CROSS-CONNECTION CONTROL
AND
BACKFLOW PREVENTION

INTRODUCTION

Backflow takes place when water in a distribution system flows in the opposite direction from what is normal. This can be caused by higher pressure in the consumer's piping (backpressure) or reduced pressure in the City's mains (backsiphonage). Backflow can take place within any water distribution system whether it is private or public.

Backflow conditions would not normally pose problems without cross-connections. Cross-connections occur in locations where the water supply is connected to some appliance, equipment, or apparatus which acts as a source for pollution or contamination. If there is any way for contaminated water or other harmful substances to get back into the distribution system by way of backpressure or backsiphonage, then it is a cross-connection.

Cross-connections can be uncontrolled or controlled. Uncontrolled cross-connections rely on nothing more than the lack of backflow events to keep harmful substances out of the water supply. If there is any occurrence of backflow, the water in the consumer's pipes or even the public water main will likely be contaminated. Uncontrolled cross-connections are time bombs waiting to go off.

Controlled cross-connections rely on either an air gap or a backflow preventer to protect the water supply. An air gap is a physical separation between the water supply and any sources of contamination. It is like the faucet on most sinks. No matter how full the sink gets, the faucet will never be submerged, thereby making it impossible for backflow to occur. Many appliances such as dishwashers, washing machines, et cetera have air gaps built into them.

HISTORY

The Safe Drinking Water Act (SDWA), passed by Congress in 1974, is credited as one of the milestones in the evolution of cross-connection regulations. Although it doesn't specifically address cross-connections, it authorized the United States Environmental Protection Agency (US EPA) to set national health-based standards for drinking water to protect against both naturally occurring and man-made contaminants. The act was meant to ensure delivery of high quality drinking water to the last free-flowing tap of water supply systems, and one way to do that is to prevent contamination due to cross-connections.

Cross-connections had been addressed in Kansas well before that time, however. In 1942, in Newton, Kansas, a backed up sewer contaminated the water distribution system via an open hydrant on a shut down main. The native inhabitants were not the only ones affected. Troop trains carrying US servicemen bound for World War Two battlefields often stopped in Newton to take on water and supplies. Before the contamination was discovered and remedied, more than 2500 troops and citizens suffered bacillary dysentery and at least two people died.

Because of this incident and others, the Kansas Legislature passed Kansas Statute Annotated (KSA) 65-163a in 1943. This statute gave a water supplier the power to refuse to deliver water to any premises where conditions existed which might lead to the contamination of the public water supply system. More important was the passing of KSA 65-171g in 1951. This statute called for the protection of water from sewage contamination in general.

As years went by, Kansas' cities and their water distribution systems became larger and more complex. With increased industrialization, cross-connections became more of a concern. It is safe to say that some cities had cross-connection programs in effect long before the SDWA was enacted. On May 1st, 1982, KDHE implemented Kansas Administrative Regulation (KAR) 28-15-18. Section (h) said that all public water systems should have regular programs for the detection and elimination of cross-connections.

In January 1998, the City of Manhattan first adopted the International Plumbing Code (IPC) to govern all plumbing work done within the city. The version of the Code at that time was the 1997 edition. When new additions are released, the City readopts them to keep up with current procedures and methods. In addition to federal, state, and city regulations concerning cross-connection control and backflow prevention, the IPC also has sections devoted to them.

On February 9th, 1998, the City of Manhattan passed Ordinance 5095 (The Cross-Connection Control and Backflow Prevention Ordinance). The ordinance was approved by KDHE a short time later, and it went into effect on July 1st of that year. Today, about 96% of public water suppliers in Kansas have KDHE approved cross-connection programs.

BACKFLOW PREVENTERS

A backflow preventer is a device installed in a water line, which prevents water or other substances from flowing backward into the water supply system. As backflow preventers are mechanical, they contain springs, moving parts, and rubber seating surfaces, all of which wear over time. Backflow preventers must be properly tested and maintained in order to keep the water supply safe.

Backflow preventers fall into two categories: testable and non-testable. Each category has several different types. As their name implies, testable backflow preventers can be tested to make sure they are working properly. They have small ports where an instrument called a differential pressure gauge can be attached by a trained technician to measure certain internal parameters. There are three types of testable backflow preventers: the double check valve assembly, the reduced pressure zone assembly, and the pressure vacuum breaker.

TESTABLE BACKFLOW PREVENTERS

Double Check Valve Assembly (DCVA) – A DCVA is made up two spring-loaded check valves sandwiched between two shut-off valves. A check valve is a one-way valve that will let water flow through it in the correct direction, but closes if water tries to go backwards. Think of it as a door you can exit through, but doesn't have a knob on the other side for you to get back in. There are two check valves on a DCVA, so if one fails, there is a back up.

Double Check Valve Assembly

A shut-off valve is just what it says; it shuts off the water. It is like the little valve where you hook up your garden hose. If you open it, water is allowed through. If you close it, the water stops. On a backflow preventer, the shut-off valves are basically there so a technician can take the device apart for maintenance without getting water everywhere.

DCVAs are only approved for low hazard, or non-health hazard, applications. That is, they are only to be used for substances that, if they do get into the water system, will only make the water look or taste bad but won't actually hurt you. High hazard, or health hazard, applications would involve substances that could make you sick.

Reduced Pressure Zone Assembly (RPZ) – These devices are also referred to as reduced pressure principal assemblies or reduced pressure backflow preventers. They are similar to DCVAs in that they have two shut-off valves and two check valves. However, an RPZ also has a discharge port as a third line of defense. If there is a backflow event and one, or both, check valves fail, any contaminated water or other hazardous materials will drain out the bottom of the device instead of flowing back into the water supply system. RPZs are approved for high hazard applications.

There are some stipulations for the installation of RPZs, though. They must be installed at least one foot off of the ground or floor to make sure there is a place for the contaminated water or hazardous materials to go if they drain out of the discharge port. Also, RPZs cannot be installed in any location that is subject to flooding such as a pit or underground valve box. The reason for this is simple if you think about it.

Reduced Pressure Zone Assembly

In a backsiphonage event, the pressure in the City's water mains drops and suction is created. As said before, if a check valve in an RPZ fails, any potentially contaminated water will be drained through the discharge port. However, if the RPZ were in a flooded location, the contaminated water would not have any place to go. Because of the suction in the main, this contaminated water, plus any other water in the pit or valve box, would be sucked into the discharge port, through the malfunctioning check valve and into the water main.

Pressure Vacuum Breaker (PVB) – Like the other two types of testable backflow preventers, PVBs have two shut-off valves. However, the PVB only has one check valve, but it also has a spring-loaded air inlet valve. PVBs can only be used in applications where there is no danger of backpressure, only backsiphonage.

Pressure Vacuum Breaker

Think of a backsiphonage event as sucking soda through a straw. If you have a large glass, soda will continue flowing through the straw as long as you keep sucking. However, if you ever get a hole in your straw, you will only suck air and not get any soda. A PVB acts like a hole in your straw, only the straw is the water supply system, and the suction is coming from the City's water main. In a backsiphonage event, the PVB's check valve will close, and the air inlet valve will open. The check valve is supposed to prevent anything from flowing back into the water supply system. If the check valve fails, though, only air from the air inlet valve will be sucked into the main.

As stated previously, PVBs can be used where there is a danger from backsiphonage only. To make sure there is no danger of backpressure, there are certain rules concerning the installation of PVBs. For example, they cannot be used in applications where there is a downstream pump or other pressure source. Pumps create pressure, and PVBs are not to be used where pressure is involved. They also have to be at least a foot higher than any downstream piping or points of use. This is because pressure is created when water flows downhill. Water towers are located on high ground or placed on tall stands for this very reason. If the PVB were in a lower location, water would flow down towards it creating pressure, and PVBs are not to be used where pressure is involved.

NON-TESTABLE BACKFLOW PREVENTERS

Just as there are different types of testable backflow preventers, there are also different types of non-testable backflow preventers. Some of the most common types are atmospheric vacuum breakers (AVBs), dual check valves, and double check valves with intermediate atmospheric vents. AVBs are probably the most prevalent of these types.

Atmospheric Vacuum Breakers (AVBs) – AVBs are often confused with PVBs, because they are similar in appearance, but there are some important differences between the two. Unlike PVBs, AVBs do not have shut-off valves. More importantly, the check valve and air inlet valve inside of an AVB are not spring-loaded, but depend on gravity to operate. For this reason, AVBs are not rated to be under continuous pressure. Continuous pressure is

Atmospheric Vacuum Breaker

defined as being under pressure for 12 hours or more. Since AVBs depend solely on gravity for their operation, the inner workings of the device can become stuck if subjected to pressure for long periods of time.

Dual Check Valves – Dual check valves are sometimes confused with double check valve assemblies (DCVAs). They are two very different things, however. Dual check valves were developed for the purpose of providing backflow protection at each individual water service connection in a distribution system. Many cities require them to be installed downstream from the meter at each business and residence connected to their water supply system. This type of protection is referred to as "containment" as it keeps any contamination contained within the home or business where it occurs and prevents the whole water system from being contaminated. The people within the home or business are not protected, however.

Dual check valve

Double Check Valve with Intermediate Atmospheric Vent These are small devices used on post-mix carbonated beverage dispensers. The International Plumbing Code specifies that they be used for such applications, but City of Manhattan staff prefers RPZs, because they can be tested. In post-mix carbonated beverage machines, there is a danger of carbon dioxide or carbonated water backflowing into the water supply (see below). Double check valves with intermediate atmospheric vents work similar to an RPZ to prevent this from happening.

Double check valve with intermediate atmospheric vent

COMMON HAZARDS

Hose Bibs, or Sillcocks – Hose bibs, or sillcocks, are the small water valves located on the outside of virtually every business and home in America. You simply connect your garden hose to them, and they provide water for many uses such as watering your flowers or washing your car. However, these hose bibs are also the largest single source of cross-connections. When you connect one end of a hose to a sillcock and stick the other end in a bucket, you have just created a cross-connection. If a backsiphonage occurs, whatever is in the bucket will be sucked through the hose and into the water system of your home. Newer sillcocks have integral vacuum breakers to combat this problem, and older ones can be fitted with inexpensive add-on devices available at most hardware stores. You have to be careful, though, because not all of the add-on devices allow the sillcock to drain once the water is shut off. If the water doesn't drain, it can freeze during the winter and cause a lot of other problems.

In 1980, in Pennsylvania, the water system in an apartment building housing some three hundred people was contaminated with pesticide. It seems an exterminator was using a garden hose to fill up a spray tank containing chlordane and heptachlor in order to treat the building for termites. At the same time, a workman had shut off a water main nearby in order to install a new valve. With the water off, a backsiphonage situation developed. As a result, the chemicals in the spray tank were sucked back into the building. Repeated efforts were made to flush out the pipes, but to no avail. Eventually, it was decided to replace all the plumbing that was affected, and the residents were without their normal water supply for 27 days.

At a prestigious golf club in Georgia in 1992, an employee reported that the water in a sink near the bar was burning people's hands as they were washing up. When inspectors from the local utility companies arrived on the scene, they discovered that the pH of the water was around 10, which is very high. Upon further inspection, it was discovered that a contractor was cleaning an exhaust hood in the kitchen with a high-pressure spray unit. The spray unit used a combination of chemical cleaners, which were mixed with water supplied from a garden hose attached to a hose bib. Neither the sprayer nor the hose bib was equipped with a backflow preventer. The high-pressure unit was found to be forcing cleaning solution back into the plumbing of the building. Due to quick action by the building superintendent an inevitable disaster was avoided.

Lawn Sprinkler Systems – These systems pose particular hazards whether they are at residential or commercial locations. The sprinkler heads, while usually acting as exit points for the distribution of water to the lawn, can act as entrances for contamination as well. Because the heads are at ground level, they are subject to applications of fertilizers and pesticides, and infiltration by parasites and bacteria. Without any type of protection, a backflow event could easily draw contaminants in though the sprinkler heads, through the irrigation piping system, and into the domestic water distribution system.

Initially, lawn sprinkler systems were deemed health hazard applications requiring high hazard backflow preventers. In 1994 the Kansas Legislature changed the law, however. The amendment stated that as long as a person didn't apply fertilizers or pesticides with their irrigation system, it would not be deemed a high hazard water system. The bill stemmed from complaints about having to use the higher priced RPZ backflow preventers that had to be exposed in the yard. The City Commission of the City of Manhattan followed suit by making amendments reflecting such changes in August 2001.

In Southgate, Michigan in 1991, a resident found nematodes swimming in his bathtub when he started filling the tub for his child. Nematodes are small, parasitic worms that are often found in the environment. It seems a recent water main break caused a backsiphonage situation, which sucked the nematodes out of a neighbor's lawn sprinkler system. The system did have an AVB on it, but it was not installed correctly, causing it to malfunction. The resident who owned the sprinkler system was issued a citation by the county for improper installation.

Fire Sprinkler Systems – Sprinkler systems are invaluable for protecting people and property in the event of fire. They stand ever vigilant with most being charged with water at all times waiting to douse a fire at first opportunity. As the water sits for long periods in the pipes, it becomes stagnate and many disinfectants such as chlorine will eventually break down. This leads to bacteria growth. Also, some sprinkler systems contain a mixture of water and some type of antifreeze, because they are located in unheated buildings. These solutions can be potentially harmful to people. As such, the IPC requires at least a low hazard backflow preventer on all systems and a high hazard device on systems containing chemical additives.

In June 1979, some residents of Meridian, Idaho complained about a strange taste and smell in their water. The problem was narrowed to an area containing a supermarket, car wash, and printing firm. It was discovered that a single check valve on the fire sprinkler system at the supermarket was leaking and allowing stagnate water to backflow into the public water supply. Subsequent tests of this water revealed that it contained Clonothrix fusa and Zoogleora ramigera bacteria in sufficient quantities to cause the taste and odor problems. Luckily, these bacteria are not dangerous to health.

At an Arizona State Park in June 1993, employees at the visitors' center began complaining that the water had an odd odor and taste. The condition persisted for the next two months, and several employees reported nausea and intestinal upsets after drinking the water. It wasn't until August that officials began searching for potential causes. Upon inspection, it was found that water in one of the fire sprinkler systems, none of which had backflow preventers, had been leaking back into the water supply system. The systems contained a solution of 30% propylene glycol, an antifreeze, and 70% water.

Boilers – The job of a boiler is to heat water, which is then used for heating or other purposes. Most boilers are piped directly to the water supply so as to maintain proper water levels. As water is heated, however, it expands and creates pressure. Without proper protection, this pressure can force boiler water back into the water supply system. The problem is that, in many cases, boiler water is treated with chemicals to help fight corrosion in the system. Most of these chemicals contain some type of chromium compound, which is toxic to humans.

In January 1984, very cold temperatures caused a four-inch cast iron water main to break outside of Marlatt Elementary School in Manhattan, Kansas. While maintenance crews had the water turned off to repair the break, water from the boiler inside the school made its way back into the plumbing of the building. The boiler water contained an anticorrosive compound known as Chromate 3333. After the water was returned to service, a workman discovered the contamination before anyone drank the affected water.

Post-Mix Carbonated Beverage Machines – We see these machines whenever we go to a restaurant, convenience store, or movie theatre. We get a cup from the dispenser, put some ice in it, and fill it with our favorite flavor. The problem with this application is probably the most difficult for people to understand. We drink soda from these machines every day, so what is the problem? These machines work by mixing flavored syrup with carbonated water at the proper ratio to make soda. The carbonated water is made by taking regular tap water and pumping it full of carbon dioxide gas creating carbonic acid.

The problem, of course, comes when a backflow situation develops. When this happens, some of the water that has already been carbonated is drawn back into the supply piping. Depending on when the building was built, it is likely that the supply piping is made from copper. When the carbonated water comes into contact with the copper pipe, the acid begins to chemically dissolve it. This copper-laden water has been known to make people sick.

On July 29, 1986, an adult woman and two girls attending a county fair in southwest Missouri came to the first aid station complaining of stomach sickness. Their symptoms included vomiting and abdominal distress. The sickness occurred after consuming a carbonated beverage from a local stand, and investigation found that the soda from this stand contained elevated levels of copper and zinc. Examination of a simple check valve in one of the lines of the carbonation system revealed a stuck spring allowing backflow to occur.

On January 1, 1989, twelve children from daycare centers in the Dallas, Texas area suffered severe vomiting and stomach cramps after drinking water and soda at a movie theatre. It was discovered that a soda dispenser had malfunctioned the previous day allowing carbonated water to flow back into the water pipes of the building. This water had remained in the lines overnight and leached copper from the pipes. The next day, the copper-laced water flowed back into the soda machine and to a nearby water fountain. Later tests confirmed that the children suffered from copper poisoning.

OTHER RESOURCES

City of Manhattan Code of Ordinances
http://www.municode.com/resources/gateway.asp?pid=11213&sid=16

EPA Cross-connection Manual
http://www.epa.gov/safewater/pdfs/crossconnection/crossconnection.pdf

Febco Cross-connection Manual
http://www.febcoonline.com/pdf/cccchb.pdf

TREEO Case Histories
http://www.treeo.ufl.edu/backflow/casehist.asp - 10

Watts Stop Backflow News
http://www.watts.com/pdf/F-sbn.pdf