DEPARTMENT OF THE ARMY
U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY
FIELD SUPPORT ACTIVITY
FORT MCPHERSON, GEORGIA 30330-5000

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SUBJECT: INFORMATION PAPER NO. 42

CROSS-CONNECTION CONTROL AND BACKFLOW PREVENTION

I. PURPOSE. The purposes of the subject information paper are as follows:

A. To provide information on cross-connections and the causes of backflow;

B. To provide information on the types of devices available for controlling cross-connections and preventing backflow;

C. To provide guidance on development of a cross-connection control program; and

D. To provide guidance and a suggested protocol for the conduct of a cross-connection control survey.

II. ABBREVIATIONS AND DEFINITIONS. See Enclosure 1.

III. REGULATORY BACKGROUND.

A. All states have laws and policies which place responsibility upon water suppliers to provide safe water to their consumers. These include provisions, as well as basic guidelines and regulations for the implementation of a comprehensive cross-connection control program. In addition, compliance with local (e.g., county, municipal cross-connection control requirements, must be ensured. Examples of such guidance documents are presented in references 10-12.

B. Paragraph 12-2f of AR 40-5 prohibits unprotected cross-connections between potable water systems and nonpotable systems. According to AR 40-5, the current NSPC (reference 13) is to be followed in the design and maintenance of a potable water distribution system. Chapter 10 of the NSPC prohibits unprotected cross-connections and requires that "suitable protective devices such as the reduced pressure zone backflow preventer, or equivalent, are installed, tested, and maintained to ensure proper operation on a continuing basis."

C. TB MED 576 requires facilities engineers to pursue, in coordination with AMEDD personnel, an aggressive program to detect and remove all existing or potential unprotected cross-connections to the distribution system. This means the facility engineer, as potable water purveyor, must develop a plan that will protect consumer interests from the raw source to the consumer tap. This plan should include organized instruction, inspection schedules, and measures to be taken upon the discovery of unprotected cross-connections. Followup inspections should be conducted to ensure that protective devices are properly installed and maintained.

D. Numerous recent court decisions have held the water purveyor liable for distributing a contaminated water through the public distribution system, even though the contamination was introduced by backflow from the premises of one of its customers. The courts apparently followed the reasoning that the water purveyor knew, or should have known, that hazardous cross-connections existed within its customers' premises. Failure to take appropriate measures to protect the system from such hazards constituted negligence on the part of the water purveyor.

IV. DISCUSSION.

A. Definition of a Cross-Connection. A cross-connection is any direct connection of a potable water system and a nonpotable system. An unprotected cross-connection is a connection where liquid from the nonpotable system could flow into the potable water system.

B. Definition of Backflow. Backflow involves a reversal of normal flow in a water system. There are two types of backflow, back-siphonage and backpressure.

1. Back-siphonage. Back-siphonage is caused by reduced or negative pressure created in the supply piping. One of the major causes of back-siphonage is undersized piping. An interruption in supply pressure, and a resultant water flow toward a low point in the system, can create negative pressures and back-siphonage. Rapid withdrawal of water from a pipe can also cause a pressure reduction, which would allow liquid to flow into the pipe from a contaminated source. Back-siphonage can result in the contamination of an entire potable water system and can cause serious health problems to consumers.

2. Backpressure. Backpressure can cause backflow if a potable water system is connected to a nonpotable system with pressures which are higher than those in the potable system. High pressures can be created by pumps, boilers, elevated storage tanks, etc. There is a high risk of nonpotable liquids being forced into the potable water system whenever these types of cross-connections are not properly protected.

C. Examples of Unprotected Cross-Connections.

1. A garden hose submerged in nonpotable fluids is an unprotected cross-connection. Direct potable water system connections to irrigation, fire, and industrial waters, are also unprotected cross-connections. These types of cross-connections, coupled with an occurrence of backflow, can lead to widespread illness among installation personnel and impair the readiness of that installation. Thus, it is imperative that commanders, working through their facilities engineer and PVNTMED Svc personnel, eliminate or control unprotected cross-connections. Common types of unprotected cross-connections which could allow contamination of a water system by back-siphonage or backpressure are shown in Figures 1, 2, 3, and 4.

Figure 1. Spray Hose In Sink

This type of cross connection is commonly found in the food industry and in janitor's sinks. A hose has been connected to the faucet on the sink. When the faucet is left running, a loss in pressure of the supply main can siphon this used water back into the potable water system.

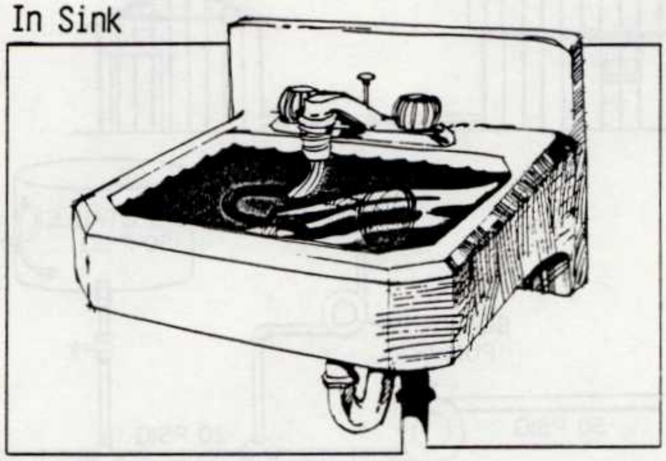


Figure 2. Submerged Inlet

In many industrial installations that use chemically treated baths, the make-up water line runs directly into the tank. If there is backsiphonage, the toxic chemicals can be sucked back into the potable water system.

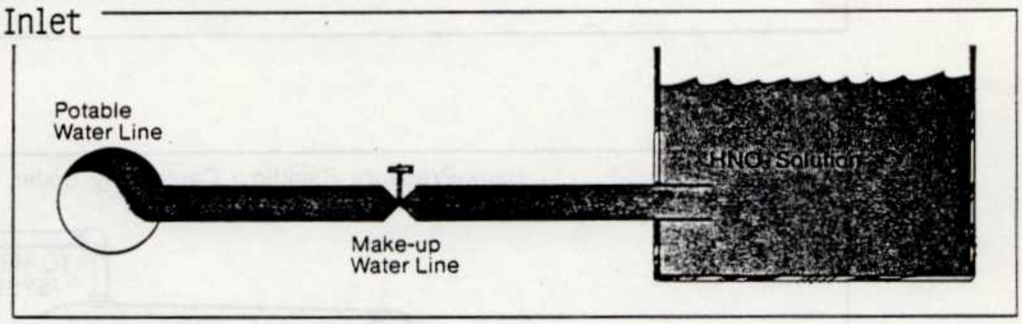
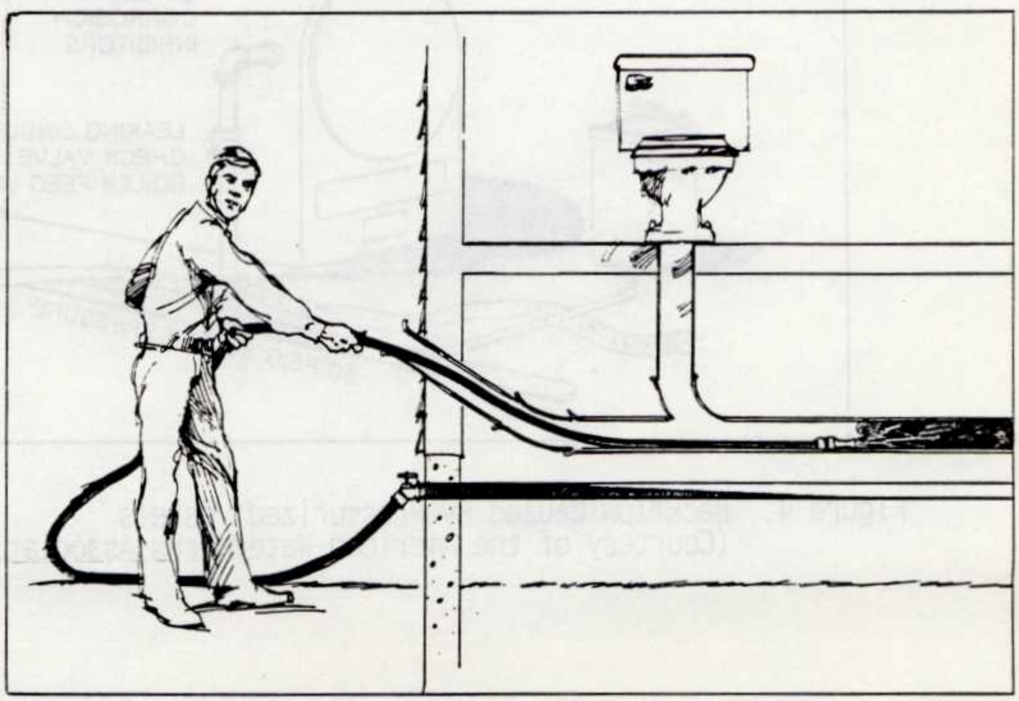


Figure 3. Sill Cocks

At first glance, a hose bib seems innocuous, but it is the things people do with the hose that creates problems. In this example, a man is trying to blow a stoppage out in a sewer line, but with a sudden drop in line pressure, this contaminated water can be backsiphoned into the potable water system.



(Courtesy of Febco Sales, Inc.)

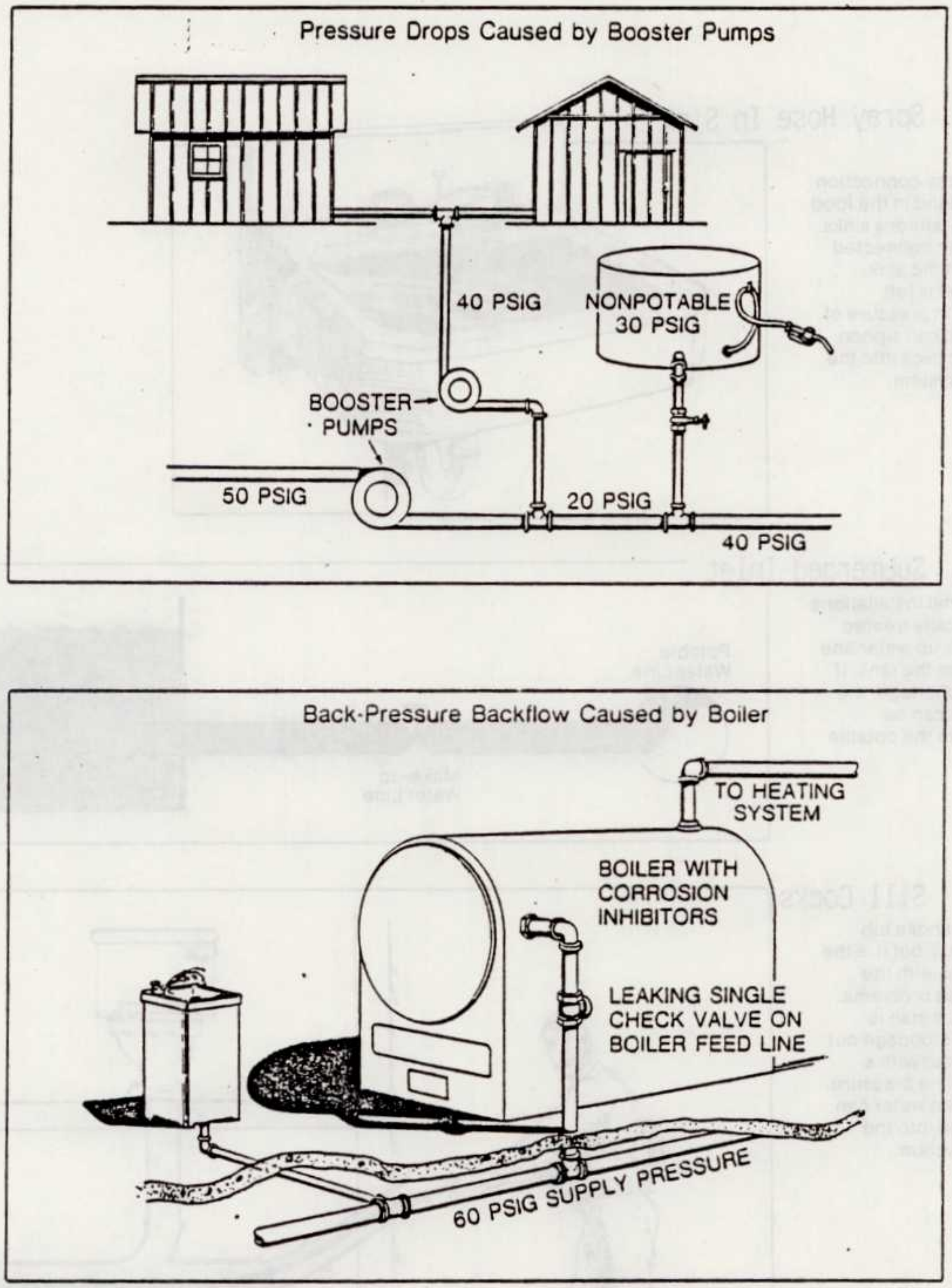


Figure 4. Backflow Caused By Pressurized Vessels
(Courtesy of the American Waterworks Association)

2. The following is a listing of facilities and systems likely to have unprotected cross-connections:

a. Auxiliary water systems.

b. Food Processing.

c. Cooling systems.

d. Farming operations (stables).

e. Fire protection systems.

f. Film processing.

g. Industrial piping systems.

h. Industrial systems.

i. Irrigation systems (golf course).

j. Laundry and dyeing facilities.

k. Plating facilities.

l. Storage tanks, cooling towers, and circulating systems.

m. Sewage systems.

n. Steam generation facilities.

o. Hospital and medical facilities.

p. Water treatment plants.

D. Health Problems Resulting from Cross-Connections. Five examples of health problems resulting from unprotected cross-connections follow. These examples illustrate how unprotected cross-connections, coupled with a backflow, can result in contamination of a potable water system and adversely affect people's health.

1. 1967. A New England town had two separate water systems: one for potable water and one for fire protection. The fire protection system was supplied untreated water directly from a river. Workers at an industrial plant in town mistook a fire system line for a potable water line and connected a bubbler to it. After drinking water from the bubbler, 7 people developed infectious hepatitis and over a 100 people were ill with gastroenteritis.

2. 1969. An air conditioning system containing chromates became blocked, preventing circulation of the coolant. In an attempt to remedy the situation, a maintenance man inserted a hose in the pipe and attempted to dislodge the blockage by water pressure. During the procedure, a reversal in flow developed, allowing chemicals in the air conditioning line to backflow through the hose into the potable water system. Consumption of the contaminated water by students in other parts of the building resulted in illness to 23 persons.

3. 1969. Most of the members of a college varsity football team became ill with infectious hepatitis. The water system on the practice field was found to supply both a drinking fountain and an irrigation system. A heavy water demand in the area had created a negative pressure in the water line which had siphoned contaminated water from around sprinklers into the water lines. Team members consuming water from the drinking fountain became ill, forcing the cancellation of the remainder of the football schedule.

4. 1972. Personnel at a gravel pit in Illinois were using a pump to supply water at 100 psi to a processing operation. The water supply to the pump was the city water system at a pressure of 45 psi. The prime line on the pump was unprotected and allowed a reversal of flow since the process water pressure was higher than the city water pressure. Contaminated water entered the city main and was channeled into a nearby bottling plant. The contamination probably would have gone undetected, except that personnel in the bottling plant noticed that their water was dirty and warm.

5. 1985. An outbreak of acute gastroenteritis among soldiers of a training battalion was reported in the installation Command Health Report. There were 163 individuals hospitalized, and 352 medical encounters reported. An epidemiological investigation implicated the battalion dining facility as the source of the epidemic. No specific food was incriminated by food histories or from cultures of food samples. The dining facility had experienced recent problems with sewage drainage. Numerous unprotected cross-connections were identified during an investigation of the outbreak. The cause of the outbreak was attributed to temporary water contamination within the facility. This is a vivid example of how a cross-connection can impair a unit's mission, and emphasizes the need for cross-connection control.

E. <u>Characteristics and Uses of Backflow Prevention Devices and Backflow Prevention Methods</u>.

1. General.

a. There are basically three methods used in cross-connection control to prevent backflow: the use of vacuum breakers; the use of backflow preventers; and the use of air gaps. Air gaps and reduced pressure zone backflow preventers are the safest and most reliable backflow prevention methods to use when hazardous fluids can potentially enter a potable water system.

b. Two backflow preventers must be installed in parallel when isolating a water supply which cannot be interrupted. The second backflow preventer is necessary to ensure protected water is available to the area, even if one backflow preventer must be taken out of service for maintenance or testing (TM 5-660, paragraph 9-37).

c. The AWWA (reference 8), the ASSE, and the FCCCHR - USC (reference 16), have established standards for vacuum breakers and backflow preventers. All devices installed at U.S. Army installations must meet these standards.

d. A system of classification of cross-connections, their related hazards, and appropriate devices to be used when correcting deficiencies is provided at Table 1 and Table 2. The tables were developed from information prepared by the AWWA, the ASSE, and the FCCCHR of USC. General classifications of cross-connection hazards are defined at Table 1. Potential cross-connections, their related hazards, and recommended backflow prevention devices are provided at Table 2. It is essential to note that in Table 2, device selection and application are directly influenced by the cause of backflow at the cross-connection. In many instances, devices applicable in backsiphonage situations are not appropriate for use in a situations with potential for backpressure. A knowledge of backflow potential at the cross-connection is essential to properly select an appropriate backflow prevention device.

TABLE 1. CROSS-CONNECTION HAZARD CLASSIFICATIONS*

Class	Degree of Hazard
Class L -	Low degree of hazard, resulting in minor changes in aesthetic quality (e.g., taste, odor, color). Contaminants are nontoxic and nonbacterial in nature.
Class M -	Moderate degree of hazard, resulting in significant changes in aesthetic quality. Contaminants must be nontoxic.
Class S -	Severe degree of hazard, resulting in illness or death if consumed by humans. Contaminants may be toxic either from a chemical, bacteriological or radiological standpoint. Reaction may originate from acute of chronic exposure.

* Section 2-2, reference 7.

TABLE 2. DEGREE OF HAZARD AND RECOMMENDED BACKFLOW PREVENTION DEVICES

TYPE OF POTENTIAL CROSS-CONNECTION	DEGREE OF HAZARD (S = SEVERE, M = MODERATE, L = LOW)	RECOMMENDED TYPE OF BACKFLOW PREVENTER: BACKFLOW CAUSED BY BACK PRESSURE	BACKSIPHONAGE OR BACKFLOW CAUSED BY BACK PRESSURE		BACKSIPHONAGE	
		AIR GAP	RPZ	DCV/DuCV	PVB	AVB
DIRECT CONNECTIONS SUBJECT TO BACK PRESSURE						
1. Pump and tank:						
- Sewage and lethal (deadly substance)	S	/////	/////			
- Toxic substance	S	/////	/////			
- Nontoxic substance	M	/////	/////	/////		
2. Water line connected to steam or steam boiler						
- Boiler or steam connection to toxic substance	S	/////	/////			
- Boiler or steam connection to nontoxic substance (boiler blow-off through gap)	M	/////	/////	/////		
3. Fire suppression system using auxillary supply	M	/////	/////			
DIRECT OR INDIRECT CONNECTIONS NOT SUBJECT TO BACK PRESSURE						
1. Sewer-connected waste line (not subject to waste stoppages)	S	/////	/////		/////	/////
2. Submergable inlet to receptacle containing toxic substances	S	/////	/////		/////	/////
3. Submergable inlet to receptacle containing nontoxic substances	M	/////	/////	/////	/////	/////
4. Submergable inlet to domestic water tank	L	Each case treated separately				
5. Lawn sprinkler or irrigation system	S	/////	/////		/////	/////
6. Coil or jacket used as heat exchanger incompressor, degreasor, or other equipment						
- In sewer line	S	/////	/////			
- In toxic-substance line	S	/////	/////		/////	/////
- In nontoxic-substance line	M	Each case treated separately				
7. Flush-valve (nontank-type) toilet	S	/////	/////			
8. Toilet tank and urinal tank	M	/////	/////			/////
9. Trough urinal	M	/////	/////			/////
10. Valved outlet or fixture with hose attachment that may be a cross-connection to:						
- Toxic substance	S	/////	/////		/////	/////
- Nontoxic substance	M	/////	/////	/////	/////	/////

///// Indicates that device is suitable for designated application.

Source: G.J. Angele Sr., *Cross-Connections and Backflow Prevention*, AWWA, Denver, (2nd ed., 1974).

NOTE: Requirements of a given state or municipality may vary from this table.

Where more than one device is recommended, any one of the devices is acceptable by itself.

Where hazard is severe, both an air gap and an RPZ may be necessary to provide in-plant protection and premises isolation.

2. Vacuum Breakers.

a. General. Vacuum breakers are backflow preventers designed to prevent back-siphonage by introducing air into a piping system where a vacuum (negative pressure) has occurred. The introduction of atmospheric pressure to a piping system between the source of contamination and the origin of the vacuum should prevent back-siphonage. Vacuum breakers are designed for use on nonpressure connections only. They must not be used on connections where backpressure can occur. Vacuum breakers must not be used in areas subject to flooding.

b. Atmospheric Vacuum Breaker.

(1) Description. The most commonly used AVB's incorporate an atmospheric vent valve. As water flows through the vacuum breaker, it lifts the disk float, closes the atmospheric vent valve against water leakage, and supplies water to downstream equipment (see Figure 5). An AVB must not be subjected to backpressure. If backpressure were to occur, the vent valve could modulate or remain in the upward position and allow backflow to occur (Figure 6). An AVB must not be subjected to continuous pressure - i.e., a valve downstream of the device. Continuous pressure might jam the device and cause the vent valve to malfunction during a pressure loss situation. Three typical uses of AVB's are provided at Figure 7.

(2) Application and Installation. Properly installed and maintained AVB's can be used to protect potable waterlines from cross-connections where backflow would create serious health hazard. Since atmospheric type vacuum breakers are subject to normal maintenance and replacement, they should be located where they can be accessible for inspection or servicing, and where there is no possibility of the device becoming submerged or flooded.

c. Hose Vacuum Breaker.

(1) Description. Hose vacuum breakers are small, inexpensive devices which can be attached to threaded faucets, wherever a hose could be attached and a contaminant introduced. The HVB includes a diaphragm type atmospheric vent valve, plus an integral check valve. Operation of these devices is illustrated in Figure 8.

(2) Application and Installation. An HVB should be installed on every threaded outlet where an attached hose could be left submerged in a nonpotable fluid (except drains, blow-offs, and fire-hose connections). When an HVB is used on a freezeless wall hydrant, the device must be equipped with a means to drain collected water from the hydrant barrel. Hose vacuum breakers should be inspected at least annually. It is important to note that some HVB devices are nonremovable and some are nonrepairable. When the nonremovable, nonrepairable devices foul and leak, the entire threaded faucet must be replaced to fix the leak.

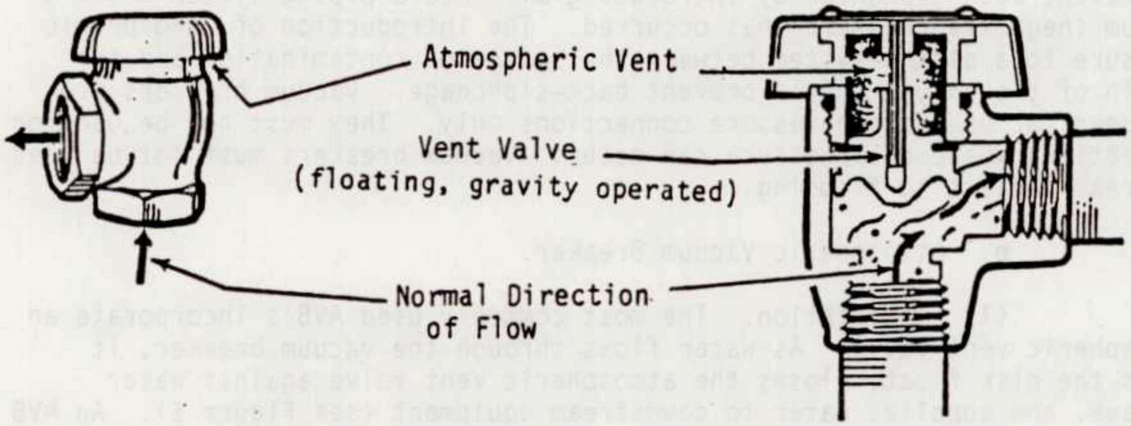


Figure 5. Features of an atmospheric vacuum breaker (courtesy of Watts Regulator Company).

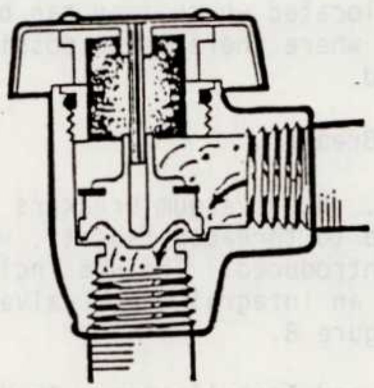
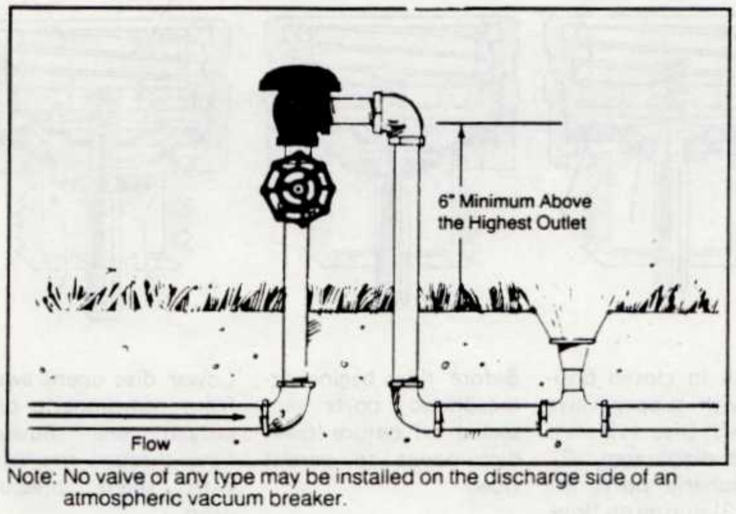
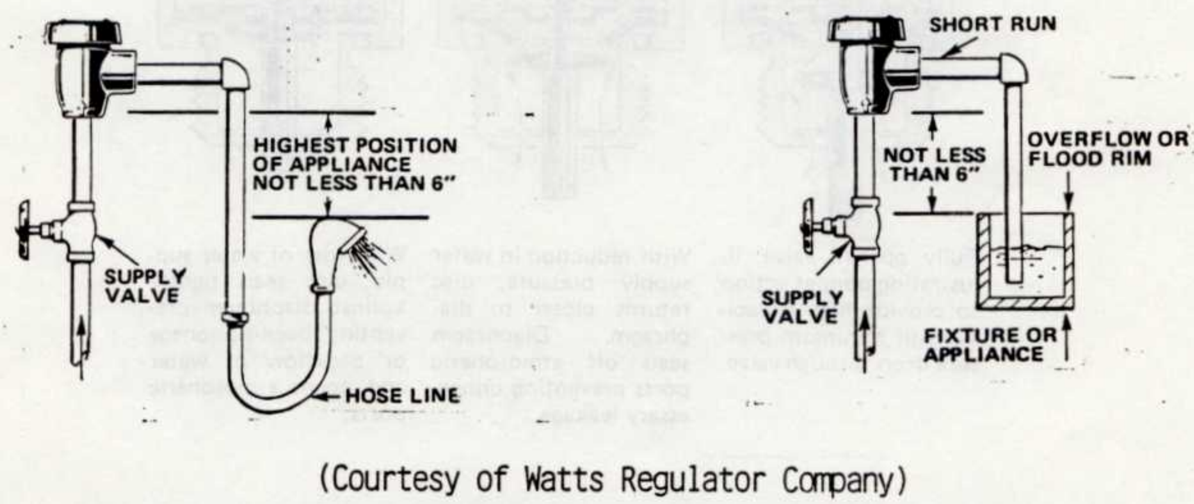


Figure 6. Atmospheric vacuum breaker subjected to backpressure, causing modulation of the vent valve and allowing backflow (courtesy of Watts Regulator Company).

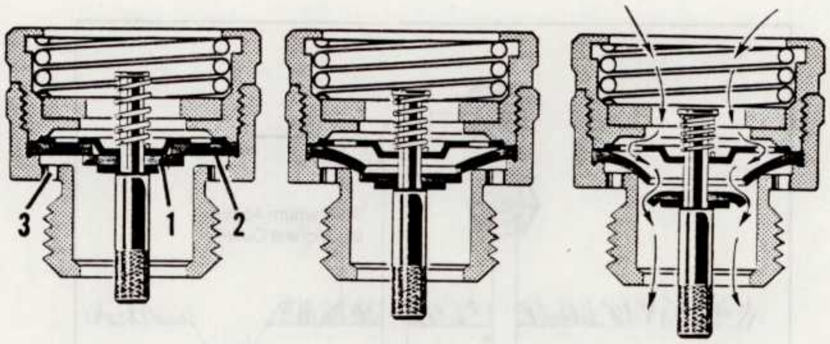


(Courtesy of Febco Sales, Inc.)



(Courtesy of Watts Regulator Company)

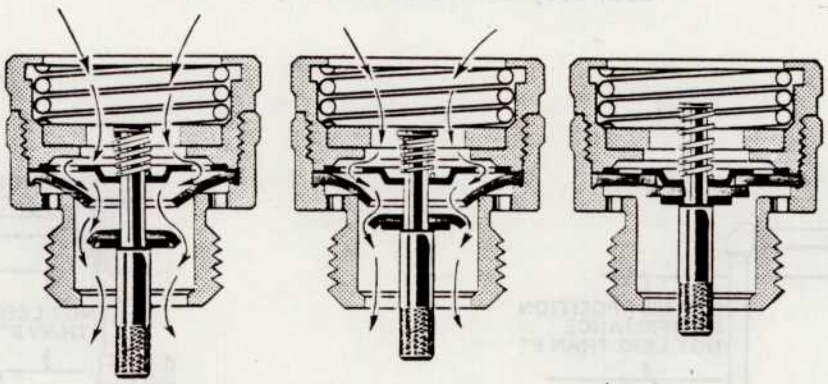
Figure 7. Typical installations of atmospheric vacuum breakers: a) irrigation system; b) portable fixture (left); and c) basin with submerged inlet (right)



No. 8A in closed position with supply valve shut off Disc (1) seats against diaphragm (2). Atmospheric ports are open (3) during no flow.

Before flow begins, atmospheric ports are sealed off before lower disc opens to permit flow.

Lower disc opens away from atmospheric diaphragm seal allowing flow through the valve with slight pressure drop.



Fully opened valve, illustrating poppet action to provide high capacity with minimum pressure drop through valve.

With reduction in water supply pressure, disc returns closer to diaphragm. Diaphragm seals off atmospheric ports preventing unnecessary leakage.

With loss of water supply, disc seals tightly against diaphragm preventing back-siphonage or backflow of water and opens atmospheric ports.

Figure 8. Operation of a hose vacuum breaker (courtesy of Watts Regulator Co.)

d. Laboratory Faucet Vacuum Breaker.

(1) Description. The LFVB, a derivative of the HVB, is designed to isolate a gooseneck water outlet which has tubing slipped over a serrated tip extending into the lab sink. Device components include one diaphragm-type atmospheric vent with integral check (similar to HVB) and one independent integral check (see Figure 9).

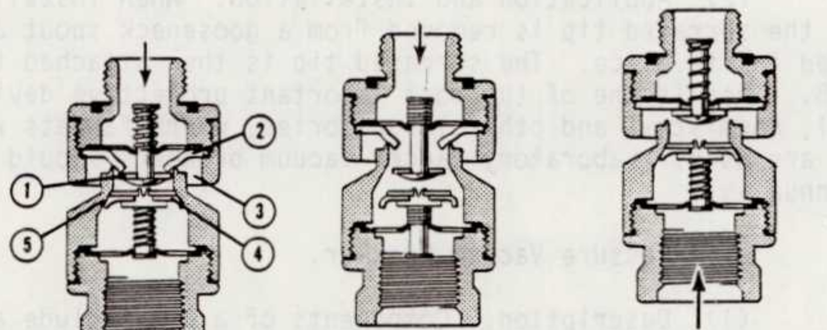
(2) Application and Installation. When installing this device, the serrated tip is removed from a gooseneck spout and an LFVB installed in its place. The serrated tip is then attached to the outlet of the LFVB. This is one of the most important protective devices required in hospital, chemistry, and other laboratories, where faucets with gooseneck outlets are used. Laboratory faucet vacuum breakers should be inspected at least annually.

e. Pressure Vacuum Breaker.

(1) Description. Components of a PVB include a spring-loaded check valve, a spring-loaded air intake valve, two test cocks and two shut-off valves (see Figure 10). The spring-loaded check valve closes when inlet pressure drops, allowing the air intake valve to open, thereby preventing a vacuum and back-siphonage. Operation of a PVB is depicted in Figure 11.

(2) Application and Installation. Pressure vacuum breakers have applications similar to AVB's, with the exception that PVB's may be subjected to continuous pressure. Thus, there may be a shut-off valve downstream of the device. However, the device must not be subjected to backpressure. The device must be placed at least 12 inches above the overflow level of a vessel or fixture being supplied, be protected from freezing, and be located near a drain. Devices for 1/2 inch through 2 inch applications must be installed vertically, with the supply line connected to the bottom. Devices for 2 1/2 inch and larger applications may be installed horizontally. Pressure vacuum breakers should be accessible and should be inspected and tested at least annually. Typical applications for the PVB include commercial laundry machines, plating tanks, large toilet facilities, open vats utilizing heat exchangers, cooling towers, and similar vessels or environments that are open to the atmosphere.

3. Backflow Preventers. Backflow preventers include double check valve assemblies and reduced pressure zone devices. These devices are designed for use on pressure connections where backpressure is possible. There are basically two types of double check valve assemblies: the double check valve backflow preventer and the dual check valve backflow preventer. The degree of protection afforded by a double check valve assembly is less than the protection afforded by vacuum breakers, by reduced pressure zone backflow preventers, or air gaps. Hence, double check valve assemblies must be used only where there are low or medium health hazards; specifically for aesthetically objectionable parameters such as taste, odor, or color (Table 1).



Static Pressure-No Flow
Illustration shows No. N-LF9 under pressure but with no demand on downstream equipment. Primary check (1) seats against diaphragm (2) with diaphragm (2) sealing off the atmospheric ports (3). Secondary check (4) seals against downstream seat (5).

Valve Opened Flowing Under Pressure
With flow through valve, primary check opens away from diaphragm seal. Atmospheric ports remain closed by deflection of diaphragm seal. Secondary check opens away from downstream seat permitting flow of water through valve.

Valve Closed By Back-Siphonage in System
With a back-siphonage condition created, secondary check seals tightly against downstream seat. Primary check seals tightly against diaphragm. Atmospheric port is now open permitting air to enter air break chamber. In the event of fouling of downstream check valve, leakage would be vented to atmosphere through the vent port thereby safeguarding the potable water system from contamination.

Figure 9. Operation of Laboratory Faucet Vacuum Breaker (Courtesy of Watts Regulator Company)

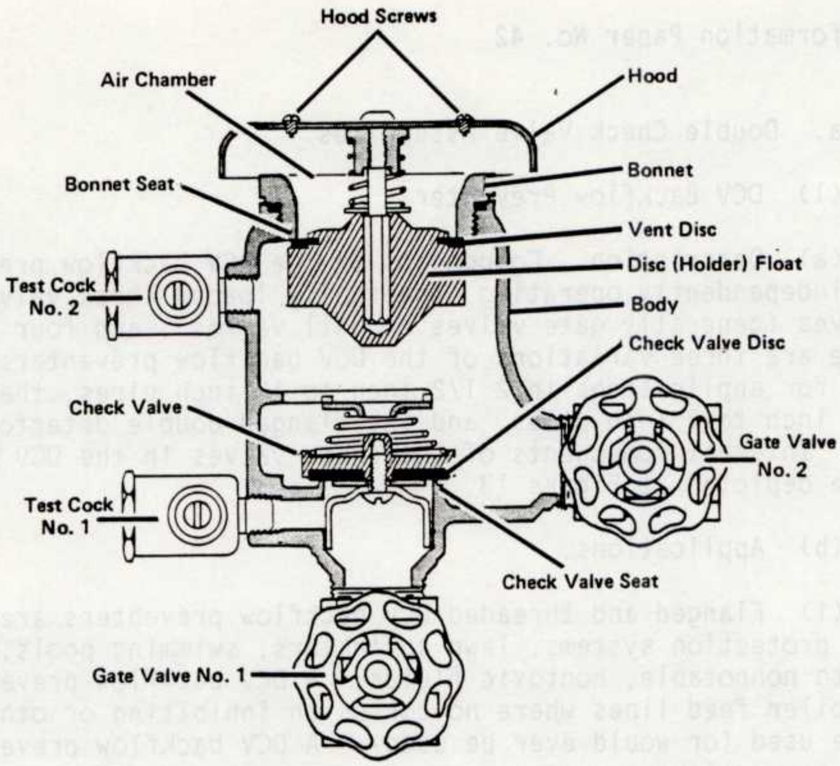


Figure 10. Components of a Pressure Vacuum Breaker (Courtesy of Watts Regulator Company)

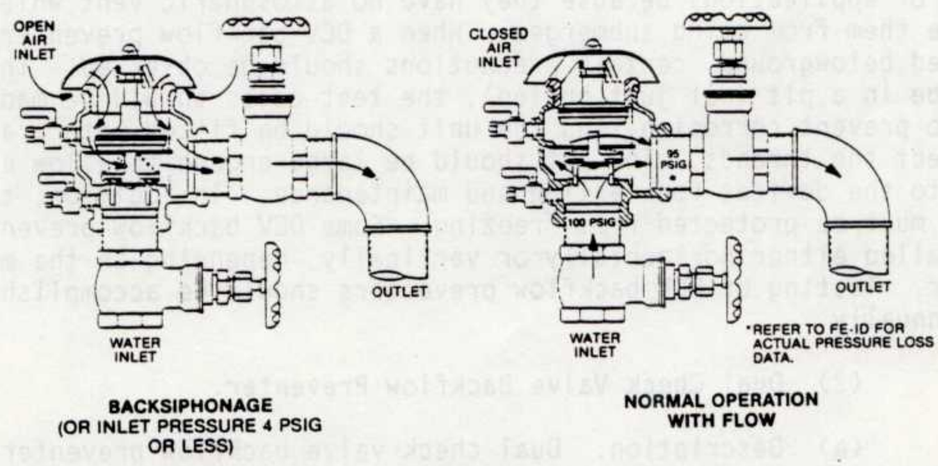


Figure 11. Operation of a Pressure Vacuum Breaker during normal and backsiphonage conditions (courtesy of Febco Sales, Inc.)

a. Double Check Valve Assemblies.

(1) DCV Backflow Preventer.

(a) Description. Components of the DCV backflow preventer include two independently operating, internally loaded check valves, two shut-off valves (generally gate valves or ball valves), and four test cocks. There are three variations of the DCV backflow preventer: the flanged type for applications in 2 1/2 inch to 10 inch pipes, the threaded type for 3/4 inch to 2 inch pipes, and the flanged double detector check (Figure 12). Internal components of the check valves in the DCV backflow preventer are depicted at Figure 13.

(b) Applications.

(i) Flanged and threaded DCV backflow preventers are used to isolate fire protection systems, lawn sprinklers, swimming pools, and other connections to nonpotable, nontoxic fluids. A DCV backflow preventer can be used on boiler feed lines where no corrosion inhibiting or other additives are used (or would ever be used). A DCV backflow preventer can be subjected to continuous pressure.

(ii) Double detector check assemblies are designed for fire protection systems. They are fitted with a bypass line containing a 3/4-inch DCV backflow preventer and a water meter (Figure 14). The meter is provided to account for leaks or to detect unauthorized water use. Low flows, up to 10 gpm, pass through the water meter and bypass line, while fire flows, or flows over over 10 gpm, flow through the main check valves.

(c) Installation. The DCV backflow preventers have a wide variety of applications because they have no atmospheric vent which would preclude them from being submerged. When a DCV backflow preventer is installed belowground, certain precautions should be observed. The DCV should be in a pit (not just buried), the test cocks should be made of brass to prevent corrosion, and the unit should be fitted with brass plugs to protect the threads. The pit should be large enough to allow easy access to the devices for testing and maintenance. In addition, the devices must be protected from freezing. Some DCV backflow preventers may be installed either horizontally or vertically, depending on the manufacturer. Testing of DCV backflow preventers should be accomplished at least annually.

(2) Dual Check Valve Backflow Preventer.

(a) Description. Dual check valve backflow preventers are small, one piece devices consisting of two independently acting, spring-loaded check valves. Each check valve is a "poppet" type, contained in a separate module or cartridge. Individual components of a DuCV backflow preventer are depicted at Figure 15. The DuCV backflow preventers generally are sized for 3/4-inch or 1-inch pipes and cause a 2-10 psi head loss. These devices are functional at pressures up to 150-170 psi and temperatures up to 180 °F.

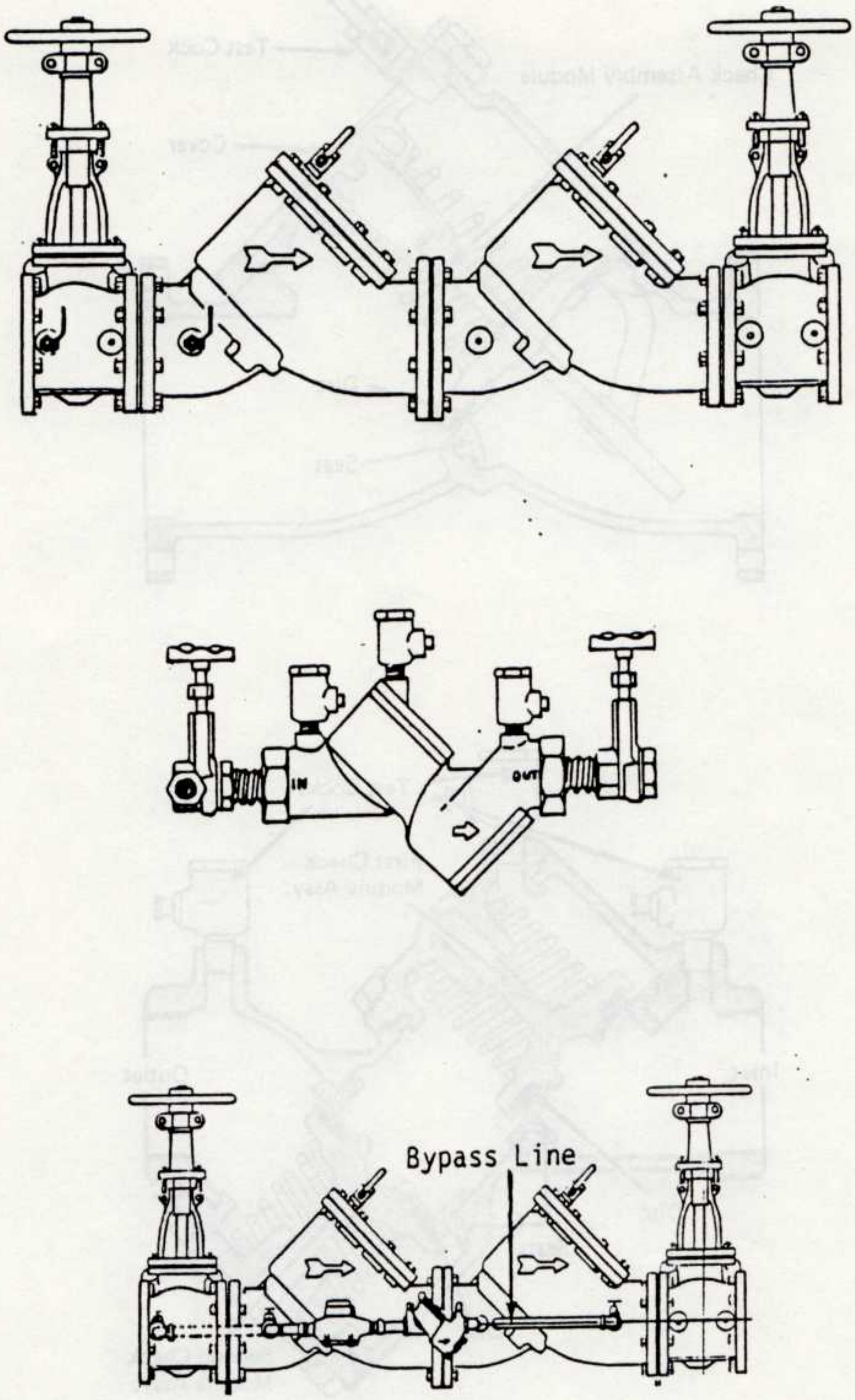
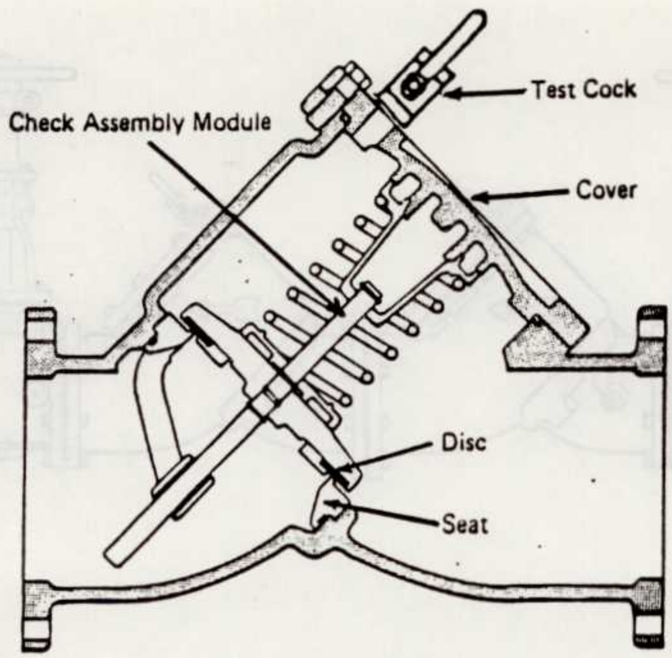


Figure 12. Variations of the double check valve backflow preventers: flanged (top), threaded (middle), and double detector (bottom)(Courtesy of Watts Regulator Company)



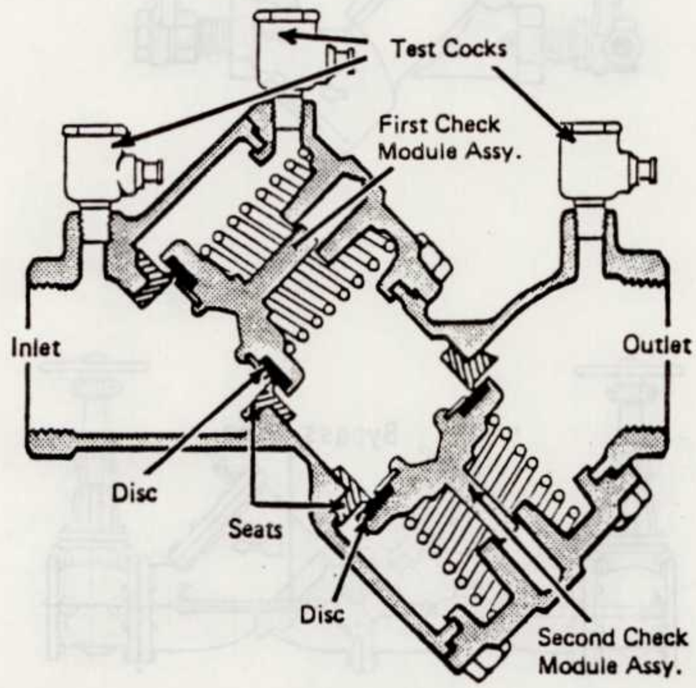
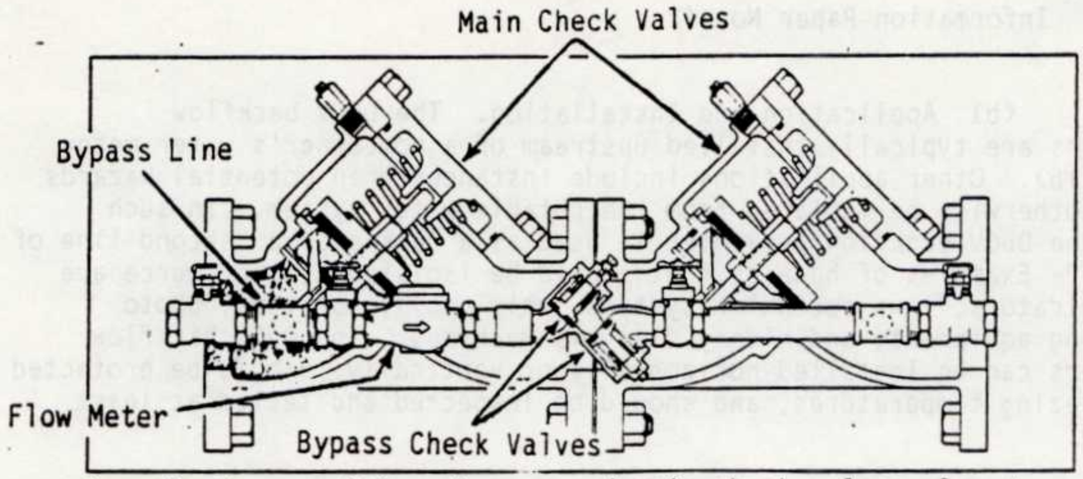
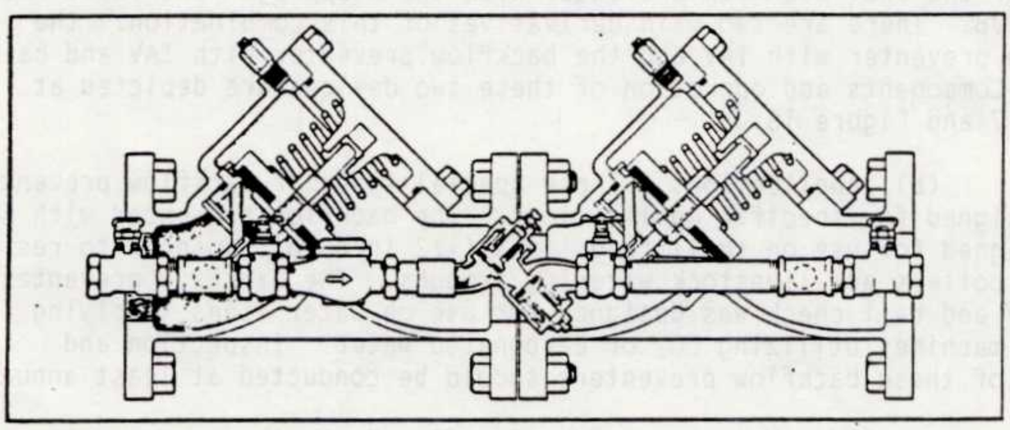


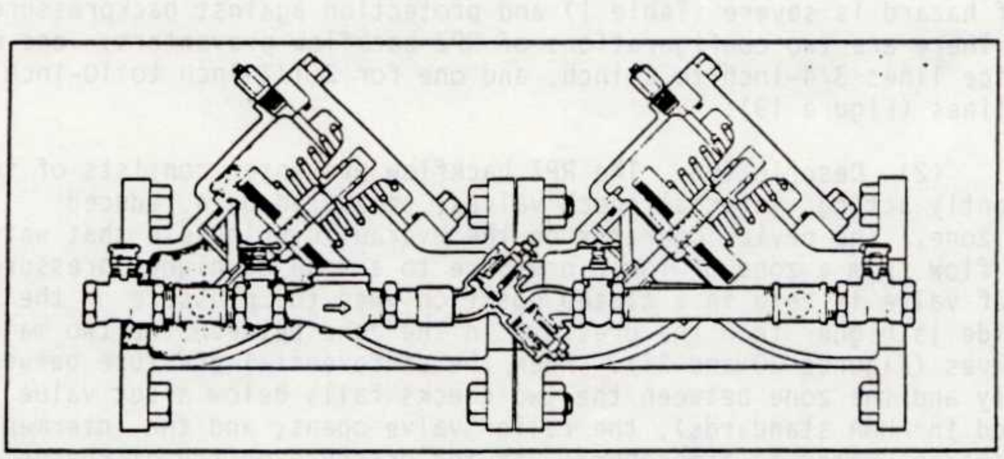
Figure 13. Internal components of double check valve backflow preventers flanged (top) and threaded (bottom) (Courtesy of Watts Regulator Company)



Non-flowing condition- bypass and main check valves closed



Low flow condition (leak or theft detection)- bypass check valves open, main check valves closed



Fire flow condition- bypass and main check valves open

Figure 14. Operation of the Double Detector Check backflow preventer (Courtesy of Febco Sales, Inc.)

(b) Application and Installation. The DuCV backflow preventers are typically installed upstream of a homeowner's water meter (Figure 16). Other applications include instances when potential hazards may not otherwise be isolated from the potable water system. In such cases, the DuCV backflow preventer is used as a backup or a "second line of defense." Examples of hazards that should be isolated at the source are hose aspirators, lawn sprinkler systems, whirlpools, hot tubs, photo developing equipment, and kidney dialysis machines. The DuCV backflow preventers can be installed horizontally or vertically, should be protected from freezing temperatures, and should be inspected and tested at least annually.

(3) Backflow Preventers with Intermediate Atmospheric Vent.

(a) Description. Some manufacturers have combined the overall design of the DuCV backflow preventer with the diaphragm vent valve found in the HVB. There are two main derivatives of this combination: the backflow preventer with IAV and the backflow preventer with IAV and ball check. Components and operation of these two devices are depicted at Figure 17 and Figure 18.

(b) Applications. These special types of backflow preventers were designed for specific applications. The backflow preventer with IAV was designed for use on small feed lines (1/2 inch to 3/4 inch) to residential boilers and livestock watering troughs. The backflow preventer with IAV and ball check was designed for use on water lines supplying vending machines utilizing CO_2 or carbonated water. Inspection and testing of these backflow preventers should be conducted at least annually.

b. Reduced Pressure Zone Backflow Preventer.

(1) General. The RPZ backflow preventer is used where the degree of hazard is severe (Table 1) and protection against backpressure is needed. There are two configurations of RPZ backflow preventers: one made for service lines 3/4-inch to 2-inch, and one for 2 1/2-inch to 10-inch service lines (Figure 19).

(2) Description. The RPZ backflow preventer consists of two independently acting, internal check valves, separated by a reduced pressure zone. The device operates on the hydraulic principle that water will not flow from a zone of lower pressure to a zone of higher pressure. The relief valve is held in a closed position when the pressure on the supply side is higher than the pressure in the zone between the two main check valves (Figures 20 and 21). When the differential pressure between the supply and the zone between the two checks falls below a set value (as prescribed in AWWA standards), the relief valve opens, and the intermediate zone discharges water to atmosphere. If the pressure on the discharge side of the device becomes higher than the supply pressure and the second check valve malfunctions, the intermediate zone also discharges water to atmosphere. During routine operation, an occasional discharge of water is normal.

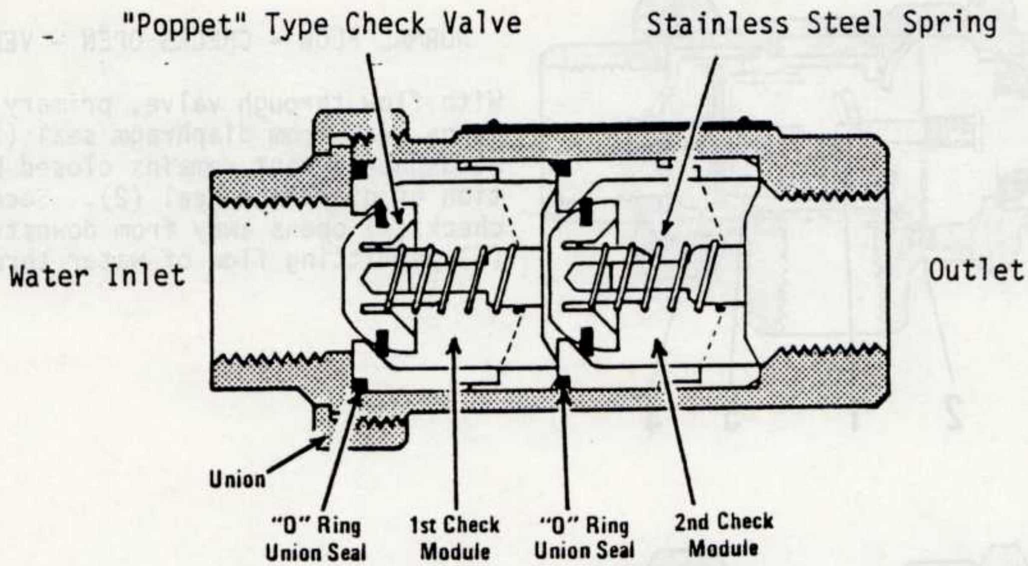


Figure 15. Components of a dual check backflow preventer (Courtesy of Watts Regulator Company)

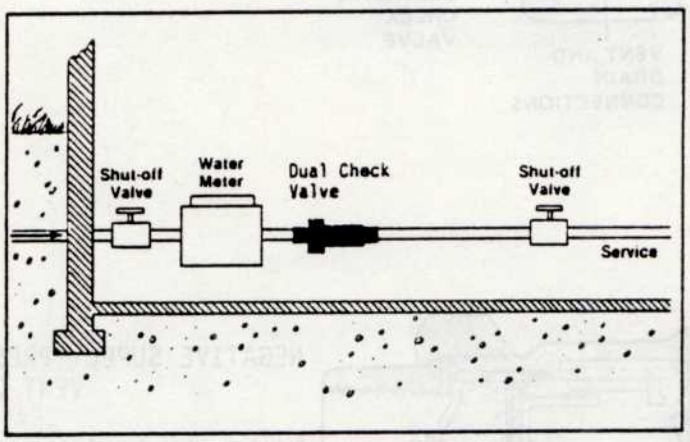
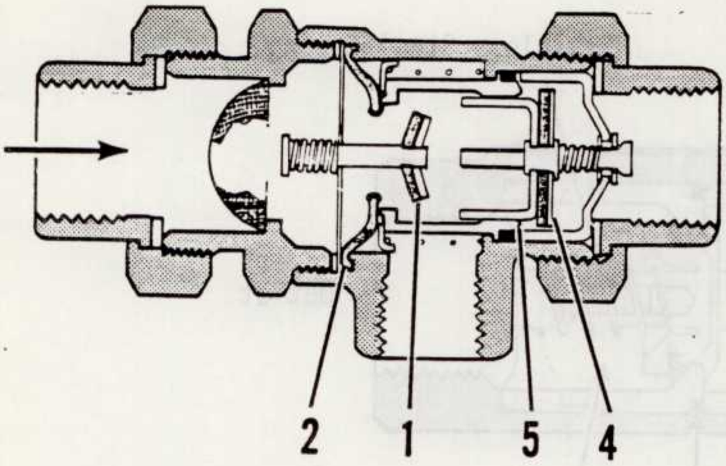
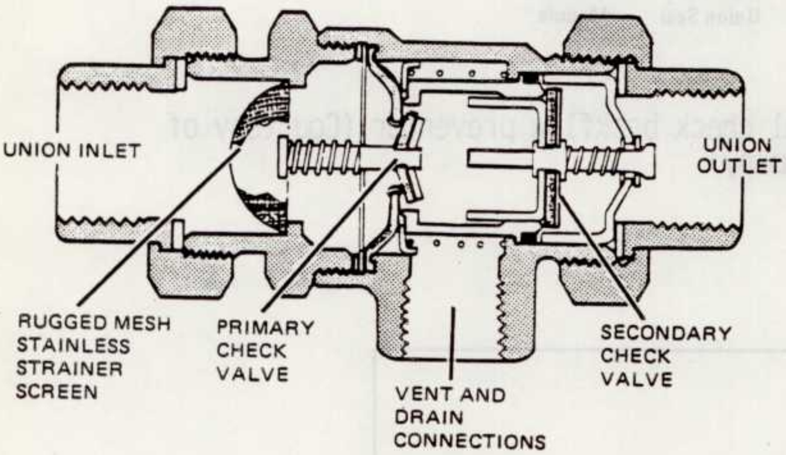


Figure 16. Typical installation of a dual check backflow preventer (Courtesy of Febco Sales, Inc.)



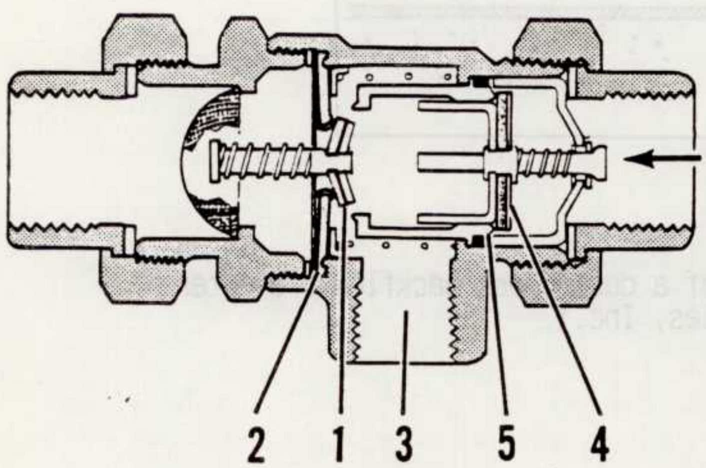
NORMAL FLOW - CHECKS OPEN - VENT CLOSED

With flow through valve, primary check (1) opens away from diaphragm seal (2). Atmospheric vent remains closed by deflection of diaphragm seal (2). Secondary check (4) opens away from downstream seat (5) permitting flow of water through valve



STATIC PRESSURE - NO FLOW

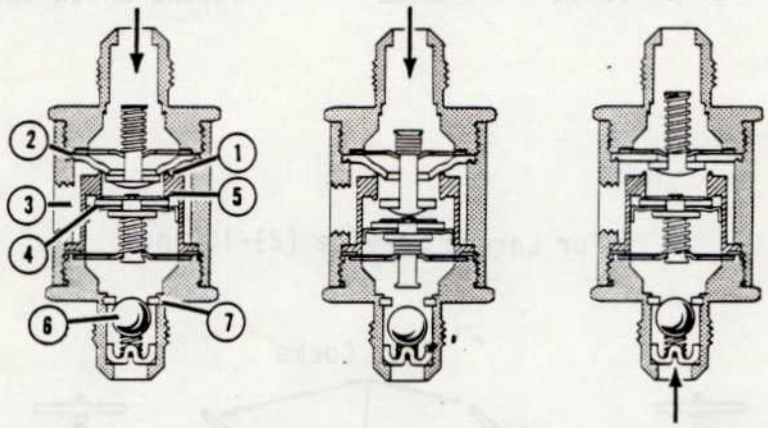
Primary and secondary checks return to closed position. Vent closed.



NEGATIVE SUPPLY PRESSURE - CHECKS CLOSED - VENT OPEN

With a back-siphonage condition created, secondary check (4) seals tightly against downstream seat (5). Primary check (1) seals tightly against diaphragm (2). Atmospheric vent (3) is now open, permitting air to enter air break chamber. In the event of fouling of downstream check valve, leakage would be vented to atmosphere through the vent port, thereby, safeguarding the potable water system from contamination.

Figure 17. Operation of a backflow preventer with intermediate atmospheric vent (Courtesy of Watts Regulator Company)



Static Pressure-No Flow
Primary disc (1) seats against diaphragm (2) with diaphragm (2) sealing off the atmospheric port (3). Secondary disc (4) seals against downstream seat (5). Ball check (6) seals against ball check seat (7). This is the normal position taken by the device when there is no demand on downstream equipment.

Valve Opened Flowing Under Pressure
With flow through valve, primary disc opens away from diaphragm seal. Atmospheric port remains closed by deflection of diaphragm seal. Secondary disc opens away from downstream seat. Ball check opens away from ball check seat permitting flow of water through valve.

Valve Closed by Back Pressure in System
With a back pressure condition created, ball check seats firmly against ball check seat. Secondary disc seals tightly against downstream seat. Primary disc seals tightly against diaphragm. Atmospheric port is now open permitting air to enter air break chamber. In the event of fouling of downstream check valve, leakage of CO_2 gas would be vented to atmosphere through the vent port thereby safeguarding the potable water system from CO_2 gas contamination.

Figure 18. Operation of backflow preventer with intermediate atmospheric vent ball and check (courtesy of Watts Regulator Co.)

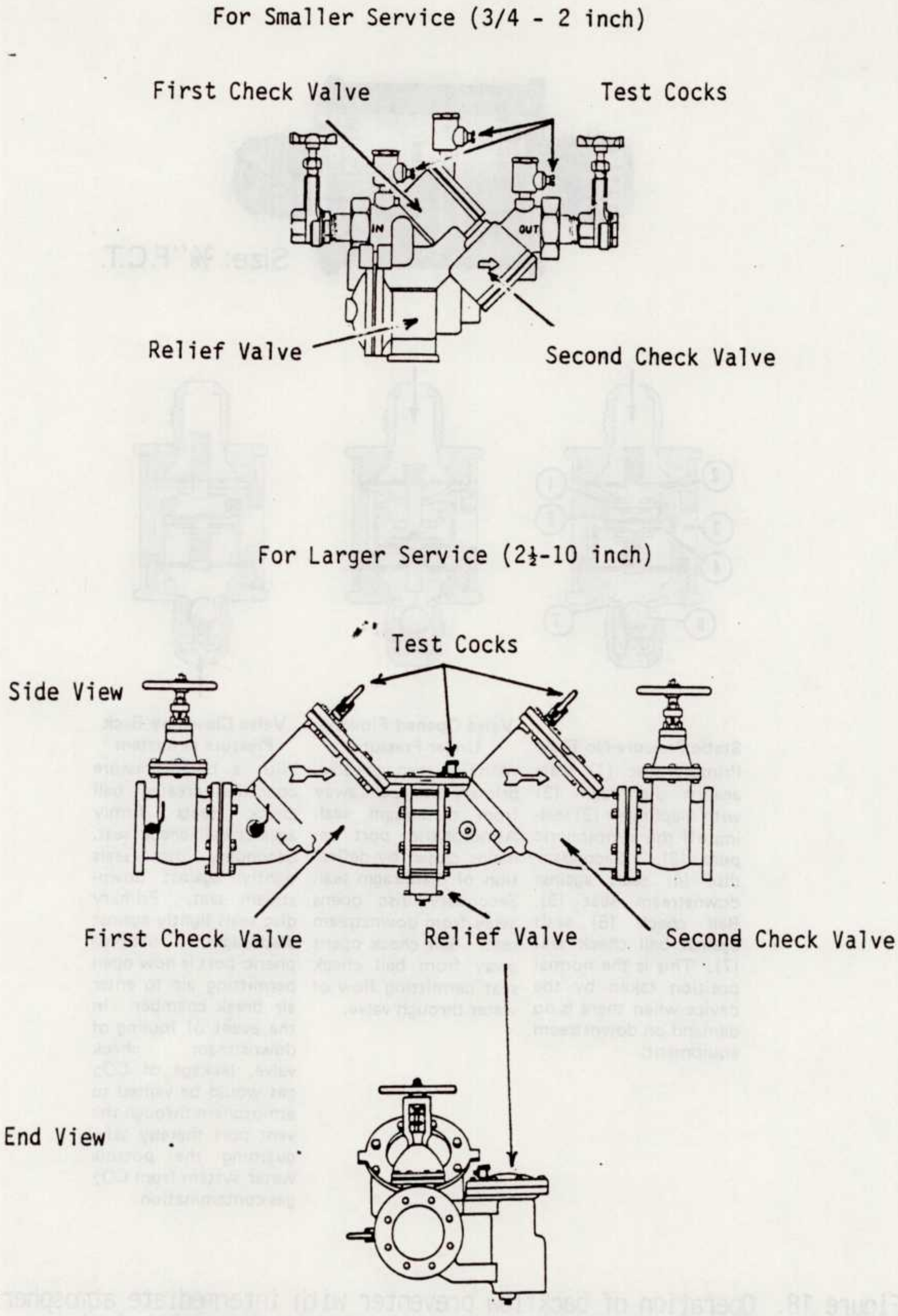


Figure 19. Reduced Pressure Zone Backflow Preventers (Courtesy of Watts Regulator Company)

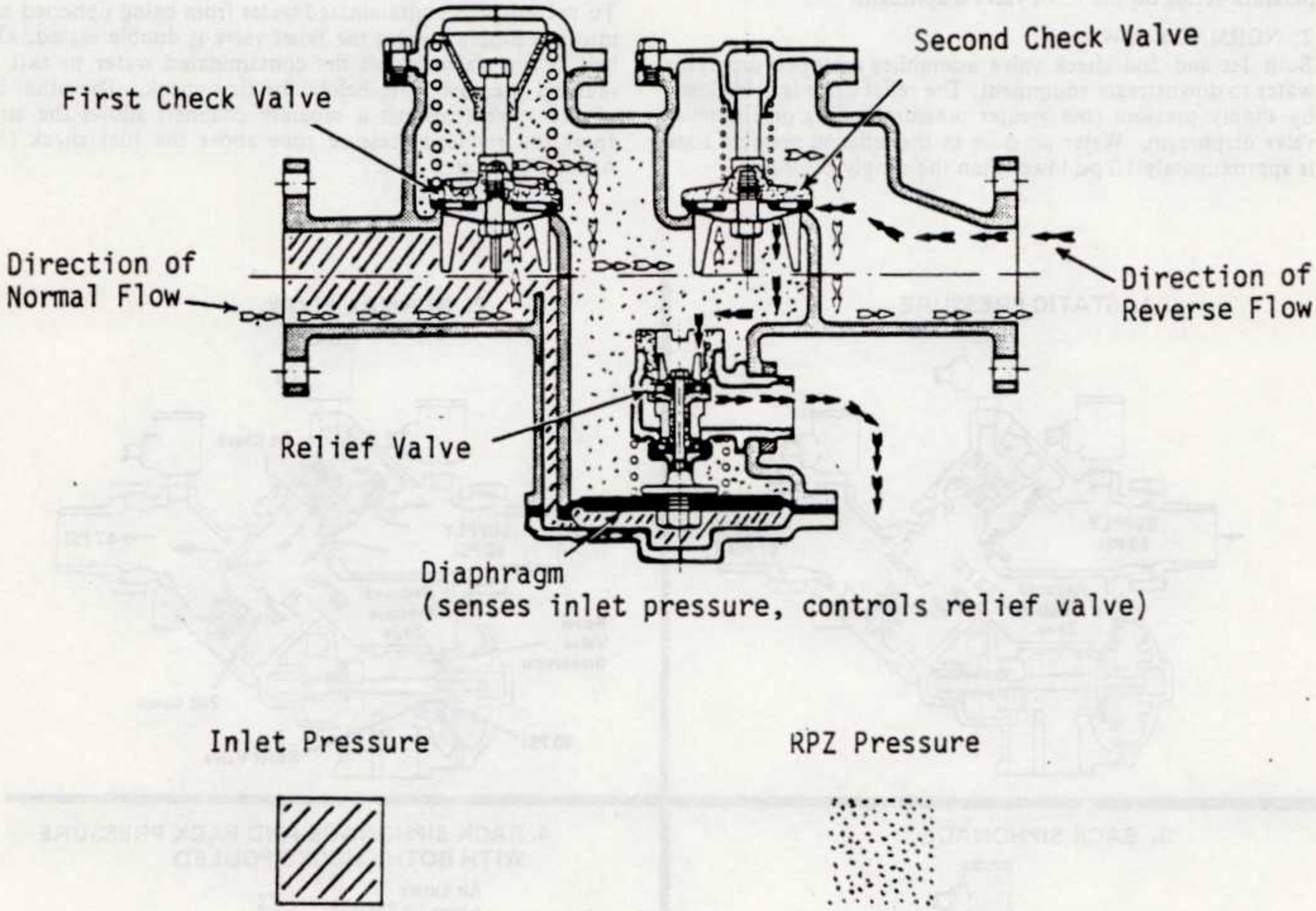


Figure 20. Cutaway view of a Reduced Pressure Zone Backflow Preventer with a common vent/relief port (Courtesy of American Water Works Association)

Watts No. 909 series reduced pressure principle backflow preventers provide superior protection for potable water supply lines against contamination caused by either backflow or back-siphonage or a combination of both. Exclusive added protection feature: Air-in/Water-out relief valve performance. Admits air directly into reduced pressure zone via a separate channel from the water discharge.

1. STATIC PRESSURE

Both 1st and 2nd check valves are closed as no water is flowing to downstream equipment. Supply pressure in the inlet side of the units is approximately 10 psi higher than the reduced pressure zone; thus, the relief valve is held closed by the supply pressure acting on the relief valve diaphragm.

2. NORMAL FLOW

Both 1st and 2nd check valve assemblies are open supplying water to downstream equipment. The relief valve is held closed by supply pressure (the greater pressure) acting on the relief valve diaphragm. Water pressure in the reduced pressure zone is approximately 10 psi lower than the supply pressure.

3. BACK-SIPHONAGE

With a negative supply pressure, both the 1st and 2nd check valves are closed tightly. The relief valve (reacting to the negative supply pressure) is now full open and discharging water trapped in the reduced pressure zone through the vent port.

4. BACK-SIPHONAGE and BACKPRESSURE WITH BOTH CHECKS FOULED (the emergency condition)

As in Fig. 3 the negative supply pressure caused the relief valve to open. Now assume a fouled first check and a fouled second check with backpressure, this allows contaminated water to enter the reduced pressure zone.

To prevent this contaminated water from being siphoned back into the supply system the relief valve is double seated. One-half of the valve allows the contaminated water to exit the reduced pressure zone below the first check. The other half of the valve (through a separate channel) allows the air to enter the reduced pressure zone above the first check (i.e. Air-in/Water-out).

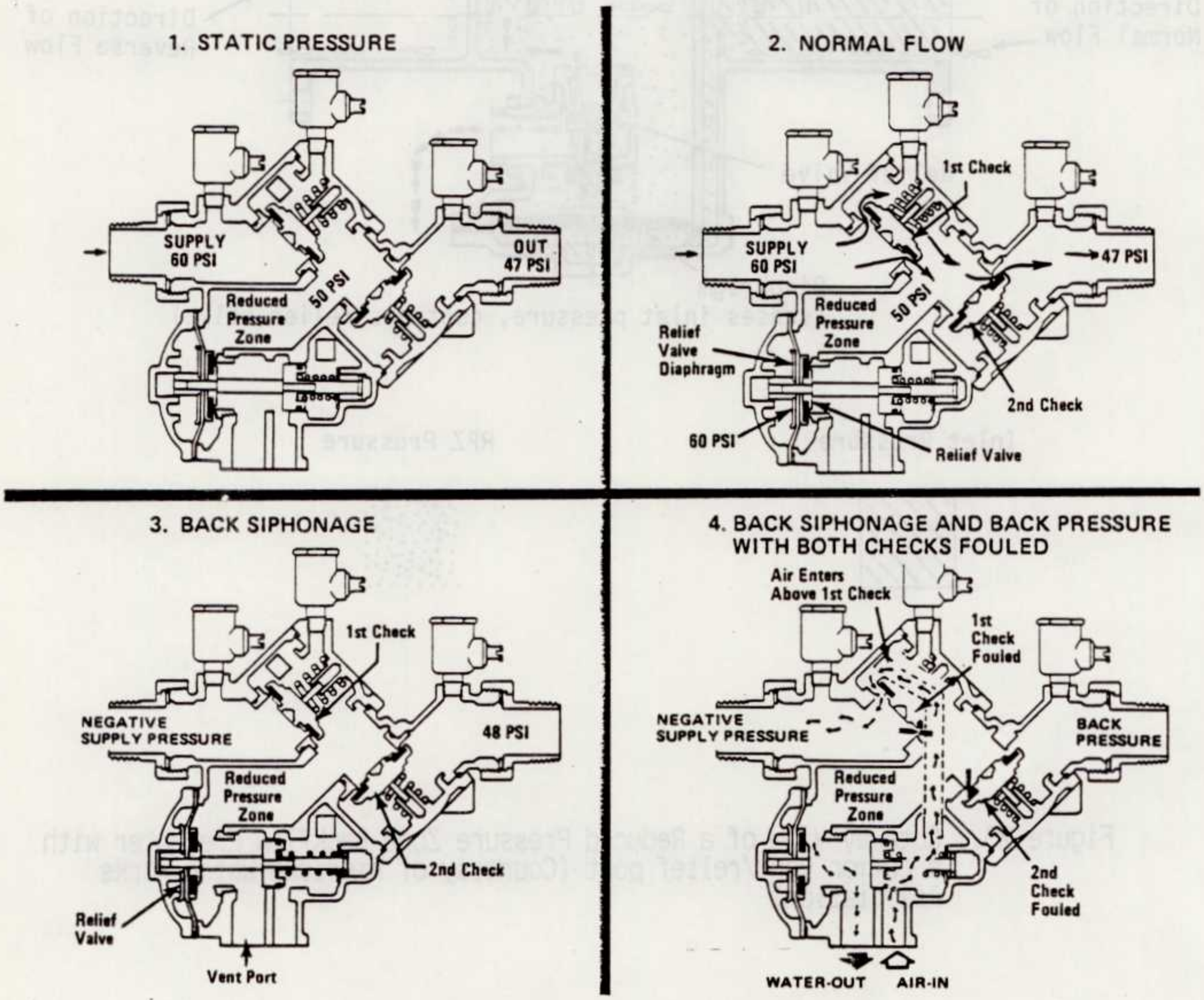


Figure 21. Operation of a Reduced Pressure Zone Backflow Preventer using separate vent and relief ports (Courtesy of Watts Regulator Company)

(3) Applications. The RPZ backflow preventer is normally used in locations where an air gap separation is impractical or where there is a tendency to modify an air gap. The RPZ is effective against backflow caused by backpressure and back-siphonage and is used to protect a water system from substances constituting severe health hazards. If hot water conditions are anticipated, the device manufacturer should be consulted. An outstanding advantage that the RPZ backflow preventer has over the DCV backflow preventer is a visible indication of a malfunction (continuous discharge) as backflow occurs.

(4) Installation. The RPZ backflow preventer is installed between two shut-off valves. The RPZ backflow preventer must be installed aboveground, and generally be in a horizontal position. The relief valve must be in a position so that discharge will not cause water damage. When this discharge is piped out of an area, the piping must be separated by an air gap at the relief valve. If a pressure reducing valve is required in the same line as the RPZ backflow preventer, the reducing valve may be located upstream of the RPZ backflow preventer. This positioning should be used when it is desired to take advantage of the check valve effect of the reducing valve. These devices should be tested at least annually using a kit similar to that depicted at Figure 22.

4. The Air Gap.

a. General.

(1) An air gap is a physical separation, by an air space, between a potable water system and a nonpotable source. Air gaps are generally limited to nonpressure applications, and are the only absolute means of eliminating physical links between a potable water system and a source of potential contamination. Air gaps should be used when possible, but must be closely monitored to prevent bypass. A typical air gap is depicted in Figure 23.

(2) The supply inlet to a fixture requiring an air gap, should be at least two times the internal diameter of the fixture, above the flood level rim of the sink. There should be no provision for extending the supply inlet below the flood level rim. If the end of the supply pipe is threaded or serrated, an HVB should be installed.

(3) If an air gap separation is provided at each fixture, complete protection will be provided to personnel within a building, as well as to the water supplier. Protection of a water system can also be achieved by installing a single air gap at the point where the water service enters the building. It must be emphasized that this configuration protects only the water supply system and not the building system or consumers within the building.

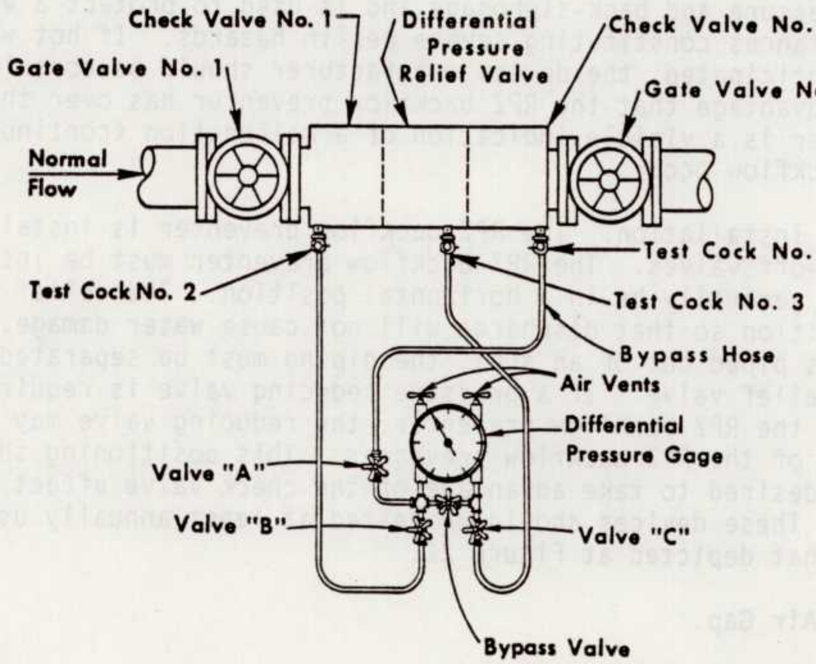


Figure 22. Field test of a Reduced Pressure Zone Backflow Preventer

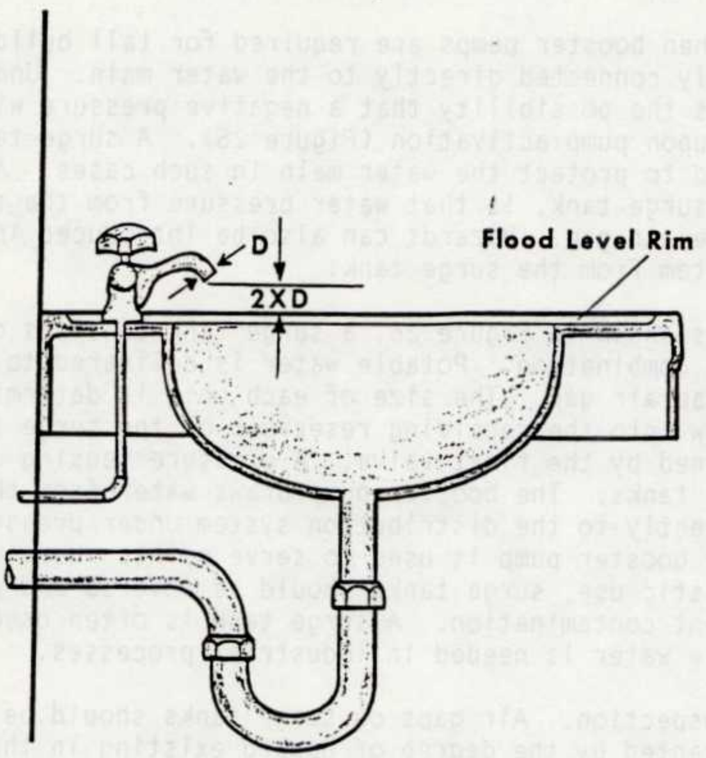


Figure 23. Typical Air Gap on a sink

b. Applications.

(1) Typical applications of air gaps are depicted in Figures 24 a, b, and c. One special application of the air gap is the surge tank and booster pump combination. This configuration is typically used to service tall buildings or some nonpotable fixtures.

(2) When booster pumps are required for tall buildings, the pumps are frequently connected directly to the water main. Under this condition, there is the possibility that a negative pressure will be caused in the water main upon pump activation (Figure 25). A surge tank with an air gap can be used to protect the water main in such cases. A major disadvantage of a surge tank, is that water pressure from the supply system is lost through the air gap. Hazards can also be introduced into the supplied water system from the surge tank.

(3) As shown in Figure 26, a surge tank consists of a reservoir and pump combination. Potable water is delivered to the reservoir through an air gap. The size of each unit is determined by the water demand. Flow into the receiving reservoir of the surge tank shown in Figure 26 is governed by the float valve. A pressure sensing device could be used for larger tanks. The booster pump draws water from the surge tank and discharges directly to the distribution system under pressure. When discharge from the booster pump is used to serve points where water will be withdrawn for domestic use, surge tanks should be covered and properly protected to prevent contamination. A surge tank is often used in installations where water is needed in industrial processes.

c. Inspection. Air gaps on surge tanks should be inspected as frequently as warranted by the degree of hazard existing in the system supplied. Where the air gap is supplying a severe hazard area, it should be inspected once a year. When serving a low or moderate hazard application, it should be inspected every 2 years (TM 5-660, Tables 9-2 and 9-3).

F. <u>Guidelines on Developing a Cross-Connection Control Program</u>.

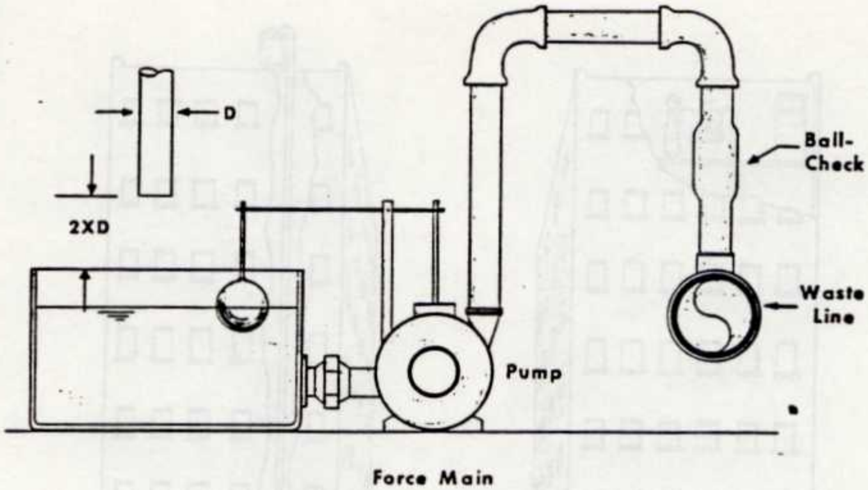
1. Development of an effective program can be divided into four distinct steps (or phases):

a. Designation of a cross-connection control authority;

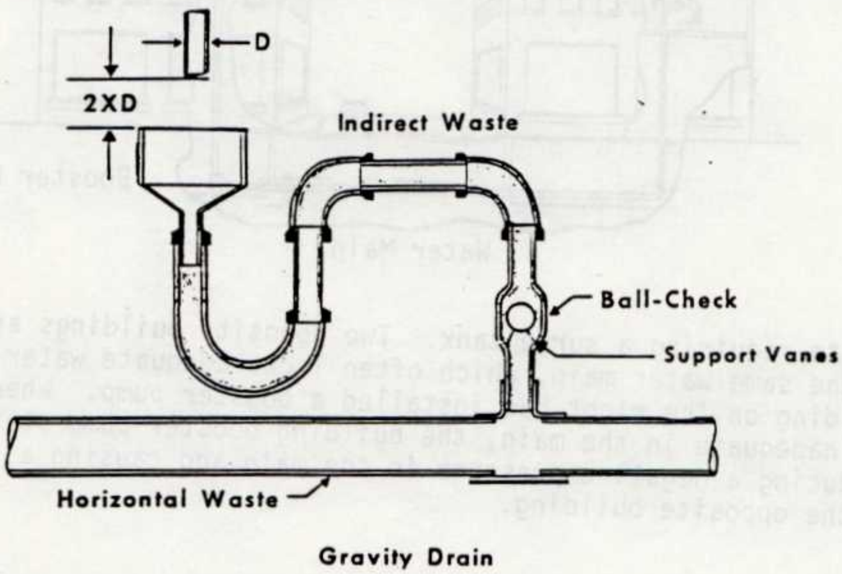
b. Building inspections and delineation of remedial measures;

c. Elimination of existing and potential cross-connections; and

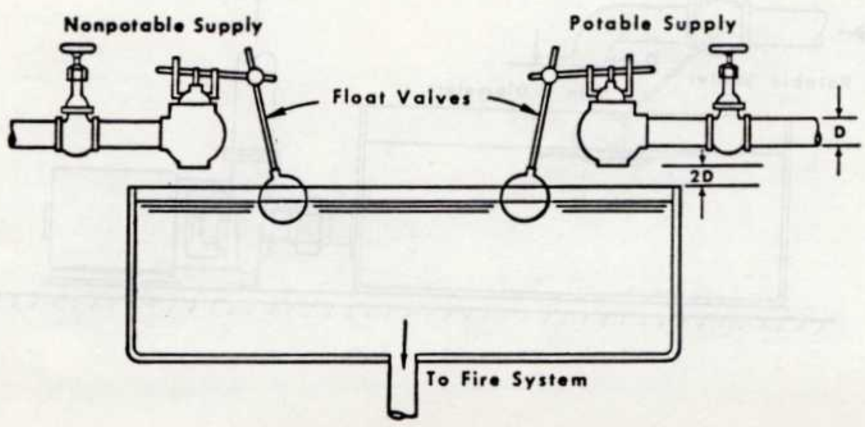
d. Institution of a routine maintenance and inspection program to include training and certification of personnel.



a. Air gap to sewer subject to backpressure-force main.



b. Air gap to sewer subject to backpressure-gravity drain.



c. Fire system make-up tank for a dual water system.

Figure 24. Typical uses of an Air Gap

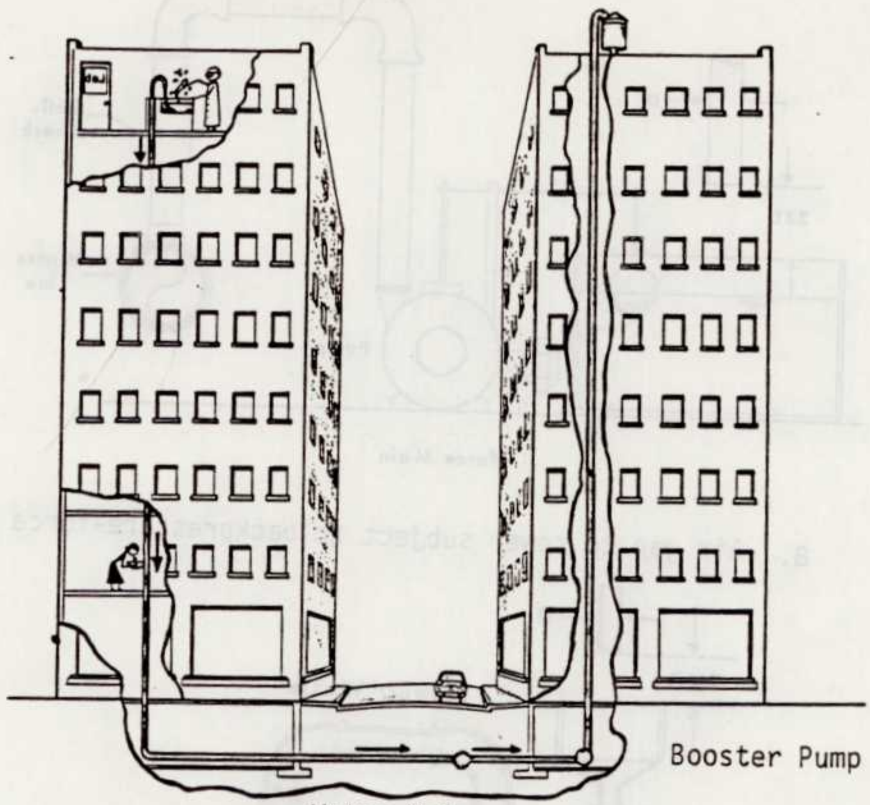


Figure 25. A site requiring a surge tank. Two opposite buildings are connected to the same water main, which often lacks adequate water pressure. The building on the right has installed a booster pump. When the pressure is inadequate in the main, the building booster pump starts pumping, producing a negative pressure in the main and causing a reversal of flow in the opposite building.

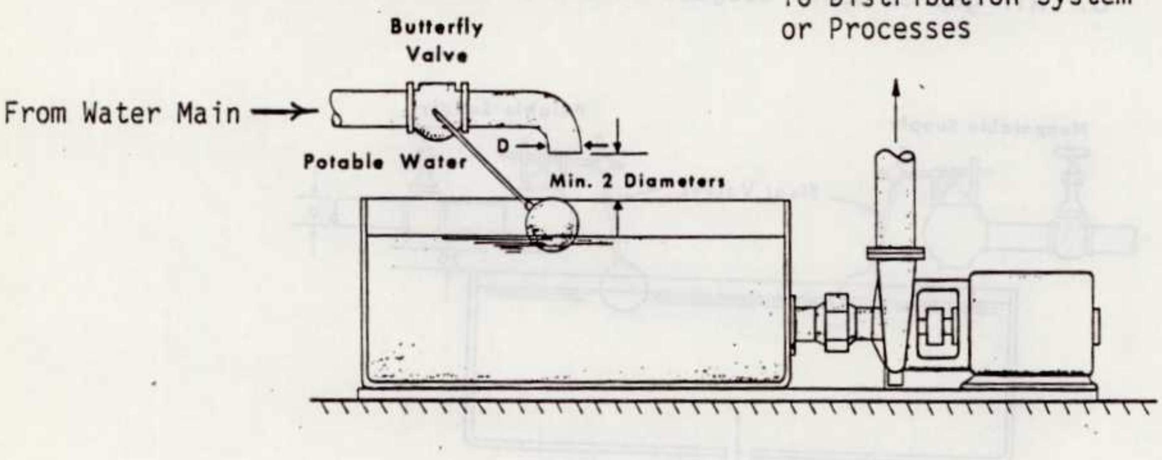


Figure 26. Surge tank and booster pump

2. Cross-Connection Control Authority.

a. The program authority will be assigned the responsibility of organizing, administering, and revising the cross-connection control program. The facilities engineer is generally tasked with this role as the Commander's representative and water purveyor. An ad hoc committee, comprised of representatives from the facilities engineering utilities section, the facilities engineering plumbing section, the environmental coordinator's office, and the PVNTMED Svc, should be formed to direct program implementation and management. This group will delegate responsibility for the accomplishment of a routine inspection of facilities and devices, establish and manage time schedules for corrective actions, determine responsibility for the installation of prevention devices, and ensure that involved personnel are properly trained and/or certified.

b. It is imperative that the PVNTMED Svc remain aware of the activities undertaken with respect to the cross-connection control program. The PVNTMED Svc should become actively involved in any issue pertaining to evaluations of potential health impacts upon consumers. Associated duties assigned to the PVNTMED Svc should include:

(1) Assist in development of policies and procedures for effective implementation of such a program.

(2) Periodically assist facilities engineering personnel on cross-connection control inspections and backflow prevention device evaluation.

(3) Remain aware of the inventory of backflow prevention devices maintained by the facilities engineer.

(4) Provide technical assistance to the commander and program authority regarding the perceived health impact of particular circumstances, and the assessment of potential health hazards encountered.

(5) Assist the facilities engineer in presenting suitable training to engineering and environmental personnel.

(6) Assist the facilities engineer in educating the general installation population.

3. Inspection and Inventory.

a. The second phase of program development is manpower intensive and must be conducted in an organized manner. This phase can be divided into three steps:

(1) Performance of an inspection of buildings and activities for potential cross-connections.

(2) Inspection of the condition of existing backflow preventers.

(3) Determination of the types of backflow preventers needed where cross-connections are identified.

b. A list delineating approved backflow prevention devices associated with various degrees of hazard is provided at Table 2. Inspection priorities are determined by the degree of hazard associated with each building. For example, inventory of a photographic film processing area would precede that of a troop barracks. Areas of concern are further identified in AWWA, NSPC, EPA and applicable State and local plumbing and utility codes.

c. An inventory is to be accomplished by closely tracing potable water lines throughout a building, noting the type and location of all cross-connections. Accurate as-built drawings, maps, and historical records (for example, both design specifications and complaint records) will prove helpful during the inventory. Tracing water lines and utilizing accurate plumbing plans is often hindered, since water lines are rarely marked and plans are often outdated. The following references, guidelines and regulatory requirements may facilitate the inventory:

(1) Where accurate as-built drawings are not available, these drawings must be developed. Accurate water system drawings are required by TM 5-660, paragraph 8-1c and AR 420-46, paragraph 5c. These regulations require operators to keep accurate records and maps of the location, type, and size of all mains, pipes, valves, meters, hydrants, backflow preventers, and other accessories of the distribution system. Accurate maps and piping networks, which are readily distinguishable, are essential to maintain segregation of potable and nonpotable water systems, and to help ensure protection from cross-connection hazards. Updated, concise plans are also necessary for plumbers to find valves and lines to allow them to make speedy repairs.

(2) Pipes must be marked (color-coded or tagged) in order to trace water lines. According to TB MED 576, all nonpotable water systems shall be designated as nonpotable or color-coded to prevent interconnection with the potable system. A recommended color coding scheme is presented in Table 3. Paragraph 10.2 of the NSPC requires all buildings with both potable and nonpotable water systems to have each system identified by color marking or metal tags.

4. Elimination of cross-connections. Elimination of cross-connections requires the identification of unprotected cross-connections and the procurement and installation of appropriate backflow prevention devices. This phase may be accomplished by:

a. Reading documented guidelines to determine what prevention device is appropriate for each designated use (e.g., AVB's on threaded faucets).

TABLE 3. SUGGESTED PIPING COLOR-CODES

WATER LINES	
Raw	Olive green
Settled or clarified	Aqua
Finished or potable	Dark blue
CHEMICAL LINES	
Alum or primary coagulant	Orange
Ammonia	White
Carbon slurry	Black
Caustic	Yellow with green band
Chlorine (gas and solution)	Yellow
Fluoride	Light blue with red band
Lime slurry	Light green
Ozone	Yellow with orange band
Phosphate compounds	Light green with red band
Polymers or coagulant aids	Orange with green band
Potassium permanganate	Violet
Soda ash	Light green with orange band
Sulfuric acid	Yellow with red band
Sulfur dioxide	Light green with yellow band

b. Researching manufacturer's literature to determine device availability and cost. Installation of devices is to be scheduled and accomplished as in-house constraints allow, once again prioritized by the degree of hazard. Should a determination be made that such constraints will preclude effective, in-house implementation of the program, said services must be retained on a contract basis.

c. Wherever possible, air gaps should be used to prevent back-siphonage and inhibit backflow. Air gaps are generally the least expensive and the easiest devices to install. They are always the most effective cross-connection control device if properly designed and maintained.

5. Maintenance, Inspection, Training and Certification.

a. Another critical phase in the development of a cross-connection control program is the testing, maintenance, and repair of installed devices. Without an effective testing and maintenance program, control devices can easily be rendered useless. The program authority can ensure that installed devices consistently provide protection, by establishing a routine inspection and maintenance program. Army regulations require that a State-certified inspector perform this task using approved testing equipment (AR 200-1, paragraph 3-13b and TM 5-660, paragraph 9-33). Such certification usually entails a period of classroom instruction and hands-on experience (often 40 hours total or less). The testing and maintenance program can be adapted such that several devices can be checked monthly, allowing all devices to receive inspection on a biannual basis. Special emphasis should be placed on ensuring that each detail of the maintenance crew's activities and findings are fully documented. Accurate and updated records will facilitate future repairs.

b. The last phase of program implementation also includes a commitment to maintain the program indefinitely. While new buildings, processes or plumbing alterations are in the design phase, blueprints should be reviewed to ensure cross-connection control devices are included where appropriate. Since alterations and repairs of the plumbing system are done by various organizations (contractors, steam fitters, plumbers, heating and air-conditioning personnel, etc.), communication efforts must be continuous, to ensure that new cross-connections are minimized and unprotected cross-connections are prevented. Education of responsible personnel is the key to successful cross-connection control. Heightened awareness of typical cross-connections should be expanded through flyers or bulletins.

G. <u>Suggested Protocol for a Cross-Connection Control Survey</u>.

1. Purpose. To evaluate an Army installation to determine the extent of potentially hazardous cross-connections, to provide guidance in development of a cross-connection control program, and to conduct limited training in selection, installation and inspection of backflow prevention devices.

2. Inbriefing.

a. Discuss the survey purpose and protocol with the facilities engineer, environmental coordinator, chief of utilities, head of the plumbing shop, and a representative from the PVNTMED Svc.

b. Review applicable Federal, State and Army regulations concerning cross-connections with key installation personnel. Ensure they are aware of their responsibilities and liabilities.

c. Familiarize key personnel with the purpose of the survey, and identify potential problem areas by determining what installation locations have the potential for cross-connections. Coordinate with personnel responsible for water at these locations and schedule visits.

3. Conduct of the Survey. During the survey, the following should be accomplished:

a. Review plans of the potable water system to identify locations of existing and potential cross-connections. A partial listing of specific equipment posing potential cross-connection hazards is provided at Table 4.

TABLE 4. PARTIAL LISTING OF COMMON EQUIPMENT HAVING CROSS-CONNECTION HAZARDS

Air-conditioning system	Ice makers
Aspirators	Irrigation systems
Autoclaves and sterilizers	Laboratory equipment
Bath tubs	Laundry equipment
Bedpan washers	Lavatory
Brine tank, softener	Lawn sprinkler systems
Bidget	Lubrication, pump bearings
Chemical feeders	Photo laboratory sinks
Coffee urns	Pressure cookers
Compressors	Process water systems
Cooling systems	Pump priming systems
Cooling towers	Sewer flush tanks
Cuspidor, dental	Slop tanks
Dishwasher	Soda fountain
Display fountain	Steam boilers
Drinking fountain	Steam tables
Ejectors, steam or water	Swimming pools
Fire sprinkler systems	Tanks and vats
Fish ponds	Toilets
Floor drains	Vegetable peelers
Garbage grinders	Vacuum systems
Garbage can washers	Urinals
Garden sprayers	Water troughs
Hydraulic equipment	Water-using mechanical equipment

b. Inspect locations that typically pose the greatest health threat, or that has equipment listed in Table 4. Demonstrate cross-connections to installation personnel. The demonstration could include:

(1) Feed lines entering vessels below their flood level.

(2) Direct connections between the potable water system and other water systems (steam lines, cooling water, fire protection systems).

(3) Submerged and dangling hoses, without vacuum breakers, in areas of potentially hazardous fluids (near garbage can clean outs, at the water and sewage treatment plants, near industrial operations, in janitor's closets).

c. Demonstrate test kits for double check valves and reduced pressure zone backflow preventers. Personnel targeted for these demonstrations should include the control authority, and plumbers and utility personnel who will conduct testing. Emphasize the need for frequent inspection, testing, and maintenance of all backflow prevention devices.

d. Provide useful documents and sources of further information on cross-connections and cross-connection control. Examples are the USAEHA Appendix on cross-connection control, manufacturer's literature, EPA and AWWA literature, and this information paper.

e. Provide assistance in development of a cross-connection control program. Identify installation personnel responsible for the program, and review with them the steps necessary to implement an effective program.

V. REFERENCES. See the Enclosure for a listing of references.

VI. TECHNICAL ASSISTANCE. Requests for services should be directed through appropriate command channels of the requesting activity to Commander, US Army Environmental Hygiene Agency, ATTN: HSHB-ME-WR, Aberdeen Proving Ground, MD 21010-5422, with an information copy furnished to the Commander, US Army Health Services Command, ATTN: HSCL-P, Fort Sam Houston, TX 78234-6000.

VIII. ACKNOWLEDGMENTS. The efforts and contributions of CPT Tom Nielson and 1LT Cody Jackson were instrumental in the development of this document.

Thomas R. Runyon for

Encl

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CPT, MS
Sanitary Engineer
Environmental Health Engineering
Division

ABBREVIATIONS AND DEFINITIONS OF TERMS

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.

ASSE - American Society of Sanitary Engineering

AVB - atmospheric vacuum breaker - a back-siphonage prevention device designed for use under flow conditions only, not to exceed 12 consecutive hours, and where it will be subject to no static pressure, and no backpressure.

AWWA - American Water Works Association

backflow - A reversal of flow in a pipe from the normal or intended direction. Backflow is generally more evident in an open supply water system.

backflow preventer - a device designed to prevent reverse flow in a water system. The term should normally be used where backpressure backflow is implied.

backflow preventer with intermediate atmospheric vent (IAV) - a small backpressure and backsiphonage backflow preventer designed to operate under continuous pressure, including backpressure, where pollutants and low-degree contaminants are involved.

backpressure - an increase in pressure in a consumer's water system, or branch of the system, above that at the water service connection. It is generally caused by pumps, thermal expansion, or reasons other than a reduction or loss of the incoming pressure. Backpressure is generally more evident in a closed water system.

backsiphonage - a reversal of flow in the water system caused by a negative pressure in the incoming pipe, when the point of use is at atmospheric pressure. Backsiphonage is generally more evident in an open water system.

backsiphonage preventer - a device designed to prevent reverse flow in a water system. The term should be used only where no backpressure is implied.

check valve - a self-closing device designed to permit the unidirectional flow of fluids and to close to prevent a reversal of flow.

closed water system - one with a checking device installed in the service pipe. A check valve, backflow preventer, or pressure reducing valve would create a closed system.

Encl 1

containment - the installation of a backflow preventer at the service connection to a premises to protect the water main only.

contaminant - any substance that, if introduced into the potable water system, would create a potential health hazard.

cross-connection - a physical connection or arrangement between two otherwise separate piping systems; one of which contains potable water, the other a nonpotable fluid, or water of unknown quality, where there could be flow from one system to the other, the direction depending on the pressure differential.

DCV - double check valve - a backpressure backflow preventer designed to operate under continuous or intermittent pressure, including backpressure, where pollutants are involved.

DDCV - double detector check valve - a backpressure backflow preventer designed to serve also as a detector check on fire protection systems where pollutants are involved. It includes a line size approved double check valve backflow preventer with a metered bypass, into which has been incorporated a 3/4 inch approved double check valve backflow preventer.

DuCV - dual check valve - a small backpressure backflow preventer designed especially for containing water systems to residences, mobile homes, etc., as the "second line of defense," and for isolating residential lawn sprinklers, etc., where pollutants are involved.

EPA - U.S. Environmental Protection Agency

ESO - Environmental Science Officer

FCCCHR of USC - Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California

gpm - gallons per minute

HVB - hose vacuum breaker - a device used where a hose connection can be made to the threaded faucet. The device is designed to prevent backsiphonage only, and not for continuous pressure, static or flowing conditions.

IAV - intermediate atmospheric vent (see backflow preventers with IAV)

isolation - the installation of a backflow preventer or a vacuum breaker at each cross-connection on a premises to protect both premises and the water main.

LFVB - laboratory faucet vacuum breaker

NSPC - National Standard Plumbing Code

open water system - one with no checking device installed in the water service line. Water from the consumer's system is free to backflow into the main, for whatever reason.

pollutant - any substance that, if introduced into the potable water system, could be objectionable but could not create a health hazard.

psi - pounds per square inch

PVB - pressure vacuum breaker - a backsiphonage prevention device designed to operate under continuous pressure, static or flowing, but not backpressure.

PVNTMED Svc - Preventive Medicine Service

RPZ - reduced pressure zone backflow preventer - a backsiphonage backflow preventer designed to operate under continuous pressure, including back pressure, where contaminants are involved.

second line of defense - a program of backflow prevention where two or more backflow prevention devices are used. The first device is installed at the source of each cross-connection to isolate some fixture that could potentially contaminate the water system. This is the first line of defense and protects the building from contamination. A second backflow preventer is installed at the service-connection to the building housing the fixture(s). The second backflow preventer contains the building from the public water supply system, and provides cross-connection protection in depth, as a second line of defense.

service connection - the point of delivery of water to a consumer's premises. It is the end of the water purveyor's jurisdiction and the beginning of the plumbing official's jurisdiction.

sight tube test kit - a clear plastic tube attached to a backflow preventer to test the seal on the check valves. The tube is held vertically and allowed to fill with water up to a height of 28". A 28" column of water equals 1 psi. The supply line is then shut off, a test cock opened, and the level of water in the tube monitored. If the water level drops, the check valve is leaking.

surge tank - the receiving, nonpressure vessel forming part of the air gap separation between a potable and auxiliary system (see Figure 25).

threaded faucet - a control valve designed with hose threads on the outlet. It is supplied in several configurations: hose bib, sill cocks, wall and yard hydrants, boiler drains, etc.

USAEHA - U.S. Army Environmental Hygiene Agency vacuum breaker - a backsiphonage prevention device that introduces air into the potable water system when the system pressure approaches zero. It is designed for use where the receptacle or environment being served is subject to atmospheric pressure only.

vacuum relief valve - a device designed to limit the degree of vacuum in a vessel or a pipe, but not for cross-connection control.

HSHB-AM-E
SUBJECT: Information Paper No. 42

REFERENCES

1. AR 40-5, 30 August 1986, Preventive Medicine.

2. AR 200-1, 15 June 1982, Environmental Protection and Enhancement.

3. AR 420-46, 1 July 1978, Water and Sewage.

4. Public Law 93-523, 17 December 1974, The Safe Drinking Water Act of 1974.

5. TB MED 576, 15 March 1982, Sanitary Control and Surveillance of Water Supplies at Fixed Installations.

6. TM 5-660, 30 August 1984, Maintenance and Operation of Water Supply, Treatment, and Distribution Systems.

7. Air Force Manual 85-21, 11 February 1982, Operation and Maintenance of Cross-Connection control and Backflow Prevention Systems.

8. AWWA, Pacific Northwest Section. Accepted Procedure and Practice in Cross-Connection Control Manual, 4th edition (August 1985).

9. EPA 430/9-73-002, 1975, U.S. Environmental Protection Agency, Cross-Connection Control Manual.

10. Cross-Connection Control Committee, City of Denver. Manual of Cross-Connection Control (1977).

11. Dekalb County (GA) Department of Public Works, Procedures for Cross-Connection Control, undated.

12. Division of Sanitary Engineering, Tennessee Department of Public Health: Cross-Connection Control Manual (1975).

13. National Association of Plumbing-Heating Cooling Contractors, National Standard Plumbing Code, Washington D.C. (1984).

14. Angele, G. J. Jr., Cross-Connections and Backflow Prevention. 2nd edition, AWWA (1974).

15. Clary, R., Georgia State Plumbing Inspectors Association, A Guide to Selection and Installation of Cross-Connection-Control Devices (1986).

16. Springer, E.K. and P.H. Schwartz, Manual of Cross-Connection Control, 7th edition, Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California (June 1985).

17. American Water Works Association, Cross-Connection Control Program, Training Manual.

Encl 2