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THE ISSUE: CROSS-CONNECTION CONTROL AND BACKFLOW PREVENTION

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INTRODUCTION

Today there are many uses for water in a variety of applications that, if not kept under strict control, may result in serious health risks for the water consumer. In virtually every place – homes, offices, and factories – water is being used to dilute, mix, cool, and clean. Water is coming into contact with hundreds of dangerous chemicals and substances. A simple accident or oversight can lead to serious consequences. Loss of water pressure or an improper connection of a pump to a water line could result in dangerous materials being siphoned or pumped back into the water supply, thus allowing that material to move through the system to other water users who may be consuming the water and be affected by it.

Within water distribution systems, there are points called cross-connections where non-potable water can be connected to potable sources. These cross-connections provide a pathway for backflow of non-potable water into potable sources. Backflow can occur either because of reduced pressure in the distribution system (backsiphonage) or the presence of increased pressure from the non-potable source (backpressure). Both situations act to change the direction of water, which normally flows from the distribution system to the customer, so that non-potable and potentially contaminated water from industrial, commercial, or residential sites flows back into the distribution system through a cross-connection. During incidents of backflow, these chemical and biological contaminants have caused illness and death. The number of incidents actually reported is believed to be a small percentage of the total number of backflow incidents in the United States.

BACKGROUND

A cross-connection is a point in the plumbing system where it is possible for a non-potable substance to come into contact with the potable drinking water supply. Common examples of cross-connections include washbasins and service sinks, sprinkler systems, auxiliary water supplies (wells), boilers, and swimming pools. The most common cross-connection is the garden hose.

Whenever there is a cross-connection between a potable water system and a non-potable environment, backflow may occur. Backflow is any unwanted flow of used or non-potable water, or other substances from any domestic, industrial, or institutional piping system that enters the potable water distribution system. The direction of flow under these conditions is opposite to that of normal flow. The reverse pressure that leads to backflow is caused by either backsiphonage or backpressure.

Backsiphonage backflow can occur when a negative pressure, such as a vacuum, develops in the distribution system allowing pollutants or contaminants to be siphoned into the water system. Undersized pipes, pipeline breaks, or high withdrawal rates can cause negative pressure, as when fire hydrants are used. Fire flow demands create a tremendous concentration of water usage in a relatively small location within the distribution system. Small systems on hilly terrain are particularly vulnerable to negative pressure, because heavy water use at the lower elevations can literally siphon the water away from the higher-elevation portion of the distribution system.

Backpressure may cause backflow to occur whenever a potable system is connected to a non-potable supply operating under a higher pressure by means of a pump, steam boiler, a difference in elevation, or by other means.

(continued on page 2)

Joint Legislative Air and Water Pollution Control and Conservation Committee

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This type of backflow is more common at commercial connections, like factories, however, it still can occur in a residence if there are pumps, or pressurized air connected to the plumbing system.

Unlike backsiphonage, it is not necessary to have a drop in distribution system pressure for backpressure to occur. Whenever the pressure at the point of the cross-connection exceeds the pressure of the distribution system, the direction of the flow will reverse. Without adequate protection non-potable water will be forced into the potable system.

REPORTED OUTBREAKS ASSOCIATED WITH CROSS-CONNECTION AND BACKFLOW

Cross-connections and backflow incidents have serious health implications. There are numerous, well-documented cases where cross-connections have been responsible for the contamination of drinking water and have resulted in the spread of disease.

A review of backflow incident data by the U.S. Environmental Protection Agency (EPA) found that between 1970 and 2001 there were 459 incidents resulting in an estimated 12,093 cases of illness. When the data analysis is narrowed from 1981-1999, (for comparison with the Center for Disease Control (CDC) data on outbreaks for that period), only 97 of 309 incidents produced reports of how many (if any) illnesses were caused, and 22 of these 97 incidents reported no illnesses. Of the remaining 75 incidents, only 26 appear in CDC's summaries as a waterborne disease outbreak. This suggests that CDC data underreport known instances of illness caused by backflow contamination. From the 75 incidents that produced reports of illness, analysis of the case reports estimated 4,416 illnesses, averaging 46 illnesses per outbreak.

Although major disease outbreaks get plenty of publicity, it is likely many backflow events occur and go unnoticed. This is because too few people may be affected to garner public attention, or persons who become ill may just think they have the flu.

A backflow incident may also be of short duration. Monthly bacteriological testing may not catch the localized and short-term contamination event. Even if contamination is widespread, contaminants can be flushed out of the system before the next sample is collected.

CONTAMINANTS ASSOCIATED WITH CROSS-CONNECTIONS AND BACKFLOW

A backflow incident could cause any substance (in most cases a liquid) that can come in contact with water to backflow into the distribution system contaminating the drinking water. The most common contaminants are pesticides, sewage, antifreeze from commercial sprinkler systems, coolants, and detergents. Almost all businesses that use water have the potential to contaminate public drinking water supplies through cross connections. Examples of consumers that pose a health or pollution hazard to the public water system are: hospitals, mortuaries, convalescent homes, film laboratories, chemical and petroleum storage facilities, car washes, and laundries.

In the past, cross-connection problems were confined mostly to commercial and industrial applications. Currently, however, the ordinary garden hose is the most common offender as it can be easily connected to the potable water system and can be used for a variety of potentially dangerous situations.

Many common household uses of water may pose a public health threat to the potable water supply system, including:

- Toilets without no-siphon ball cocks
- Lawn sprinkler systems
- Water softeners
- Hose connections to water outlets or laundry tubs
- Swimming pools
- Solar heating systems
- Water operated sump drain devices

The list of potential cross-connection hazards is by no means complete and a home that has any of these situations (without the proper backflow devices being installed) may jeopardize its own potable water system and that of the surrounding community.

The likelihood and severity of illness and the number of people affected depends on a number of factors, including how much contamination enters the system, the dilution rate, the type of contaminant, the magnitude and duration of the pressure difference causing the backflow, and the number of users exposed.

COSTS OF CONTAMINATION THROUGH CROSS-CONNECTIONS

In 1981, Allegheny County, Pennsylvania, spent approximately $300,000 to replace plumbing and water mains of a large housing authority development. The piping was permanently contaminated when chlordane and heptachlor, toxic chemicals which have been banned since 1976 for agricultural use, entered the potable water supply system through a cross-connection. A pesticide contractor was mixing the chemicals in a tank truck, using water from a garden hose attached through one of the apartments. The end of the hose was submerged in the chemical solution. At the same time, a gate valve was being installed in the distribution line. Water to the area was shut off, allowing the chemical to back-siphon into the potable water system as the distribution lines drained.

(continued on page 3)

Water services to seventy-five apartments housing nearly three hundred people were contaminated. Attempts to clean and flush the lines were not successful; evidence of contamination remained and water quality standards could not be met. The housing authority was without water for 27 days while the main and all affected plumbing were replaced (both inside and outside). Water was transported to the area for drinking and cooking purposes. Costs to the water company were substantial, but an estimate of the damage incurred by water consumers cannot be reasonably determined. A simple hose bib or hose connection vacuum breaker could have prevented the incident.

MEASURES FOR PREVENTING AND CORRECTING PROBLEMS CAUSED BY CROSS-CONNECTION AND BACKFLOW

Currently, there are several backflow measures that can be used to correct cross-connections: air gap, reduced-pressure principle backflow-prevention assembly, double check valve assembly, pressure vacuum breaker, and atmospheric vacuum breaker. Each backflow measure is designated as a method, a device, or an assembly. Specific criteria apply to each. The air gap qualifies as a method. An air gap is not a specialized piece of mechanical equipment, but a plumbing configuration. The hose bib vacuum breaker and the atmospheric breaker are both devices, and the other three measures are assemblies. A self-contained device has neither shutoff valves or test cocks. An assembly must have test cocks and shut-off valves and must be capable of being tested and repaired in line.

Many residential cross-connections can be eliminated by installing a hose bib (threaded faucet) vacuum breaker on each outside hose connection and hose connections in the garage, basement, and laundry room. These devices are available at many hardware, plumbing and home improvement stores. Other cross-connection situations may require more complex protection devices.

Overview Of Cross-connection Control And Backflow Prevention Regulations

Under the provisions of the Safe Drinking Water Act (SDWA) of 1974 and the amendments of 1986 and 1988, the federal government established national standards for safe drinking water. The states are responsible for the enforcement of these standards as well as the supervision of public water supply systems. The water purveyor (supplier) is held responsible for compliance to the provisions of the SDWA. This includes ensuring water meets the safe drinking water standards and its quality is not compromised during delivery to the consumer through the distribution system. However, contaminants added to the water under circumstances controlled by the user are excluded from this definition.

In the past decade, the protection of potable water from potential backflow has moved forward in priority for state regulatory authorities. This has been accented by the adoption and enforcement of regulations focusing on the elimination of cross-connections and/or their control by installation of backflow prevention devices, the establishment and implementation of specific management programs, and updated or revised plumbing and building codes to reflect cross-connection control.

A total of 47 states have specific or applicable regulations for cross-connection control and backflow prevention. Twenty states (including Massachusetts, California, Iowa, Oregon, and New York) mandate the establishment and implementation of a written cross-connection control program or plan. Additionally, the majority of those states also require approval of such a program by the applicable regulatory authority prior to implementation, and specific key elements that must be contained within. Pennsylvania is one of the few states that still does not have a state mandated cross-connection control plan requirement.

Cross-connections are addressed in Chapter 109 of Pennsylvania's Safe Drinking Water Act. Section 709 states, "At the direction of the department, the public water supplier shall develop and implement a comprehensive control program for the elimination of existing cross-connections or the effective containment of sources of contaminations, and prevention of future cross-connections."

Several water utilities in Pennsylvania have taken the initiative and implemented comprehensive cross-connection control programs in the municipalities they serve. Water utilities that serve Edinboro, Erie, North Wales, State College, and York have taken the lead in establishing cross-connection programs. The York Water Company was one of the first utilities to implement a cross-connection program. It requires a backflow prevention device/assembly at all service connections. This includes the smallest residential service connection to the largest industrial connection. The majority of the cost for the residential devices to be purchased, installed and maintained is addressed by the York Water Company and is rolled into the water rates. Commercial/industrial assemblies are purchased, installed, and maintained by the property owner. Devices are tested annually and replaced on a 10-year schedule.

At the federal level, the EPA is now focusing on the distribution system as a major source of potable water system contamination and it may mandate cross-connection control programs in the future.

CONCLUSION

In spite of the progress made in cross-connection control, the potential for contamination is growing. Anyone is capable of making a cross-connection. It is estimated that over 100,000 new cross-connections are created in the United States every day. Continued improvements are necessary to properly protect potable water systems from potential contamination or pollution that can result from backflow through cross-connections, and more importantly, to protect the health of the consumer.

A proper, actively enforced cross-connection control program is critical to the safety of all community water supplies. Protection can be ensured only through a program which not only locates potential cross-connections and requires installation of devices, but which also requires the inspection, testing, and maintenance of those devices.

Just as anyone can make a cross-connection, anyone can prevent a cross-connection. An ongoing, thorough educational program for water consumers is one of the most effective means of controlling cross-connections. Most consumers do not understand the potential hazard which is created by a common garden hose, dishwasher, or other home plumbing attachment which extends the potable water line beyond its safe extension.

Industrial, institutional or commercial customers who understand the implications and costs associated with a cross-connection incident are willing to cooperate with the program. Adverse publicity and lawsuits are a high price to pay for failing to install protection on the public drinking water supply system.

Continued and improved emphasis in the increasingly important issue of cross-connection control and backflow prevention will benefit municipalities by helping to ensure that contamination-free and/or pollution-free water is provided to the consumer. This can reduce the number of incidents of illness and ensure compliance with applicable regulations, plumbing codes, and technical guidelines.

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EDITOR'S NOTE

Green Papers will be issued periodically by the Joint Legislative Air and Water Pollution Control and Conservation Committee staff. As indicated by the subtitle, each Green Paper will be a monograph on a specific environmental issue that has come to the attention of or is being dealt with by the committee. Each Green Paper is intended to provide a more in-depth look at specific issues than normally permitted by other committee publications, such as the committee's monthly newsletter the *Environmental Synopsis*.

Each Green Paper may also be found on the committee's Internet website, in addition to on-line editions of the *Environmental Synopsis*, and other committee news and events. Please visit the website at **http://jcc.legis.state.pa.us.**

The Joint Conservation Committee is a bipartisan committee consisting of 18 members of the state House and Senate which conducts studies, holds hearings and makes recommendations to the General Assembly on air and water pollution laws, mining practices, land reclamation and other environmentally-related issues.

For more information about the committee, or to be added to the mailing list for future Green Papers or the *Environmental Synopsis*, call the committee office at (717) 787-7570.