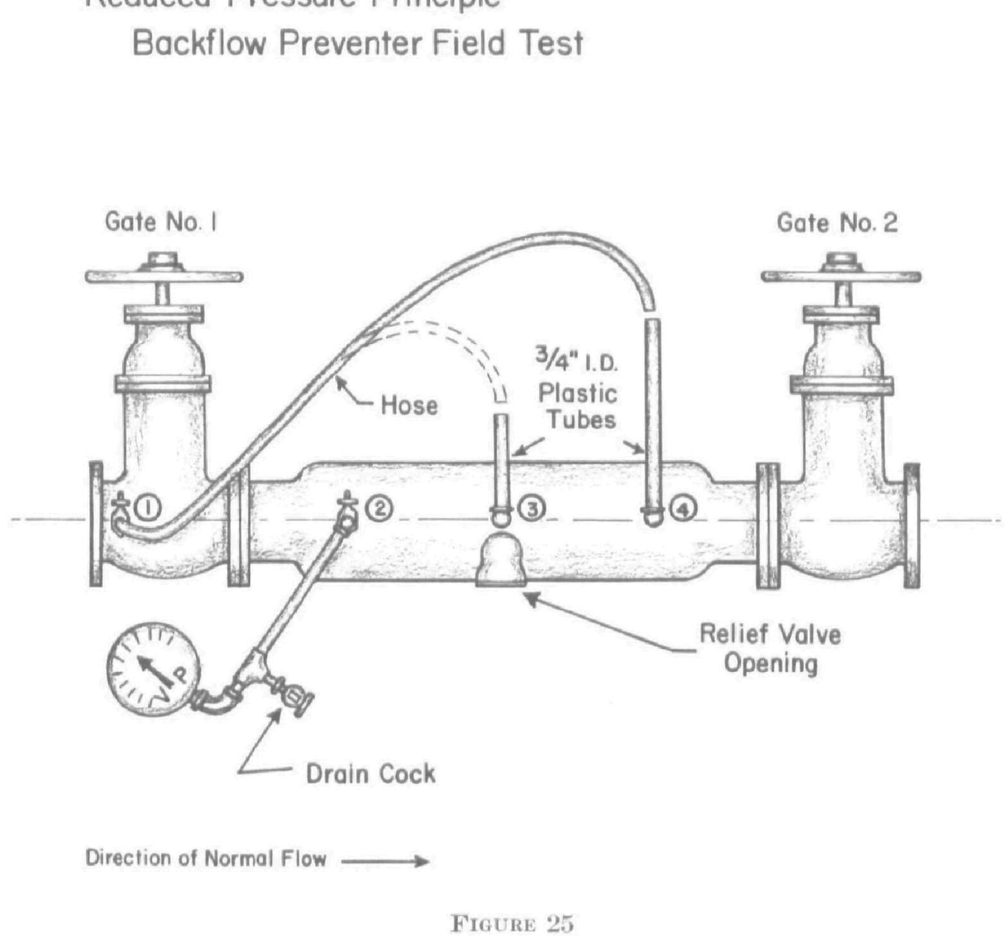


FIGURE 25

Four threaded ½-inch test cocks should be installed as indicated in figure 25. Additional equipment required to conduct the tests is as follows:

1. One—Compound gage capable of indicating a vacuum equal to 30 inches of mercury or about 15 psi.
2. One—Plastic tube 1 inch O.D. x ¾-inch I.D. x 6 inches long with an adapter to ½-inch pipe thread and a ½-inch street ell.
3. One—Plastic tube as above; 12 inches long with adapter and street ell.
4. One—Compound gage and connecting piping with drain cock as shown on the diagram.
5. One—Eight-foot length of ¼-inch hose with an adapter to ¼-inch pipe.

In the operation of the RPPBP, the reduced pressure zone between the two check values is maintained at a pressure less than the supply line pressure by the action of the relief valve. The relief valve should be capable of maintaining a reduced pressure zone, which is at least 2 psi less than the supply pressure. Both check valves should close tightly against backflow under adverse pressure differentials.

TEST PROCEDURE. Attach equipment as shown in the diagram.

A. Close gate valve No. 2. If the relief valve starts to drain, the first check valve is leaking.
B. Close gate valve No. 1.
C. Open test cock No. 4 to fill the plastic tube, and crack open gate valve No. 1, until a small dribble continues over the top of the tube.
D. Open test cock No. 3. Water will then spill over the top of the short tube.
E. Open test cock No. 2.
F. Open the drain cock No. 1 slowly until the spillage over the top of the short tube stops. Check the gage reading at this point. This reading is the pressure drop across the first check valve and should be not less than 6 psi nor more than 11 psi.
G. Slowly open the drain cock, thereby causing the gage pressure to fall.
H. As the gage pressure approaches 2 psi, the water column in tube No. 3 will slowly fall, and should rapidly fall, just as the relief valve opens. (In valves 6 inches and larger, it may be necessary to refill tube with hose.) The gage reading at this point should not be less than 2 psi.
I. Open the drain cock wide, causing relief valve to open wide.

J. If the water level in the tube at test cock No. 4 remains at top of tube, the check valve No. 2 is tight. If the water level falls when the relief valve is open, refill No. 4 tube with the hose and maintain the water level at the top of the tube. If the relief valve drains continually, the second check valve is leaking. If there is no drainage from the relief valve, but flow through the hose is required to maintain water level in the No. 4 tube, then the second gate valve is leaking.

DOUBLE CHECK-DOUBLE GATE VALVES

The double check-double gate valve assembly should include test, hose-bibbs as shown in figure 26. A method for testing the check valves is as follows:

A. WHERE BACK-PRESSURE IS AVAILABLE ON PRIVATE SUPPLY

1. Open all Test Hose Bibbs individually to flush out any sediment or scale.
2. Close Gate Valves A and G.
3. Open Test Hose Bibbs B and F, successively. If leakage occurs, Gate Valve(s) A and/or G are leaking and must be repaired before continuing test.
4. If no leakage at Test Hose Bibbs B and F with Gate Valves A and G closed, proceed with the following:
   a. Open Gate Valve G and Test Hose Bibb D. If leakage does not cease, Check Valve E is leaking and must be repaired. If leakage ceases, Check Valve E is tight.
   b. Temporarily connect a hose between Test Hose Bibbs D and F and open these Hose Bibbs. Open Test Hose Bibb B. If leakage does not cease, Check Valve C is leaking and must be repaired. If leakage ceases, Check Valve C is tight.
   c. If Check Valves are repaired, repeat the test as above.
5. When the test is complete, close Test Hose Bibbs and remove the hose. Leave Gate Valves A and G in their proper position.

B. WHERE INSUFFICIENT BACKPRESSURE IS AVAILABLE ON PRIVATE SUPPLY

1. Open all Test Hose Bibbs individually to flush out any sediment or scale.
2. Close Gate Valves A and G.
3. Open Test Hose Bibbs B and F, successively. If leakage occurs, Gate Valve(s) A and/or G are leaking and must be repaired before continuing test.

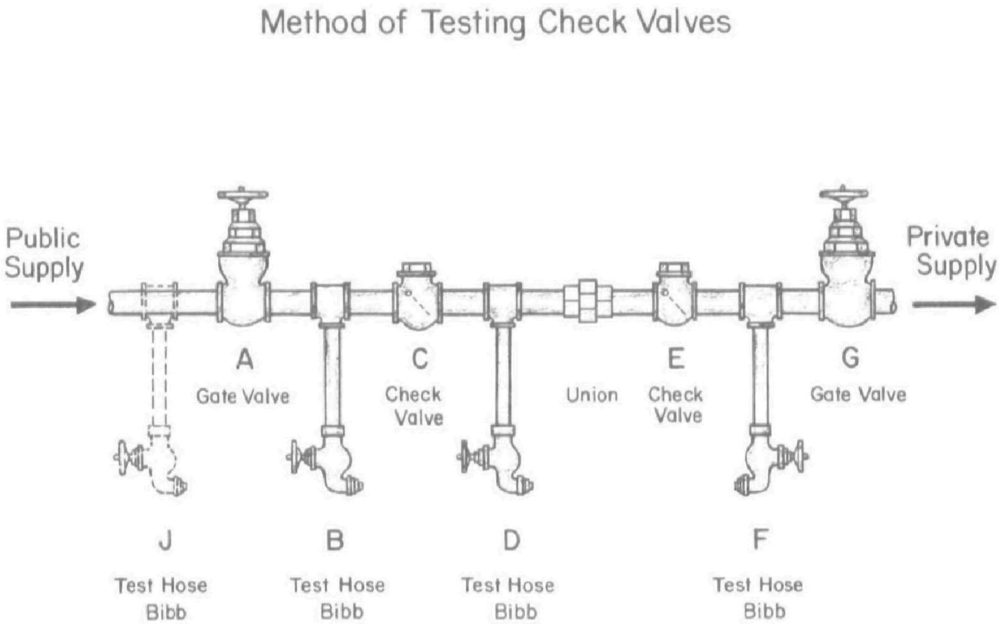


FIGURE 26

4. If no leakage at Test Hose Bibbs B and F with Gate Valves A and G closed, proceed with the following:
   a. Temporarily connect a hose between Test Hose Bibbs J and F and open these Test Hose Bibbs. Open Test Hose Bibb D. If leakage does not cease, Check Valve E is leaking and must be repaired. If leakage ceases, Check Valve E is tight.
   b. Close Hose Bibbs J and F. Temporarily connect the hose between Test Hose Bibbs J and D and open these Test Hose Bibbs. Open Test Hose Bibb B. If leakage does not cease, Check Valve C is leaking and must be repaired. If no leakage occurs, Check Valve C is tight.
   c. If Check Valves are repaired, repeat the test as above.
5. When the test is complete, close Test Hose Bibbs and remove the hose. Leave Gate Valves A and G in their proper position.

Chapter 6. PROTECTION OF PUBLIC WATER SUPPLY

Public water supply distribution systems must be protected against the hazards of contamination of the potable water in the pipes. The text thus far has dealt mainly with the subject of building plumbing but frequent reference has also been made to the main water supply system. Other health hazards affecting a community water supply distribution system include the following types.

1. Direct connection to an auxiliary piping system carrying nonpotable water. *Example:* Some municipalities have a separate water distribution system containing untreated river water for fire fighting. There are recorded instances where the potable and nonpotable systems were directly connected with only a valve separating them.
2. Connection to a well water pump system containing nonpotable or questionable water.
3. Fire hydrants with weep holes are a hazard. Note: It is difficult to obtain from a fire hydrant a water sample free from coliform organisms.
4. Interconnections with other public water supply systems supposed to contain potable water but which actually do not.
5. Connections to premises such as industrial establishments, shipyards, docks, abbatoirs, and others where major contamination of water can take place and the polluted water be forced or sucked back into the public water supply distribution system.
6. Open reservoirs of finished water are always points where accidental or covert contamination of water can occur.
7. Inadequately sized piping in a public water supply system sets the stage for the reduced pressures and negative head conditions conducive to backflow and backsiphonage.

Water supply and public health officials should assure themselves that hazards of the above or other types are eliminated or safely controlled. The preceding text has dealt with methods of protecting water service lines on a premise. The requirement of an air gap in the service line to a premise where extreme hazard is possible may be warranted. Reduced pressure principle or double check-double gate backflow preventers are often used in cases of lesser hazard.

The appearance of fire hydrants without weep holes holds promise but filling hydrant risers with toxic antifreeze solutions should be prohibited as should their use in sprinkler systems.

Direct connections between potable and nonpotable water supply systems should be eliminated or properly protected and interconnections with other public water supply systems should be permitted only with the approval of health authorities.

The potable water distribution system should be so designed that the sizes of pipes are adequate to supply water in the amounts and at the pressures in which it is needed. When a system is sized to meet the needs of peak fire demand, other uses are usually covered but at the time of large fires water pressure in remote parts of the system may be reduced even to the point of vacuum. Following a large fire, water and health authorities should be alert for appearances of contamination.

Private wells should have no connection to the potable, public water supply system. Open reservoirs should be covered or, where this is not possible, auxiliary chlorination should be provided.

When there are main breaks due to deterioration or damage such as by flood, large quantities of water escape at the affected point and pressures elsewhere in the system may drop seriously. Breaks should be repaired promptly and an alert maintained for the appearance of contamination. The precaution of first thoroughly flushing, then disinfecting repaired and new pipe sections should be observed.

Chapter 7. ADMINISTRATION OF A CROSS CONNECTION CONTROL PROGRAM

RESPONSIBILITY. Public health personnel, water works officials, plumbing inspectors, building managers, plumbing installers, and maintenance men all share to some degree the responsibility for protecting the health and safety of individuals and the public from contaminated water. These responsibilities include insuring sanitary design and installation practices in piping systems and the supervision of the installation and maintenance of these systems. Public health officials should promote the development of sanitary design of plumbing systems and encourage as well as assist in the training of persons responsible for their installation and maintenance. Officials responsible for the inspection of plumbing installations should require the maximum protection against backflow which is consistent with good judgement and the public safety. Plumbing installers and maintenance personnel should observe and avoid or eliminate possibilities for backflow and be diligent in adherence to plumbing codes and ordinances.

Where plumbing defects are detected, notification of the persons having authority for the correction of such defects should be made in writing and the responsible person should cause these defects to be corrected as soon as possible.

Water works officials should survey their own and their customers' distribution systems for cross-connections on a continuing basis and should provide a satisfactory program for the elimination of health hazards. Frequently, their responsibility ends at the property line but in some municipalities it extends to the building piping. Water works officials often prescribe the installation of a backflow prevention device in the service line to a premise where hazardous use of water is found.

PRIORITY OF ACTION. Plumbing defects are in existence and defects are constantly being created in new plumbing systems and in altering existing systems. The elimination of these health hazards will be possible only through a well-planned and continuing program of instruction, plumbing surveillance, and repair. Many types of cross-connections exist, and the danger to public health resulting from each differs widely. The possibility of causing serious pollution of the potable water supply system is dependent upon the degree of hazard of the contaminant and the probability of reversed flow.

Although, statistically, the probability of reversed flow may seem remote, reliance should not be placed upon this factor. Complete removal of all cross-connections should be undertaken in an organized manner and a priority system based upon the degree of hazard involved should be established. It is not feasible in this manual to assign priority to all types of cross-connections or even to classify them except in a general way. Determining priority of action in their removal should be based primarily on the nature of the pollutant. High priority should be given any cross-connection between a potable water supply and a piping system or reservoir conveying or containing SEWAGE, TOXIC OR HAZARDOUS CHEMICALS OR NON-POTABLE WATER. All such connections should be broken IMMEDIATELY and properly protected.

Obsolete fixtures, such as tubs and lavatories, having inlets terminating below the overflow level, have a lower priority but outlets should be raised or the fixtures replaced. Fixtures which have serrated or threaded inlets that would permit the extension of these inlets below the flood level rim could be particularly hazardous and should be provided with vacuum breakers. Where this is not possible, the fixtures should be replaced on a systematic, improvement basis. Fixtures which can siphon only a SMALL AMOUNT of relatively LOW HAZARD WASTE water, do not warrant urgent or drastic action and can be given a lower priority. These illustrations describe the common extremes of urgency or priority and only a careful evaluation of the circumstances surrounding each specific plumbing hazard will enable establishing reasonable priority for intermediate situations. As stated previously, in establishing a priority of action, RELIANCE SHOULD *NOT* BE PLACED UPON THE PROBABILITY FACTOR OF THE OCCURRENCE OF REVERSED FLOW.

METHOD OF ACTION. A broad program of cross-connection control should include INSTRUCTION, INSPECTION, AND IMPROVEMENT or NEW INSTALLATION. Methods applied to new installations, however, are different from those applied to existing plumbing systems. Control of NEW INSTALLATIONS should be accomplished through PLAN REVIEW AND INSTALLATION INSPECTION. Control and elimination of EXISTING HAZARDS should be accomplished through ROUTINE INSPECTION AND PERIODIC SURVEYS at definite intervals. Trained personnel, competent in plan examination and hazard evaluation, should supervise the control program. Sanitary inspectors who have qualifications equivalent to licensed plumbers and who have been specially instructed in cross-connection control should be assigned to the task of inspecting new and existing plumbing installations. The results of periodic surveys should be tabulated and summarized for comparison with the results of previous surveys. Only through this means will improvement, or lack of improvement, be noted. Through a summarization of the number of violations of specific types effective action may be directed against the most prevalent and most hazardous violations.

As an aid to the less experienced inspector, a limited tabulation of typical hazardous connections is listed in the appendix of this manual along with several illustrations of backsiphonage and backflow. Also shown in the appendix is a survey form for reporting on inspections for health hazards.

Chapter 8. CROSS-CONNECTION CONTROL ORDINANCE PROVISIONS

INTRODUCTION

The successful promotion of a cross-connection and backflow connection control program in a municipality will be dependent upon legal authority to conduct such a program. Where a community has adopted a modern plumbing code such as the National Plumbing Code, ASA A40.8–1955 or subsequent revisions thereof, provisions of the code will govern backflow and cross-connections. It then remains to provide an ordinance which will establish a program of inspection for an elimination of cross and backflow connections within the community. Frequently authority for such a program may already be possessed by the water department or water authority. In such cases no further document may be needed. A cross-connection control ordinance should have at least three basic parts.

1. Authority for establishment of a program.
2. The technical provisions relating to eliminating backflow and cross-connections, and
3. Penalty provisions for violations.

The following simple form is suggested for municipalities who desire to adopt a cross-connection control ordinance. The technical provisions are excerpted from a revision of the National Plumbing Code prepared by the Public Health Service Technical Committee on Plumbing Standards. Where the National Plumbing Code or subsequent revisions thereof is in effect, the technical sections of the following can be replaced by a statement of reference to the Code. Communities adopting ordinances should check with State Health Officials to assure conformance with state codes. The form of the ordinance should comply with local legal requirements.

ORDINANCE FOR THE CONTROL OF BACKFLOW AND CROSS-CONNECTIONS

Section 1. Authority

1.1 *Responsibility of the Director.* The Director, Department of ————, or his designated agent, shall inspect the plumbing in every building or premises in this City as frequently as in his judgment may be necessary to ensure that such plumbing has been installed in such a manner as to prevent the possibility of pollution of the water supply of the city by the plumbing. The director shall notify or cause to be notified in writing the owner or authorized agent of the owner of any such building or premises, to correct, within a reasonable time set by the Director, any plumbing installed or existing contrary to or in violation of this ordinance, and which is his judgment, may, therefore, permit the pollution of the city water supply, or otherwise adversely affect the public health.

1.2 *Inspection.* The Director, or his designated agent, shall have the right of entry into any building, during reasonable hours, for the purpose of making inspection of the plumbing systems installed in such building or premises provided that with respect to the inspection of any single family dwelling, consent to such inspection shall first be obtained from a person of suitable age and discretion therein or in control thereof.

Section 2. Definitions

2.1 *Agency.* The Department of the municipal government invested with the authority and responsibility for the enactment and enforcement of this ordinance.

2.2 *Air Gap.* The unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet supplying water to a tank, plumbing fixture, or other device and the flood level rim of the receptacle.

2.3 *Approved.* Accepted by the Agency as meeting an applicable specification stated or cited in this ordinance, or as suitable for the proposed use.

2.4 *Auxiliary Supply.* Any water source or system other than the city water supply which may be available in the building or premises.

2.5 *Backflow.* The flow of water or other liquids, mixtures or substances into the distributing pipes of a potable supply of water from any source or sources other than its intended source. Backsiphonage is one type of backflow.

2.6 *Backflow Preventer.* A device or means to prevent backflow.

2.7 *Backsiphonage.* The flowing back of used, contaminated or polluted water from a plumbing fixture or vessel or other sources into a water supply pipe due to a negative pressure in such pipe.

2.8 *Barometric Loop.* A loop of pipe rising approximately 35 feet, at its topmost point, above the highest fixture it supplies.

2.9 *Check Valve.* An automatically operated device which is designed to permit the flow of fluids in one direction and to close if there is a reversal of flow.

2.10 *Contamination.* See pollution.

2.11 *Cross-connection.* Any physical connection or arrangement between two otherwise separate piping systems, one of which contains potable water and the other water of unknown or questionable safety, steam, gases or chemicals whereby there may be a flow from one system to the other. See BACKFLOW AND BACKSIPHONAGE.

2.12 *Drain.* Any pipe which carries waste water or water-borne wastes in a building drainage system.

2.13 *Fixture, Plumbing.* Installed receptacles, devices, or appliances supplied with water or which receive or discharge liquids or liquid-borne wastes.

2.14 *Flood Level Rim.* The edge of the receptacle from which water overflows.

2.15 *Hazard, Health.* Any conditions, devices, or practices in the water supply system and its operation which create, or, in the judgment of the Director, may create, a danger to the health and well-being of the water consumer. An example of a health hazard is a structural defect in the water supply system, whether of location, design, or construction, which may regularly or occasionally prevent satisfactory purification of the water supply or cause it to be polluted from extraneous sources.

2.16 *Hazard, Plumbing.* Any arrangement of plumbing including piping and fixtures whereby a cross-connection is created.

2.17 *Hydropneumatic Tank.* A pressure vessel in which air pressure acts upon the surface of the water contained within the vessel, pressurizing the water distribution piping connected to the vessel.

2.18 *Inlet.* The open end of the water supply pipe through which the water is discharged into the plumbing fixture.

2.19 *Plumbing System.* Includes the water supply and distribution pipes, plumbing fixtures and traps; soil, waste, and vent pipes; building drains and building sewers including their respective connections, devices, and appurtenances within the property lines of the premises, and water treating or water using equipment.

2.20 *Pollution.* The presence of any foreign substance (organic inorganic, radiological or biological) in water which tends to degrade its quality so as to constitute a hazard or impair the usefulness of the water.

2.21 *Reduced Pressure Principle Backflow Preventer.* An assembly of differential valves and check valves including an automatically opened spillage port to the atmosphere designed to prevent backflow.

2.22 *Surge Tank.* The receiving, nonpressure vessel forming part of the airgap separation between a potable and an auxiliary supply.

2.23 *Vacuum.* Any pressure less than that exerted by the atmosphere.

2.24 *Vacuum Breaker, Nonpressure Type.* A vacuum breaker which is designed so as not to be subjected to static line pressure.

2.25 *Vacuum Breaker, Pressure Type.* A vacuum breaker designed to operate under conditions of static line pressure.

2.26 *Water, Potable.* Any water which, according to recognized standards, is safe for human consumption.

2.27 *Water, Nonpotable.* Water which is not safe for human consumption or which is of questionable potability.

Section 3. General (Technical) Requirements

3.1 *General.* A potable water supply system shall be designed, installed and maintained in such manner as to prevent contamination from nonpotable liquids, solids or gases, from being introduced into the potable water supply through cross-connections or any other piping connections to the system.

3.2 *Cross-Connections Prohibited.* Cross-connections between potable water systems and other systems or equipment containing water or other substances of unknown or questionable safety are prohibited except when and where, as approved by the authority having jurisdiction, suitable protective devices such as the reduced pressure zone backflow preventer or equal are installed, tested and maintained to insure proper operation on a continuing basis.

3.3 *Interconnections.* Interconnection between two or more public water supplies shall be permitted only with the approval of the health authority having jurisdiction.

3.4 *Individual Water Supplies.* Cross-connections between an individual water supply and a potable public supply shall not be made unless specifically approved by the health authority having jurisdiction.

3.5 *Connections to Boilers.* Potable water connections to boiler feed water systems in which boiler water conditioning chemicals are introduced shall be made through an airgap or provided with an approved backflow preventer * located in the potable waterline before the point where such chemicals are introduced.

3.6 *Prohibited Connections to Fixtures and Equipment.* Connection to the potable water supply system for the following is prohibited unless protected against backflow in accordance with Section 3.8 or as set out herein.

(*a*) Bidets.

(*b*) Operating, dissection, embalming, and mortuary tables or similar equipment—in such installation the hose used for water supply shall terminate at least 12 inches away from every point of the table or attachments.

(*c*) Pumps for nonpotable water, chemicals or other substances—priming connections may be made only through an airgap.

(*d*) Building drainage, sewer or vent systems.

(*e*) Any other fixture of similar hazard.

3.7 *Refrigerating Unit Condensers and Cooling Jackets.* Except where potable water provided for a refrigerator condenser or cooling jacket is entirely outside the piping or tank containing a toxic refriger-

*Reduced pressure principal or double check-double gate valves.

ant, with two separate thickness of metal separating the refrigerant from the potable water supply, inlet connection shall be provided with an approved check valve. Also adjacent to and at the outlet side of the check valve, an approved pressure relief valve set to relieve at 5 psi above the maximum water pressure at the point of installation shall be provided if the refrigeration units contain more than 20 pounds of refrigerants.

3.8 *Protection Against Backflow and Backsiphonage.*

3.81 *Water Outlets.* A potable water system shall be protected against backflow and backsiphonage by providing and maintaining at each outlet:

(*a*) *Airgap:* An airgap as specified in § 3.82 between the potable water outlet and the flood level rim of the fixture it supplies or between the outlet and any other source of contamination, or

(*b*) *Backflow Preventer:* An approved backflow preventer device or vacuum breaker to prevent the drawing of contamination into the potable water system.

3.82 *Minimum Required Airgap.* (*a*) *How Measured:* The minimum required airgap shall be measured vertically from the lowest end of a potable water outlet to the flood rim or line of the fixture or receptacle into which it discharges.

(*b*) *Size:* The minimum required airgap shall be twice the effective opening of a potable water outlet unless the outlet is a distance less than three times the effective opening away from a wall or similar vertical surface in which cases the minimum required airgap shall be three times the effective opening of the outlet. In no case shall the minimum required airgap be less than shown in table 3.82, "Minimum Airgaps for Generally Used Plumbing Fixtures."

TABLE 3.82.—*Minimum airgaps for generally used plumbing fixtures*

Fixture	Minimum airgap	
	When not affected by near wall [1] (inches)	When affected by near wall [2] (inches)
Lavatories and other fixtures with effective openings not greater than ½-in. diameter	1.0	1.50
Sink, laundry trays, goose-neck bath faucets and other fixtures with effective openings not greater than ¾-in. diameter	1.5	2.25
Over rim bath fillers and other fixtures with effective openings not greater than 1-in. diameter	2.0	3.0
Drinking water fountains—single orifice 7/16 (0.437) in. diameter or multiple orifices having total area of 0.150 sq. in. (area of circle 7/16-in. diameter)	1.0	1.50
Effective openings greater than 1 inch	(3)	(4)

[1] Side walls, ribs, or similar obstructions do not affect airgaps when spaced from inside edge of spout opening a distance greater than 3 times the diameter of the effective opening for a single wall, or a distance greater than 4 times the diameter of the effective opening for 2 intersecting walls.

[2] Vertical walls, ribs, or similar obstructions extending from the water surface to or above the horizontal plane of the spout opening require a greater airgap when spaced closer to the nearest inside edge of spout opening than specified in note 1 above. The effect of 3 or more such vertical walls or ribs has not been determined. In such cases, the airgap shall be measured from the top of the wall.

[3] 2 times diameter of effective opening.

[4] 3 times diameter of effective opening.

3.83 *Approval of Devices.* Before any device for the prevention of backflow or backsiphonage is installed, it shall have first been certified by a recognized testing laboratory acceptable to the agency Director. Devices installed in a building potable water supply distribution system for protection against backflow shall be maintained in good working condition by the person or persons responsible for the maintenance of the system.

The agency Director or his designee shall inspect routinely such devices and if found to be defective or inoperative shall require the replacement thereof.

3.84 *Installation of Devices.* (*a*) *Vacuum Breakers:* Vacuum breakers shall be installed with the critical level at least 6 inches above the flood level rim of the fixture they serve and on the discharge side of the last control valve to the fixture. No shutoff valve or faucet shall be installed beyond the vacuum breaker. For closed equipment or vessels such as pressure sterilizers the top of the vessel shall be treated as the flood level rim but a check valve shall be installed on the discharge side of the vacuum breaker.

(*b*) *Reduced Pressure Principle Backflow Preventer:* A reduced pressure principle type backflow preventer may be installed subject to full static pressure.

(*c*) *Devices of all Types:* Backflow and backsiphonage preventing devices shall be accessibly located preferably in the same room with the fixture they serve. Installation in utility or service spaces, provided they are readily accessible, is also permitted.

3.85 *Tanks and Vats-Below Rim Supply.* (*a*) Where a potable water outlet terminates below the rim of a tank or vat and the tank or vat has an overflow of diameter not less than given in Table 3.85, "Sizes of Overflow Pipes for Water Supply Tanks", the overflow pipe shall be provided with an airgap as close to the tank as possible.

TABLE 3.85.—*Sizes of overflow pipes for water supply tanks*

Maximum capacity of water supply line to tank	Diameter of overflow pipe (Inches ID)	Maximum capacity of water supply line to tank	Diameter of overflow pipe (Inches ID)
0–50 gpm	2	400–700 gpm	5
50–150 gpm	2½	700–1,000 gpm	6
100–200 gpm	3	Over 1,000 gpm	8
200–400 gpm	4		

(*b*) The potable water outlet to the tank or vat shall terminate a distance not less than 1½ times the height to which water can rise in the tank above the top of the overflow. This level shall be established at the maximum flow rate of the supply to the tank or vat and with all outlets except the airgap, overflow outlet closed.

(c) The distance from the outlet to the high water level shall be measured from the critical point of the potable water supply outlet.

3.86 *Protective Devices Required.* Approved devices to protect against backflow and backsiphonage shall be installed at all fixtures and equipment where backflow and/or backsiphonage may occur and where a minimum airgap cannot be provided between the water outlet to the fixture or equipment and its flood level rim.

(*a*) *Connections Not Subject to Back Pressure:* Where a water connection is not subject to back pressure, a nonpressure type vacuum breaker shall be installed on the discharge side of the last valve on the line serving the fixture or equipment. A list of some conditions requiring protective devices of this kind is given in Table 3.86A, "Cross-Connections Where Protective Devices are Required and Critical Level (C-L) Settings for Backflow Preventers".

TABLE 3.86A.—*Cross-connections where protective devices are required and critical level (C-L) settings for backflow preventers* [1]

Fixture or equipment	*Method of installation*
Aspirators and ejectors	C-L at least 6 in. above flood level of receptacle served.
Dental units	On models without built-in vacuum breakers—C-L at least 6 in. above flood level rim of bowl.
Dishwashing machines	C-L at least 6 in. above flood level of machine. Install on both hot and cold water supply line.
Flushometers (closet & urinal)	C-L at least 6 in. above top of fixture supplies.
Garbage can cleaning machine	C-L at least 6 in. above flood level of machine. Install on both hot and cold water supply lines.
Hose outlets	C-L at least 6 in. above highest point on hose line.
Laundry machines	C-L at least 6 in. above flood level of machine. Install on both hot and cold water supply lines.
Lawn sprinklers	C-L at least 12 in. above highest sprinkler or discharge outlet.
Steam tables	C-L at least 6 in. above flood level.
Tank and vats	C-L at least 6 in. above flood level rim or line.
Trough urinals	C-L at least 30 in. above perforated flush pipe.
Flush tanks	Equip with approved ball cock. Where ball cocks touch tank water equip with vacuum breaker at least 1 in. above overflow outlets. Where ball cock does not touch tank water install ball cock outlet at least 1 in. above overflow outlet or provide vacuum breaker as specified above.
Hose bibbs (where aspirators or ejectors could be connected).	C-L at least 6 in. above flood level of receptacle served.

[1] Critical Level (C-L) is defined as the level to which the backflow preventer (vacuum breaker) may be submerged before backflow will occur. Where the C-L is not shown on the preventer, the bottom of the device shall be taken as the C-L.

(*b*) *Connections Subject to Back Pressure:* Where a potable water connection is made to a line, fixture, tank, vat, pump, or other equipment with a hazard of backflow or backsiphonage where the water connection is subject to backpressure, and an airgap cannot be installed, the Director may require the use of an approved reduced pressure principle backflow preventer. A partial list of such connections is shown in Table 3.86B, "Partial List of Cross-Connections Subject to Back Pressure".

TABLE 3.86B.—*Partial list of cross-connections which may be subject to back pressure.*

Chemical lines	Pumps
Dock water outlets	Steam lines
Individual water supplies	Swimming pools
Industrial process water lines	Tank and vats—Bottom inlets
Pressure tanks	Hose bibbs

3.87 *Barometric Loop.* Water connections where an actual or potential backsiphonage hazard exists may in lieu of devices specified in section 3.86 be provided with a barometric loop. Barometric loops shall precede the point of connection.

3.88 *Double Check-Double Gate Valves.* The Director may authorize installation of approved, double check-double gate valve assemblies with test cocks as protective devices against backflow in connections between a potable water system and other fluid systems which present no significant health hazard in the judgment of the Director.

3.89 *Low Pressure Cutoff Required on Booster Pumps.* When a booster pump is used on a water pressure booster system and the possibility exists that a positive pressure of 10 psi or less may occur on the suction side of the pump, there shall be installed a low pressure cutoff on the booster pump to prevent the creation of a vacuum or negative pressure on the suction side of the pump, thus cutting off water to other outlets.

Section 4. Maintenance Requirements

4.1 *General Requirements.* It shall be the responsibility of building and premise owners to maintain all backflow preventers and vacuum breakers within the building or on the premises in good working order and to make no piping or other arrangements for the purpose of bypassing backflow devices.

4.2 *Reduced Pressure Principle Backflow Preventers.* Periodic testing and inspection schedules shall be established by the Director for all reduced pressure type preventers and the interval between such testing and inspections and overhauls of each device shall be established in accordance with the age and condition of the device. Inspection intervals should not exceed 1 year, and overhaul intervals should not exceed 5 years. These devices should be inspected frequently after the initial installation to assure that they have been installed properly and that debris resulting from the installation has not interfered with the functioning of the device. The testing procedures shall be in accordance with the manufacturer's instructions when approved by the Director.

Section 5. Violations and Penalties

5.1 *Notification of Violation.* The Director shall notify the owner, or authorized agent of the owner, of the building or premises in which there is found a violation of this ordinance, of such violation. The Director shall set a reasonable time for the owner to have the violation removed or corrected. Upon failure of the owner to have the defect corrected by the end of the specified time interval the Director may, if in his judgment an imminent health hazard exists, cause the water service to the building or premises to be terminated, and/or recommend such additional fines or penalties to be invoked as herein may be provided.

5.2 *Fines.* The owner or authorized agent of the owner responsible for the maintenance of the plumbing systems in the building who knowingly permits a violation to remain uncorrected after the expiration of time set by the Director shall, upon conviction thereof by the court, be required to pay a fine of not more than $100 for each violation. Each day of failure to comply with the requirements of the Ordinance, after the specified time provided under 5.1, shall constitute a separate violation.

APPENDIX A—PARTIAL LIST OF PLUMBING HAZARDS

Fixtures With Direct Connections

Description
Air conditioning, air washer
Air conditioning, chilled water
Air conditioning, condenser water
Air line
Aspirator, laboratory
Aspirator, medical
Aspirator, weedicide and fertilizer sprayer
Autoclave and sterilizer
Auxiliary system, industrial
Auxiliary system, surface water
Auxiliary system, unapproved well supply
Boiler system
Chemical feeder, pot-type
Chlorinator
Coffee urn
Cooling system
Dishwasher
Fire standpipe or sprinkler system
Fountain, ornamental
Hydraulic equipment
Laboratory equipment
Lubrication, pump bearings
Photostat equipment
Plumber's friend, pneumatic
Pump, pneumatic ejector
Pump, prime line
Pump, water operated ejector
Sewer, sanitary
Sewer, storm
Swimming pool

Fixtures With Submerged Inlets

Description
Baptismal fount
Bathtub
Bedpan washer, flushing rim
Bidet
Brine tank
Cooling tower
Cuspidor
Drinking fountain
Floor drain, flushing rim
Garbage can washer

Ice maker
Laboratory sink, serrated nozzle
Laundry machine
Lavatory
Lawn sprinkler system
Photo laboratory sink
Sewer flushing manhole
Slop sink, flushing rim
Slop sink, threaded supply
Steam table
Urinal, siphon jet blowout
Vegetable peeler
Water closet, flush tank, ball cock
Water closet, flush valve, siphon jet

APPENDIX B

The following pages illustrate typical plumbing installations where back-siphonage is possible.

Back Siphonage-Case I

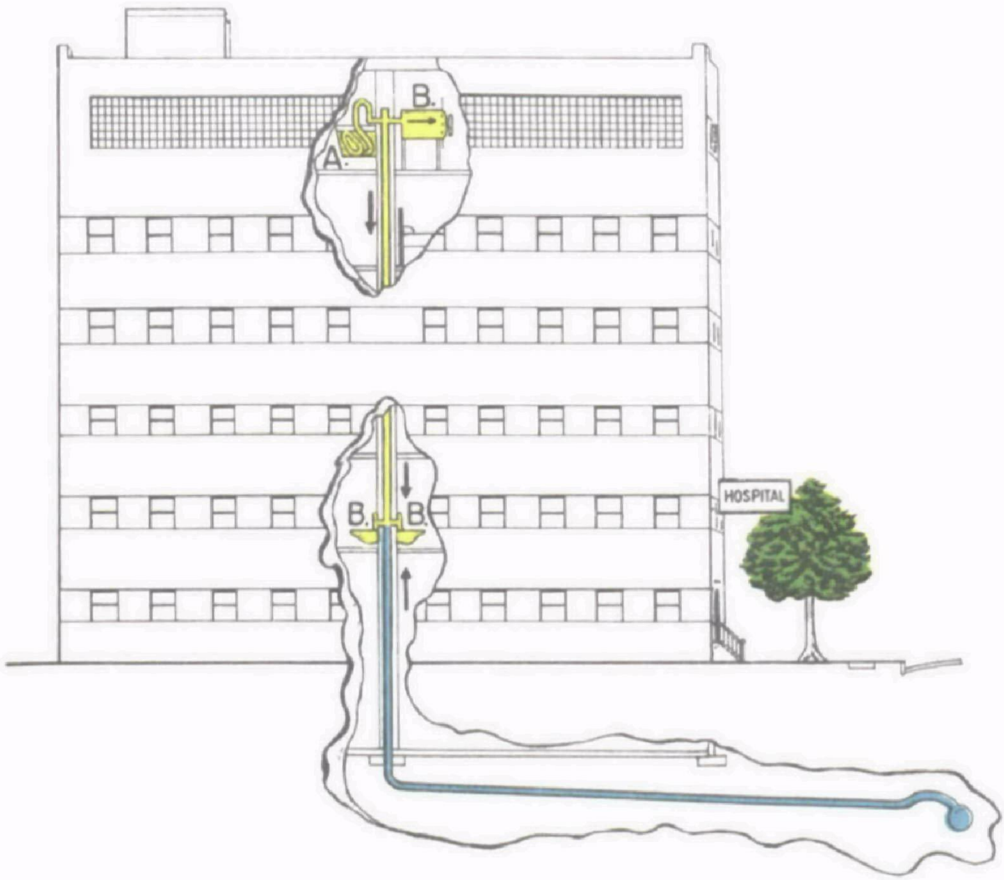


FIGURE 27

A. CONTACT POINT: A rubber hose is submerged in a bedpan wash sink.

B. CAUSES OF REVERSED FLOW: (1) A sterilizer connected to the water supply is allowed to cool without opening the air vent. As it cools, the pressure within the sealed sterilizer drops below atmospheric producing a vacuum which draws the polluted water into the sterilizer contaminating its contents. (2) The flushing of several flush valve toilets on a lower floor which are connected to an undersized water service line reduces the pressure at the water closets to atmospheric producing a reversal of the flow.

C. SUGGESTED CORRECTION: The water connection at the bedpan wash sink should be provided with a properly installed backflow preventer and also the sterilizer.

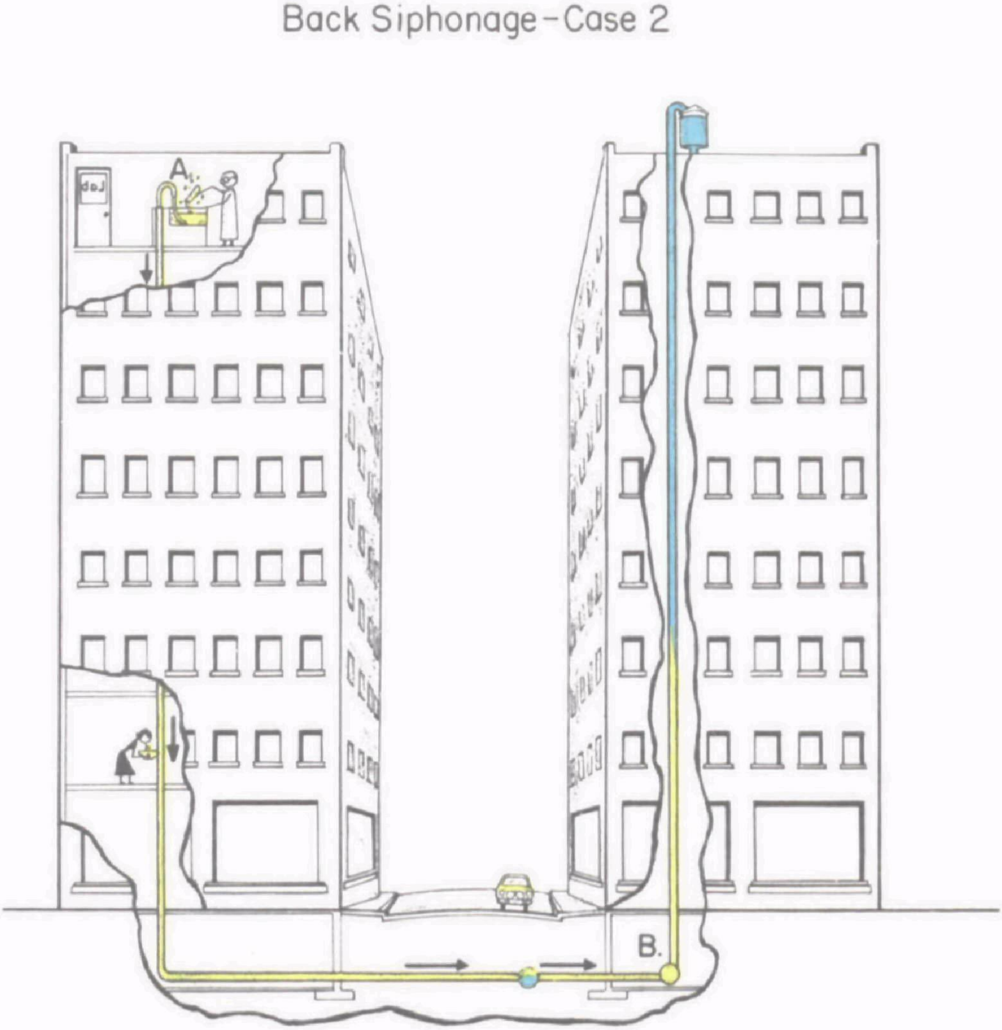


FIGURE 28

A. CONTACT POINT: A rubber hose is submerged in a laboratory sink.

B. CAUSE OF REVERSED FLOW: Two opposite multistory buildings are connected to the same water main which often lacks adequate pressure. The building on the right has installed a booster pump. When the pressure is inadequate in the main, the building booster pump starts pumping, producing a negative pressure in the main and causing a reversal of flow in the opposite building.

C. SUGGESTED CORRECTION: The laboratory sink water outlet should be provided with a vacuum breaker. The water service line to the booster pump should be equipped with a device to cut off the pump when pressure approaches a negative head or vacuum.

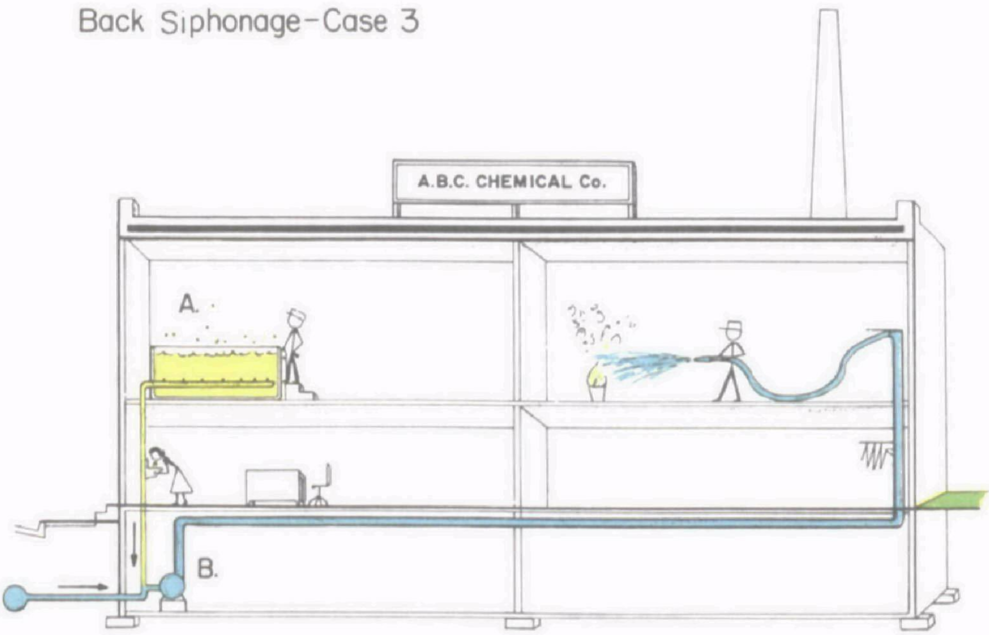


FIGURE 29

A. CONTACT POINT: A chemical tank has a submerged inlet.
B. CAUSE OF REVERSED FLOW: The plant fire pump draws suction directly from the city water supply line which is insufficient to serve normal plant requirements and a major fire at the same time. During a fire emergency, reversed flow may occur within the plant.
C. SUGGESTED CORRECTION: The water service to the chemical tank should be provided through an airgap.

Back Siphonage - Case 4

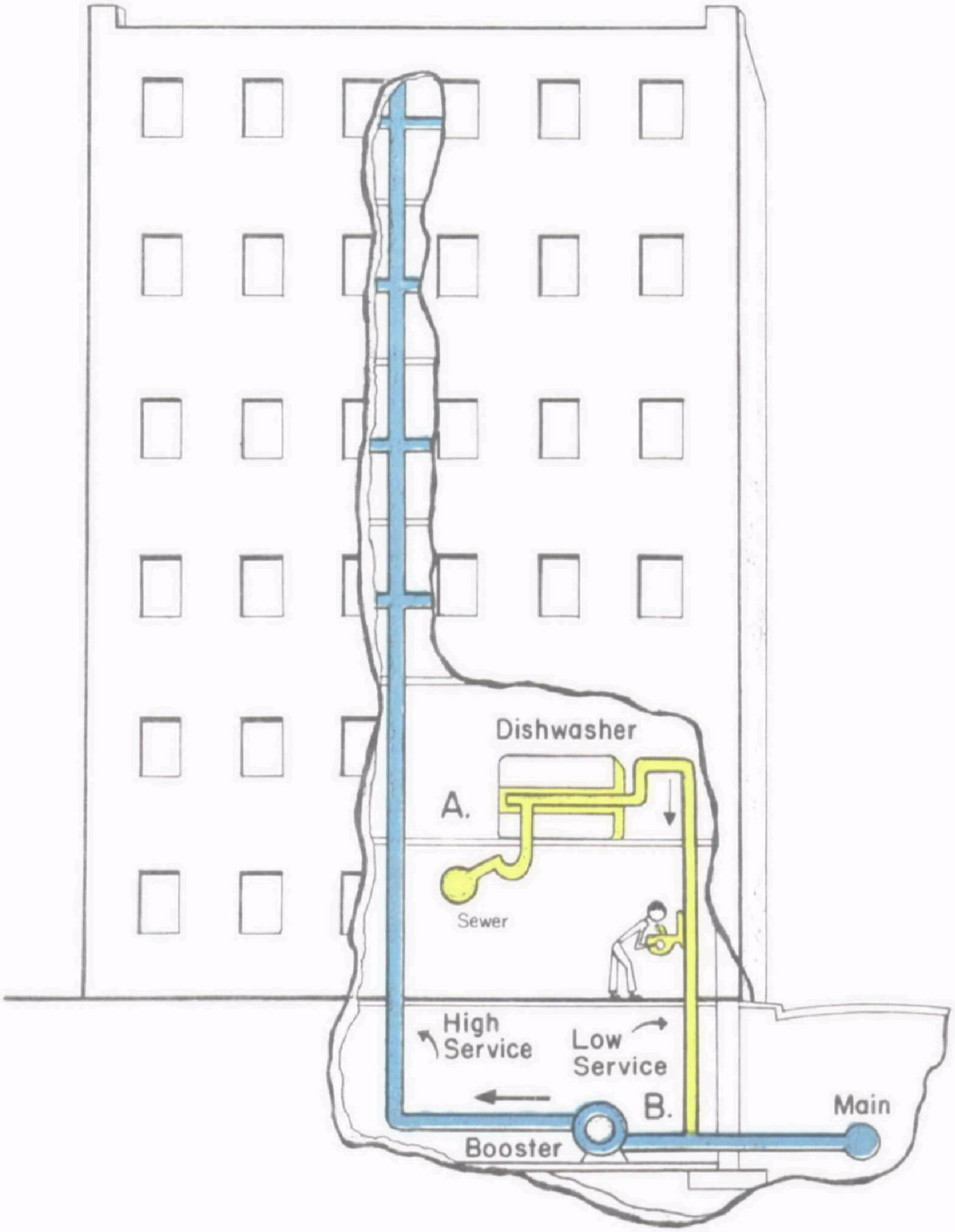


FIGURE 30

A. CONTACT POINT: The water supply to the dishwasher is not protected by a vacuum breaker. Also, the dishwasher has a solid waste connection to the sewer.

B. CAUSE OF REVERSED FLOW: The undersized main serving the building is subject to reduced pressures, and therefore only the first two floors of the building are supplied directly with city pressure. The upper floors are served from a booster pump drawing suction directly from the water service line. During periods of low city pressure, the booster pump suction creates negative pressures in the low system, thereby reversing the flow.

C. SUGGESTED CORRECTION: The dishwasher hot and cold water should be supplied through an airgap and the waste from the dishwasher should discharge through an indirect waste. The booster pump should be equipped with a low pressure cutoff device.

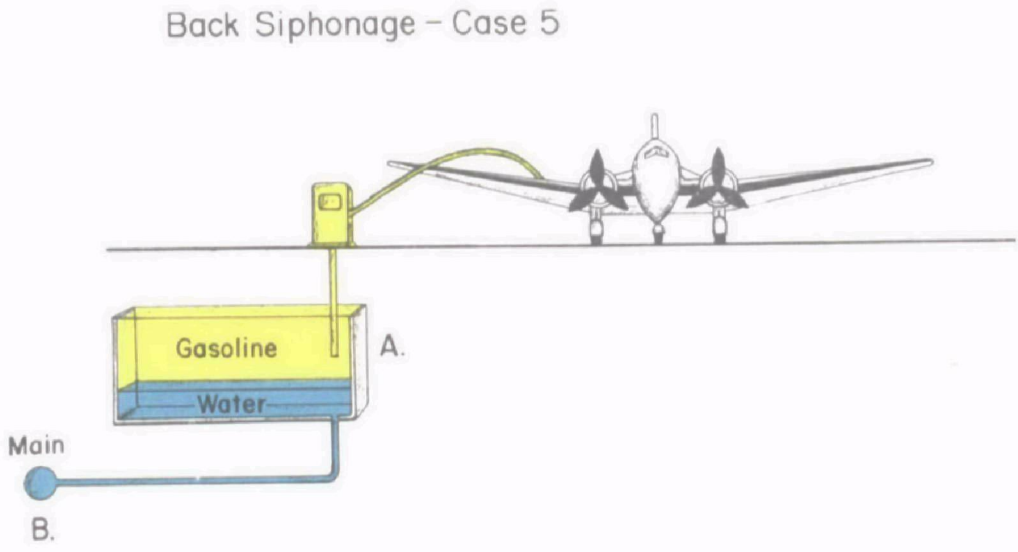


FIGURE 31

A. CONTACT POINT: The gasoline storage tank is maintained full and under pressure by means of a direct connection to the city water distribution system.

B. CAUSE OF REVERSED FLOW: Gasoline may enter the distribution system by gravity or by siphonage in the event of a leak or break in the water main.

C. SUGGESTED CORRECTION: A reduced pressure principle backflow preventer should be installed in the line to the gasoline storage tank or a surge tank and pump should be provided in that line.

Back Siphonage - Case 6

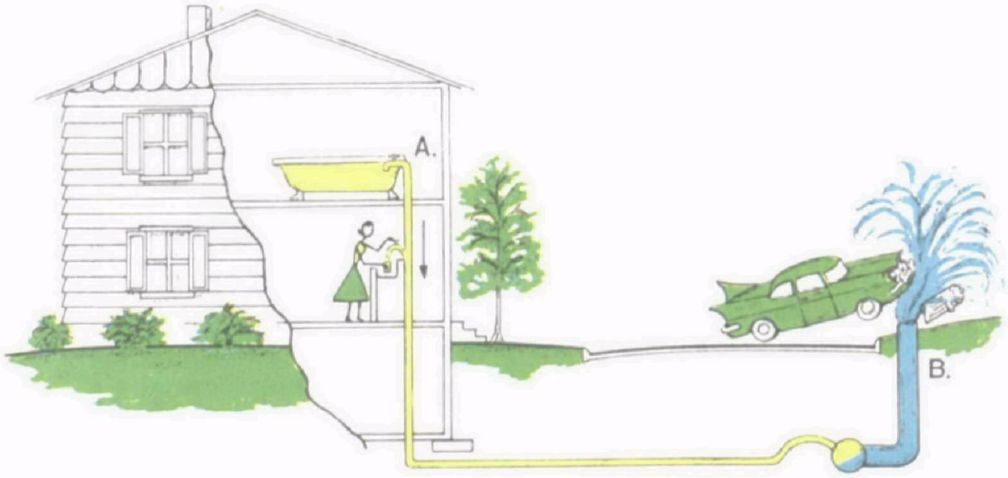


FIGURE 32

A. CONTACT POINT: There is a submerged inlet in the second floor bathtub.
B. CAUSE OF REVERSED FLOW: An automobile breaks a nearby fire-hydrant causing a rush of water and a negative pressure in the service line to the house, sucking dirty water out of the bathtub.
C. SUGGESTED CORRECTION: The hot and cold water inlets to the bathtub should be above the rim of the tub.

APPENDIX C

The following pages are illustrations of typical plumbing installations where backflow resulting from backpressure is possible.

Back Flow – Case 1

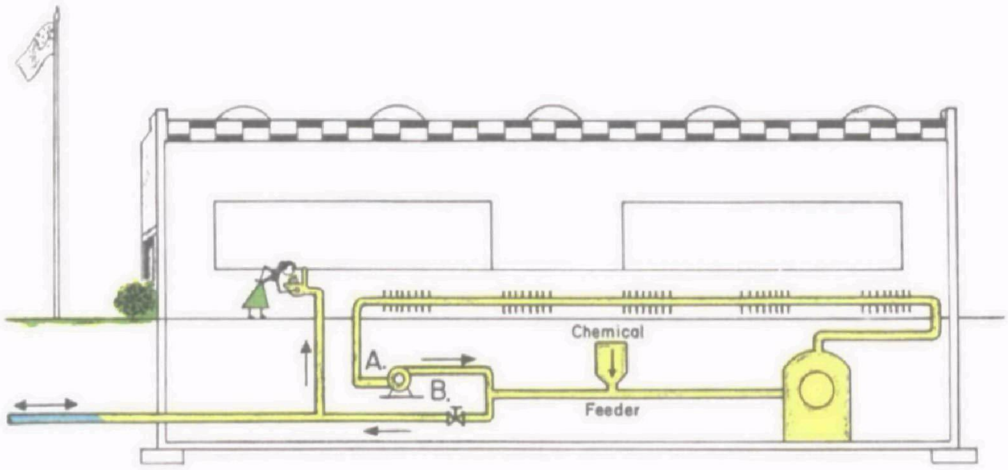


FIGURE 33

A. CONTACT POINT: A direct connection from the city supply to the boiler exists as a safety measure and for filling the system. The boiler water system is chemically treated for scale prevention and corrosion control.

B. CAUSE OF REVERSED FLOW: The boiler water recirculation pump discharge pressure or backpressure from the boiler exceeds the city water pressure and the chemically treated water is pumped into the domestic system through an open or leaky valve.

C. SUGGESTED CORRECTION: As minimum protection two check valves in series should be provided in the makeup waterline to the boiler system. An air gap separation or reduced pressure principle backflow preventer is better.

Back Flow – Case 2

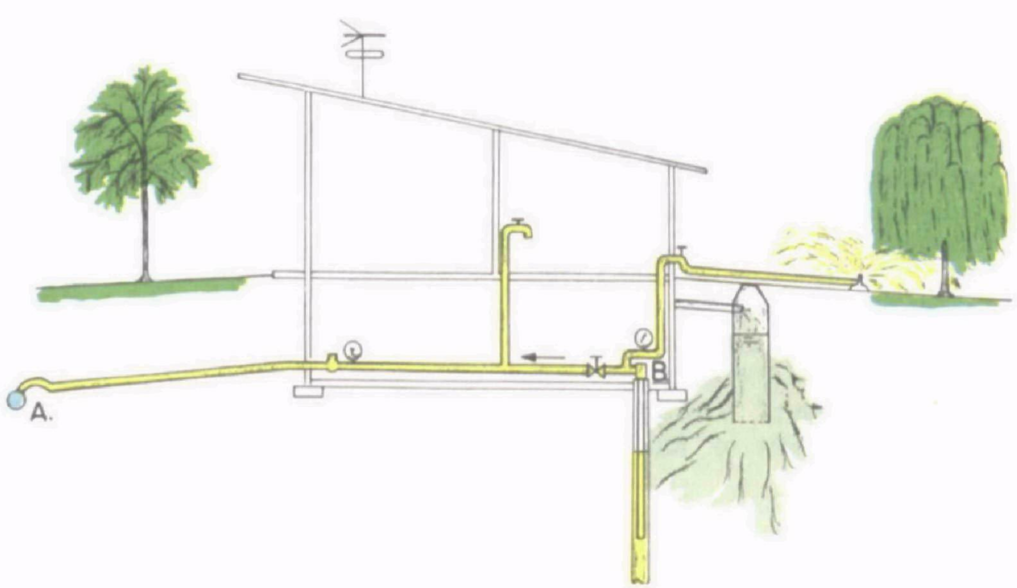


FIGURE 34

A. CONTACT POINT: Sewage seeping from a residential cesspool pollutes the private well which is used for lawn sprinkling. The domestic water system, which is served from a city main, is connected to the well supply by means of a valve. The purpose of the connection may be to prime the well supply for emergency domestic use.

B. CAUSE OF REVERSED FLOW: During periods of low city water pressure, possibly when lawn sprinkling is at its peak, the well pump discharge pressure exceeds that of the city main and well water is pumped into the city supply through an open or leaky valve.

C. SUGGESTED CORRECTION: The connection between the well water and city water should be broken.

Back Flow – Case 3

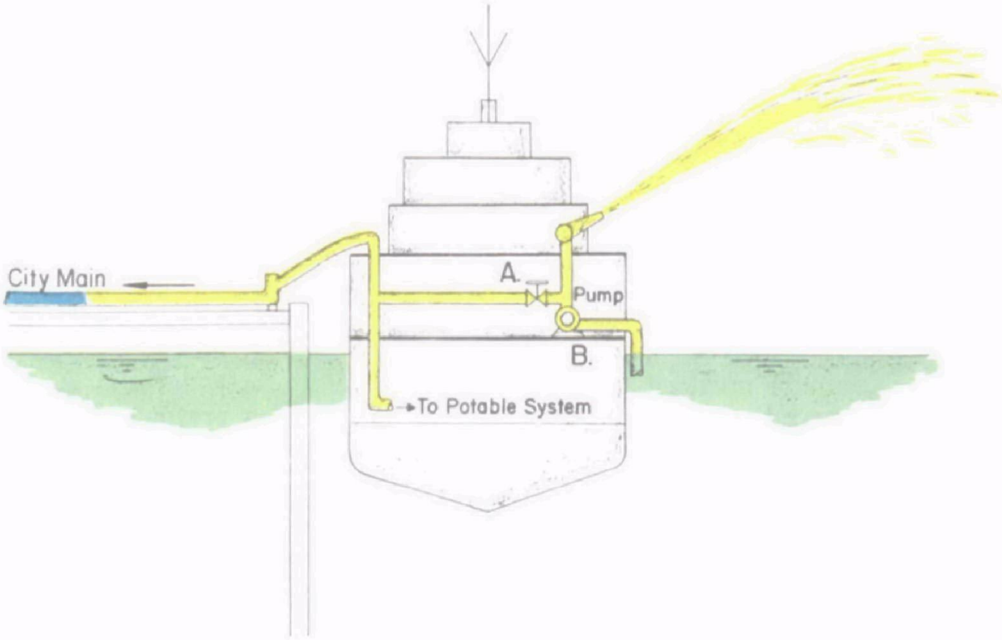


FIGURE 35

A. CONTACT POINT: A valve connection exists between the potable and the nonpotable systems aboard the ship.

B. CAUSE OF REVERSED FLOW: While the ship is connected to the city water supply system for the purpose of taking on water for the potable system, the valve between the potable and nonpotable systems is opened, permitting contaminated water to be pumped into the municipal supply.

C. SUGGESTED CORRECTION: Each pier water outlet should be protected against backflow. The main water service to the pier should also be protected against backflow by an air gap or reduced pressure principle backflow preventer.

Back Flow – Case 4

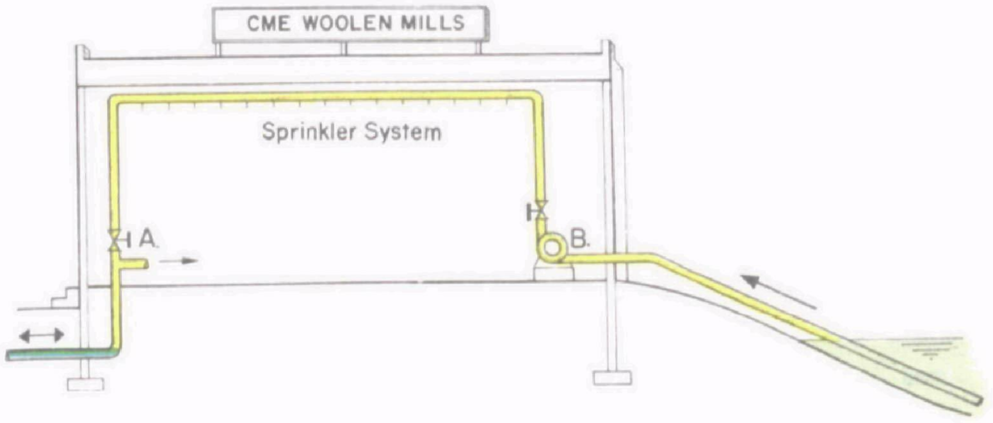


FIGURE 36

A. CONTACT POINT: A single valved connection exists between the public, potable water supply and the fire-sprinkler system of a mill.

B. CAUSE OF REVERSED FLOW: The sprinkler system is normally supplied from a nearby lake through a high pressure pump. About the lake are large numbers of overflowing septic tanks. When the valve is left open, contaminated lake water can be pumped to the public supply.

C. SUGGESTED CORRECTION: The potable water supply to the fire system should be through an air-gap or a reduced pressure principle backflow preventer should be used.

APPENDIX D

The following illustrations describe methods of providing an air gap discharge to a waste line which may be occasionally or continuously subject to backpressure.

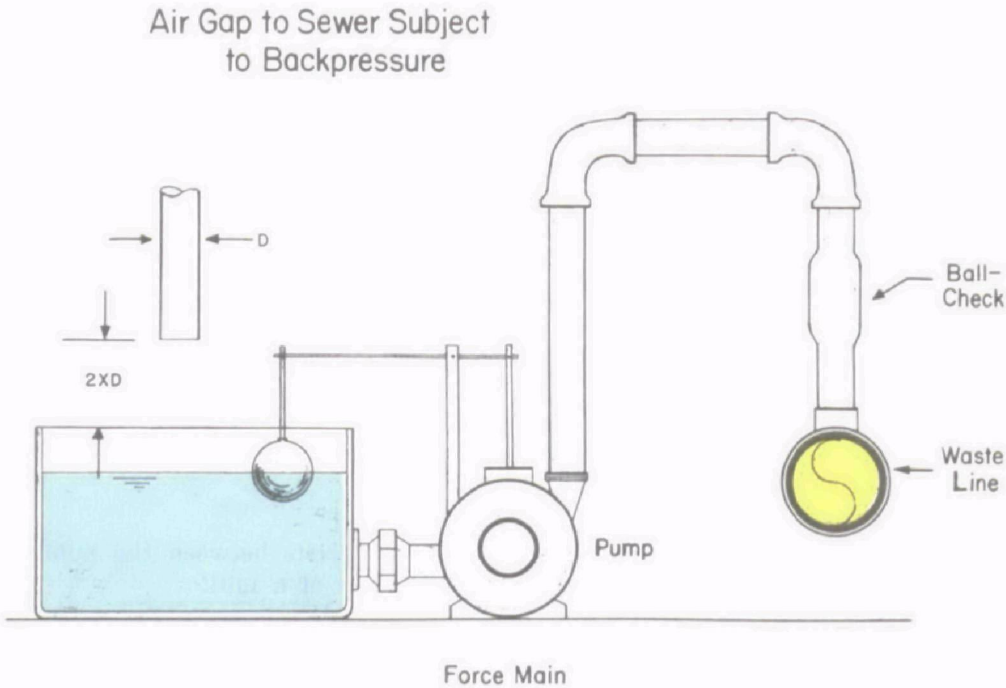


FIGURE 37

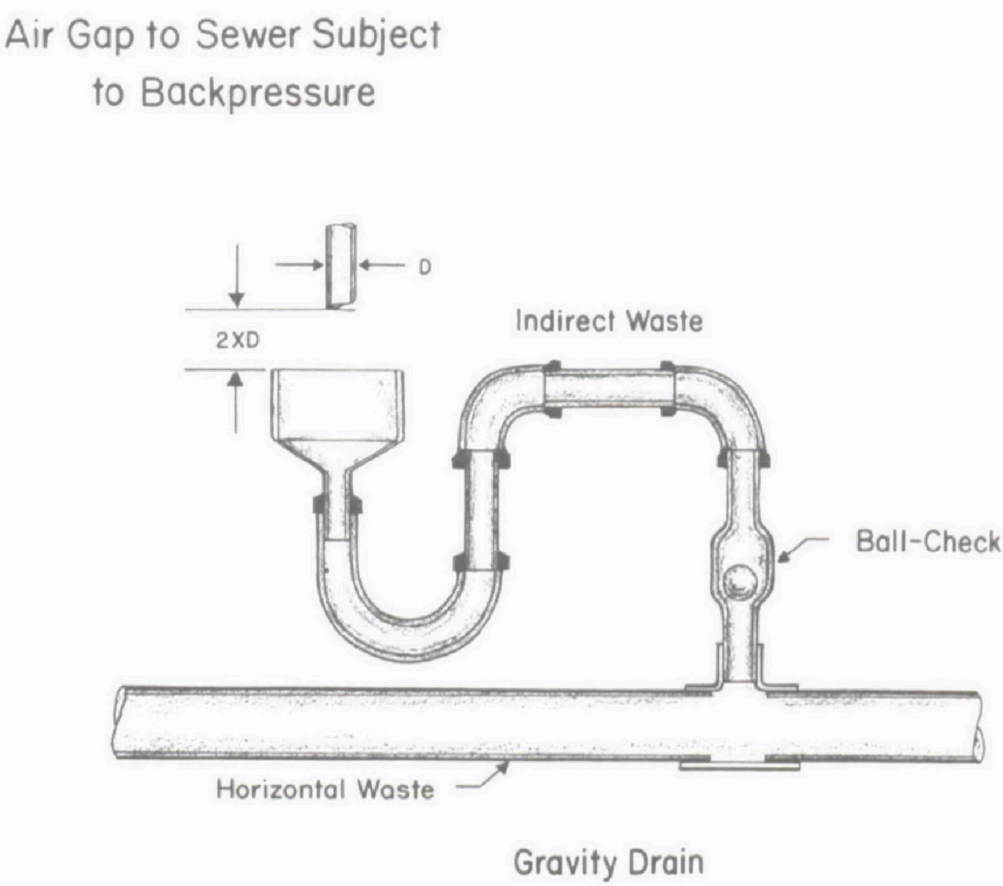


FIGURE 38

The following illustrations describe methods by which air gap protection may be achieved and splashing reduced.

Anti-Splash, Anti-Siphon Arrangement

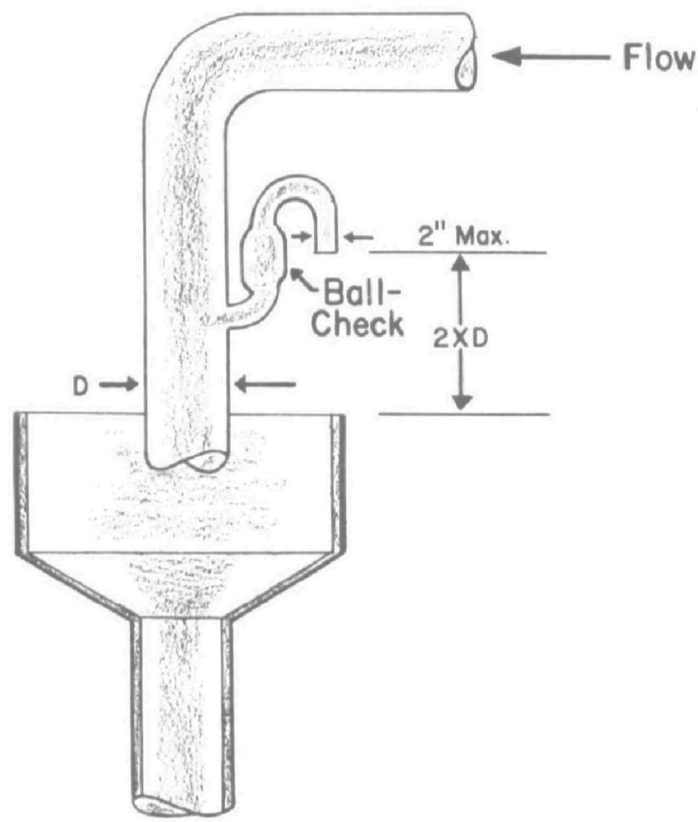
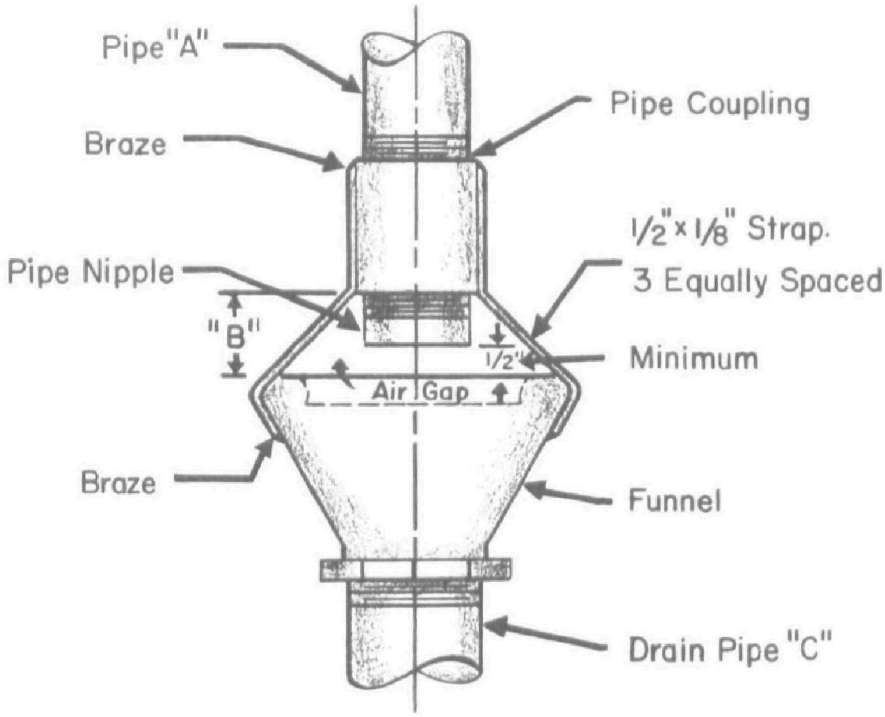


FIGURE 39

NOTE—Where D is less than 2 inches, a vacuum breaker may be substituted for the ball-check device.

Drain Funnel Air Gap



Drain Funnel

Pipe "A"	1/8"	1/4"	3/8"	1/2"	3/4"	1"	1-1/2"	2"
Dimen."B"	1-1/2	1-1/2	1-1/2	1-1/2	2-1/4	2-1/4	2-5/8	3
Pipe "C"	1	1	1	1	1-1/2	1-1/2	2	3

NOTE: This installation is in accordance with the National Plumbing Code.

FIGURE 40

(By permission of Mr. Gustave John Angele, Plant Sanitary Engineer, Union Carbide Nuclear Co., Oak Ridge, Tenn.)

APPENDIX E—GLOSSARY

Airgap

The unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet supplying water to a tank, plumbing fixture, or other device and the flood level rim of the receptacle.

Backflow

The flow of water or other liquids, mixtures, or substances into the distributing pipes of a potable supply of water from any source or sources other than its intended source. Backsiphonage is one type of backflow.

Backflow Connection

Any arrangement whereby backflow can occur.

Backflow Preventer

A device or means to prevent backflow.

Backflow Preventer, Reduced Pressure Principle Type

An assembly of differential valves and check valves including an automatically opened spillage port to the atmosphere.

Backsiphonage

The flowing back of used, contaminated, or polluted water from a plumbing fixture or vessel or other sources into a water supply pipe due to a negative pressure in such pipe.

Cross-Connection

Any physical connection or arrangement between two otherwise separate piping systems, one of which contains potable water and the other either water of unknown or questionable safety or steam, gas, or chemical whereby there may be a flow from one system to the other, the direction of flow depending on the pressure differential between the two systems. See *Backflow and Backsiphonage.*

Effective Opening

The minimum cross-sectional area at the point of water supply discharge, measured or expressed in terms of (1) diameter of a circle, or (2) if the opening is not circular, the diameter of a circle of equivalent cross-sectional area.

Flood Level Rim

The edge of the receptacle from which water overflows.

Flushometer Valve

A device which discharges a predetermined quantity of water to fixtures for flushing purposes and is actuated by direct water pressure.

Frostproof Closet

A hopper with no water in the bowl and with the trap and water supply control valve located below frost line.

Indirect Waste Pipe

A drain pipe used to convey liquid wastes which does not connect directly with the drainage system, but which discharges into the drainage system through an air break into a vented trap or a properly vented and trapped fixture, receptacle, or interceptor.

Nonpotable Water

Water not safe for drinking, personal, or culinary use.

Plumbing

The practice, materials, and fixtures used in the installation, maintenance, extension, and alteration of all piping, fixtures, appliances, and appurtenances in connection with any of the following: Sanitary drainage or storm drainage facilities, the venting system and the public or private water-supply systems, within or adjacent to any building structure, or conveyance; also the practice and materials used in the installation, maintenance, extension, or alteration of storm water, liquid waste, or sewerage, and water-supply systems of any premises to their connection with any point of public disposal or other acceptable terminal.

Potable Water

Water free from impurities present in amounts sufficient to cause disease or harmful physiological effects. Its bacteriological and chemical quality shall conform to the requirements of the Public Health Service Drinking Water Standards or the regulation of the public health authority having jurisdiction.

Vacuum

Any pressure less than that exerted by the atmosphere.

Vacuum Breaker

See *Backflow Preventer.*

Vacuum Breaker, Nonpressure Type

A vacuum breaker which is not designed to be subjected to static line pressure.

Vacuum Breaker, Pressure Type

A vacuum breaker designed to operate under conditions of static line pressure.

Water Outlet

A discharge opening through which water is supplied to a fixture, into the atmosphere (except into an open tank which is part of the water supply system), to a boiler or heating system, to any devices or equipment requiring water to operate but which are not part of the plumbing system.

Water Supply System

The water service pipe, the water-distributing pipes, and the necessary connecting pipes, fittings, control valves, and all appurtenances in or adjacent to the building or premises. The water supply system is part of the plumbing system.

APPENDIX F—BIBLIOGRAPHY

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APPENDIX G

The following is a sample cross-connection survey form.

CROSS-CONNECTION SURVEY FORM

Place: .... Date: ....

Location: .... Investigator(s): ....

Building Representative(s) and Title(s):

....

....

Water Source(s): ....

....

....

Piping System(s): ....

....

....

Points of Interconnection: ....

....

....

....

....

Special Equipment Supplied with Water & Source:

....

....

....

Remarks or Recommendations: ____

____

____

____

____

____

Note: Attach sketches of cross connections found where necessary for clarity of description. Attach additional sheets for room by room survey under headings

Room Number	*Description of Cross Connection (s)*

INDEX

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