Backflow Prevention & Cross-Connection Control

Submitted by:

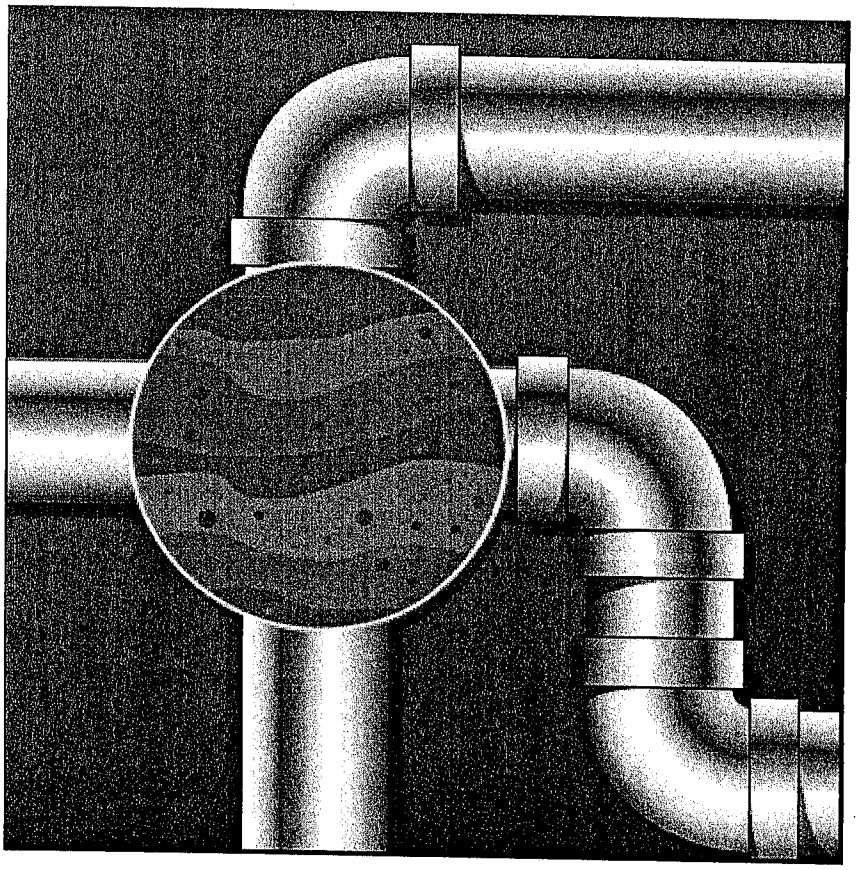
Rathipriya Narayanan
Employee ID: 127854
Student Intern II
PWE-Water Production
City of Houston

Date of Submission: 04/20/2006

Thong T. Nguyen

Supervisor's Signature

CROSS-CONNECTION



ABSTRACT

The City's Water Treatment Plant produces and delivers high-quality drinking water. This water quality is maintained in the distribution system through a combination of backflow prevention, cross-connection control and monitoring. Cross-connection is an actual or potential physical connection between a potable water system and any other source or system through which it is possible to introduce into any part of the potable system any contaminant and/or pollutant. Backflow is the flow of water in the reverse direction due to certain pressure variations in the public water supply. Although backflow itself is difficult to prevent, there are ways to protect the water supply from the dangers by eliminating the cross-connections by installing an approved backflow prevention assembly.

The main objective of this assignment is to perform cross-connection surveys of industrial and commercial facilities and also conduct on-site technical evaluations to determine the need for installation of backflow prevention devices. The test and maintenance reports of the installed assemblies need to be analyzed and organized in the Cross-Connection Control Database along with the details of the survey and recommendations of cross-connection. The nature of the job also includes resolving general public queries and providing alternative rectification procedures, which are in accordance with the Cross-Connection Control Program and Backflow protection, in order to keep the City of Houston distribution system protected from actual and potential physical connections with any contaminant or pollutant sources.

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CHAPTER – 1

INTRODUCTION

BACKFLOW PROTECTION FOR DISTRIBUTION SYSTEMS OF CITY OF HOUSTON

Safe drinking water is the foremost and the basic necessary nutrient for the survival of all living beings. There are many cases where cross connections in the public water system have been responsible for the contamination of potable water, and therefore triggering the dispersion of disease. For this reason the City of Houston has implemented a Cross-Connection Control program, which helps protects the public water supply from the dangers of Cross-connection and thereby provides safe and healthy water to the residents of Houston.

1.1 ABOUT CROSS-CONNECTION AND BACKFLOW

A cross-connection is an actual or potential connection between any part of a potable water system and any other environment that contains other substances that, under any circumstances, would allow such substances to enter the potable water system. Other substances include gases, liquids, or solids, such as chemicals, water products, steam, water from other sources (potable or nonpotable), and any matter that may change the color or taste of water or add odor to water. Contamination occurs when nonpotable water or any of these foreign materials flow into the water system through the cross-connection. This is called a backflow event, since it requires a reversal in the normal direction of flow in the water line.

1.2 PICTORIAL REPRESENTATION

Figure 1.1: CROSS-CONNECTION WITHOUT PROTECTION

The figure displayed above could cause a potential backflow incident to occur at this cross-connection. One end of the hose is connected to the city water main whereas; the other ends to a nonpotable system (for instance, a sewage connection). Thus, the picture clearly represents the hose being directly submerged into the sewer line (nonpotable system), which could cause the contaminants if present, to pollute the potable water in the case of a backflow event. If a backflow incident occurs while even this incidental and seemingly innocent cross-connections are in place, then it is possible that harmful and even lethal chemicals will be sucked back into the water system, causing serious threat to the public health.

1.3 EXAMPLE OF A CROSS-CONNECTION

"A garden hose connected to the distribution system of the public water supply being submerged in a swimming pool."

This connection between the swimming pool (nonpotable water) and the garden hose (potable water) could result in a potential cross connection thereby endangering the public water supply because of the backflow of contaminants from the nonpotable water system to the potable system due to various pressure variations.

Though these types of backflow are difficult to prevent, there are ways to protect the public water supply from the dangers by eliminating cross-connections by installing approved backflow prevention assemblies depending upon the degree of hazard at the location of the cross-connection and also on the type of backflow.

CHAPTER – 2

BACKFLOW THEORY

2.1 BACKFLOW

Backflow is the reversal flow of water in a system, which can be caused due to two different scenarios.

Figure 2.1: REGULAR FLOW

The above shown diagram depicts the scenario of flow of water in regular conditions when the pressure level is maintained the same at both the ends. When there is a difference in the pressure level at either of the ends, the water flows backwards thereby letting the contaminants enter the potable water system.

2.2 TYPES OF BACKFLOW

The two types of backflow could be

1. *Backsiphonage Backflow*
2. *Backpressure Backflow*

2.2.1 Backsiphonage Backflow

Backsiphonage backflow occurs when a vacuum is generated in a piping system. Any time, there's an opening in a supply line, loss of pressure in the line can cause the foreign materials to be sucked in. This type of event can occur, such as when heavy equipment accidentally breaks a waterline during construction or repair work.

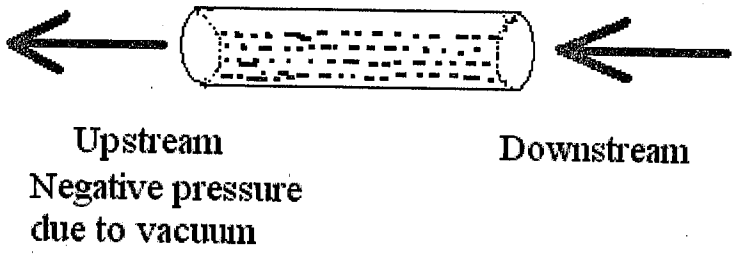

Figure 2.2: BACKSIPHONAGE BACKFLOW

Example

Backsiphonage can be caused by

- water pumps that stop working properly.
- water lines that burst during a winter cold snap.

2.2.2 Backpressure Backflow

Backpressure backflow is caused because of excess pressure downstream of the distribution system, than that of the supply pressure. This actually forces contamination into the water line. Backpressure requires a direct cross-connection. This type of cross-connection is less common than backsiphonage, and it's easy to guard against.

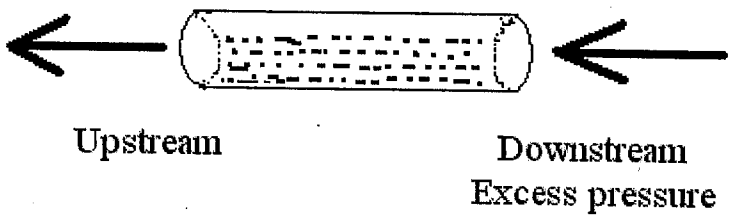

Figure 2.3 BACKPRESSURE BACKFLOW

Example

Backpressure contamination can occur when

- a commercial or industrial customer has a pressurized subsystem that is plumbed directly into a water line with insufficient protection.

Thus, backflow prevention control methods need to be implemented and the assemblies or devices used required be installing and field-testing to ensure the continued protection of an identified actual or potential cross-connection caused by the two different types of backflow. Backflow-prevention assemblies or devices are installed in locations where a reliable means of backflow protection has been determined to be necessary. Thus, determination for the required backflow protection and selection of appropriate backflow prevention control method requires taking into consideration the assessment factors for the degrees of hazard, the risks of cross-connections, and the type of backflow.

CHAPTER – 3

CONTROL METHODS

3.1 BACKFLOW PREVENTION CONTROL METHODS

Backflow prevention control methods are the technological developments used to prevent contamination due to cross-connection. These methods range from simple air gaps to more complex valves, in order to protect the public distribution system from any potential hazard. There are three categories of backflow protection methods namely,

1. *Air Gap*
2. *Backflow Prevention Assemblies (Testable)*
3. *Backflow Prevention Devices (Non-testable)*

3.1.1 Air Gap

Air gap is a non-mechanical backflow preventer that is a very effective device to be used where either backsiphonage or backpressure conditions may exist.

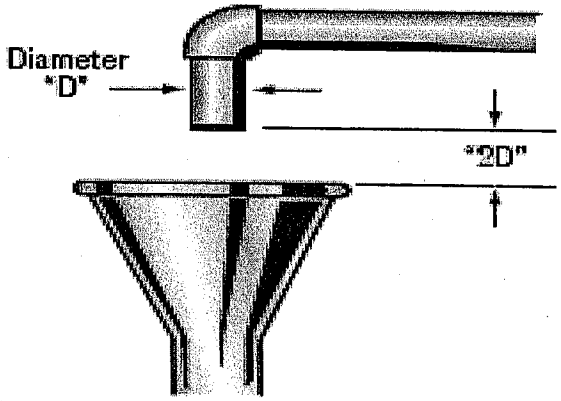

Figure 3.1: AIR GAP

The unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet conveying water or waste to a tank, plumbing fixture, receptor, or any other assembly and the flood level rim of the receptacle. These vertical, physical separations must be at least twice the diameter of the water supply outlet, never less than 1 in. (25 mm).

3.1.2 Backflow Prevention Assemblies

Backflow prevention assemblies shall mean an assembly that has been manufactured in full compliance with the standards established by the American Water Works Association (AWWA) and has met completely the laboratory and field performance specifications of the Foundation for Cross-Connection Control and Hydraulic Research of the University of Southern California (USCFC & HR). Assemblies are backflow preventers that are required to have certain parts, such as test cocks and shutoff valves that are used for field-testing. They must be able to be tested and repaired in-line. Few of the backflow control methods used to protect the distribution system from the dangers of cross-connections would include the following. They are,

Reduced-Pressure Principle Backflow-Prevention Assembly

Maximum protection is achieved against backsiphonage and backpressure conditions

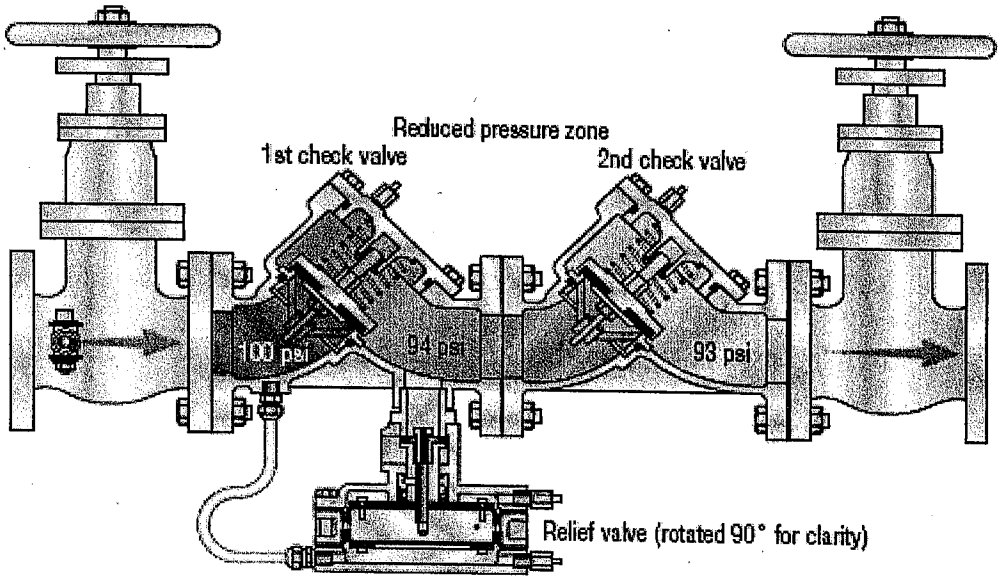

Figure 3.2: REDUCED PRESSURE PRINCIPLE BACKFLOW PREVENTER

utilizing reduced pressure principle backflow preventer. These devices are essentially

modified double check valves with an atmospheric vent capability placed between the two checks and designed such that this "zone" between the two checks is always kept at least two pounds less than the supply pressure. With this design criterion, the reduced pressure principle backflow preventer can provide protection against backsiphonage and backpressure when both the first and second checks become fouled. They can be used at constant pressure and at high hazard installations.

Double Check Valve Backflow-Prevention Assembly

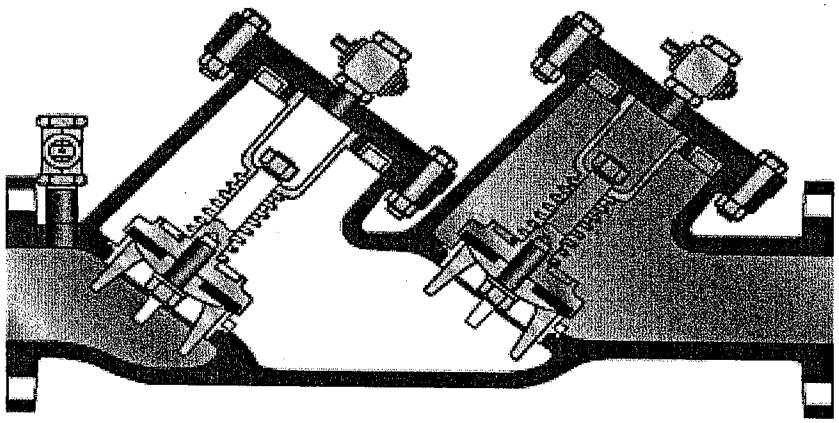

Figure 3.3: DOUBLE CHECK VALVE BACKFLOW PREVENTER

A double check valve is essentially two single check valves coupled within one body and furnished with test cocks and two tightly closing gate valves. During normal operation, the check valves will open in response to demand for water at the outlet. When the demand for water ceases, the check valves will close.

In a backpressure condition, the increase of pressure on the outlet will cause the second check to close. If the second check does not seal properly, the first check will act as a backup to the second check. In a backsiphonage condition, the inlet pressure will be reduced to a sub atmospheric pressure. The greater pressure on the downstream side of

the second check will cause the second check to close. If the second check does not seal off properly, the first check will act as a backup.

Reduced-Pressure Principle Detector Backflow-Prevention Assembly

The reduced-pressure principle detector backflow-prevention assembly (RPDA) shall consist of a main line RP with a bypass arrangement around the RP that shall contain a bypass water meter and a bypass RP. The RPDA operates similar to an RP except for the bypass, which is engineered to detect the first 3 gpm (11.4 L/min) of flow through the assembly. Thus, the flow is registered by the water meter in the bypass and is utilized to detect any unauthorized usage or leakage in the fire protection system.

Double Check Detector Backflow-Prevention Assembly

This device is an outgrowth of the double check valve backflow preventer consisting of two spring loaded check valves, a bypass assembly with water meter to show any

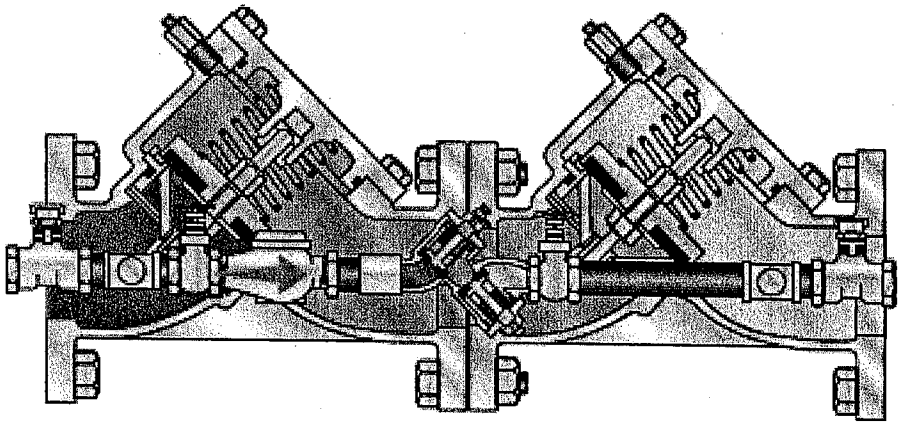

Figure 3.4: DOUBLE CHECK DETECTOR BACKFLOW PREVENTER

unauthorized usage or leaks in the fire protection system. It also is incorporated with a double check valve and two tightly closing gate valves. It is primarily used in fire line installations and the purpose is to protect the potable supply line from possible

contamination or pollution from fire line chemical additives, booster pump fire line backpressure, stagnant "black water" that sits in fire lines over extended periods of time, the addition of "raw" water through fire pump connections, and the detection of any water movement in the fire line water due to fire line leakage or deliberate theft.

Pressure Vacuum-Breaker Assembly

This device is evolved in response to a need to have an atmospheric vacuum breaker that can operate under constant pressure and also could be tested in line. A spring on top of the disc and float assembly, two added gate valves, test cocks and an additional first check provided the answer to achieve this device. These devices can be used under constant pressure, but cannot be used under backpressure conditions.

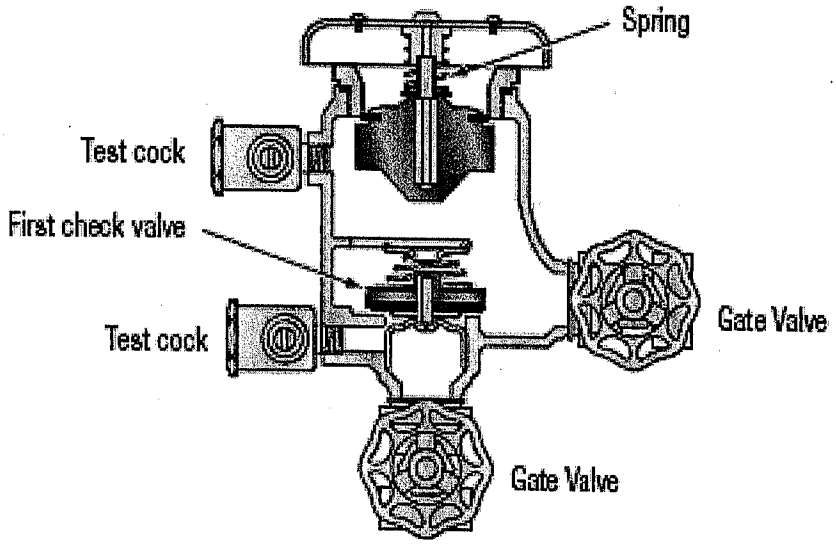

Figure 3.5: PRESSURE VACUUM BREAKER

During normal operation, the check valve will open in response to demand for water on the downside and the air inlet will remain closed. When the demand for water ceases, the check valve will close.

Spill-Resistant Vacuum Breaker

A Spill Resistant Vacuum Breaker is a modification to the standard Pressure Vacuum Breaker but specifically designed to minimize water spillage. The SVB is ideally suited for continuous pressure, indoor applications where water spillage is undesirable. During nomal conditions, the check valve remains open and the atmospheric vent seals in the bonnet assembly. As the line pressure falls to 1 psi, the spring-loaded atmospheric vent opens and the check valve closes, breaking the vacuum and thereby preventing back-siphonage.

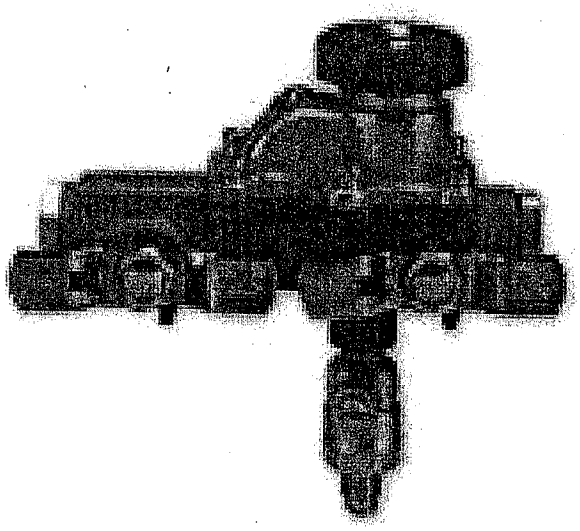

Figure 3.6: SPILL-RESISTANT VACUUM BREAKER

Water is not allowed to spill at any time during operation. The SVB should not be installed where it will be subjected to backpressure.

3.1.3 Backflow Prevention Devices

Devices are backflow preventers that do not include certain parts such as shutoff valves or test cocks, and they usually cannot be used for field-testing, neither can they be

repaired in-line. Many devices have restrictive head-loss and flow restrictions. These devices are used for internal protection and usually come only in smaller sizes of range two inches and smaller. Some of the most commonly used backflow devices would include the following. They are,

Atmospheric Vacuum Breaker:

The most commonly used atmospheric anti-siphon vacuum breaker incorporates an atmospheric vent in combination with a check valve.

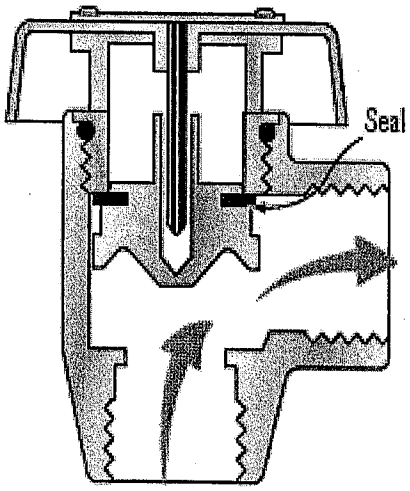

Figure 3.7: AVB – REGULAR FLOW CONDITION

Its operation depends on a supply of potable water to seal off the atmospheric vent, admitting the water to downstream equipment. If a negative pressure develops in the supply line, the loss of pressure permits the check valve to drop sealing the orifice while at the same time the vent opens admitting air to the system to break the vacuum. An AVB shall be installed to prevent backflow from backsiphonage only. An AVB can protect both high-hazard and low-hazard applications.

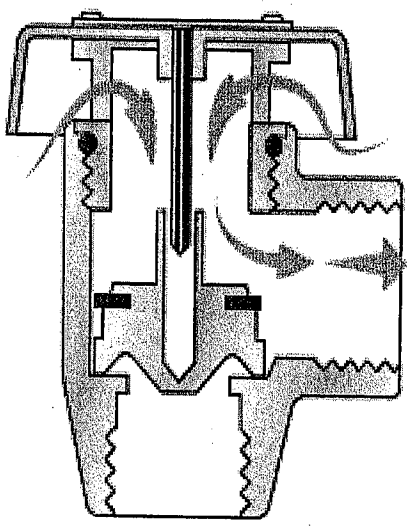

Figure 3.8: AVB – BACKFLOW CONDITION

Dual Check

A dual check shall contain two internally loaded, independently operating check valves. In a backsiphonage condition, a sub atmospheric condition is present at the inlet, and the loading of the checks will cause the checks to close.

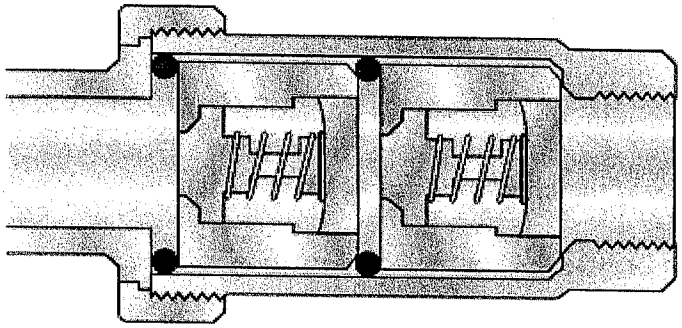

Figure 3.9: DUAL CHECK

In a backpressure condition, the increase in pressure will cause the checks to close. If the second check is not working, the first check can act as a backup to stop the backpressure from going through the device.

Dual Check with Atmospheric Vent

This device is incorporated with two internally loaded check valves in combination with a vent valve located between the two check valves, which shall open when subjected to reversal flow conditions. The inlet check valve opens as the flow begins. After the water flows via the first check, it shall cause the vent to close and thereby allowing water to flow past the second check valve.

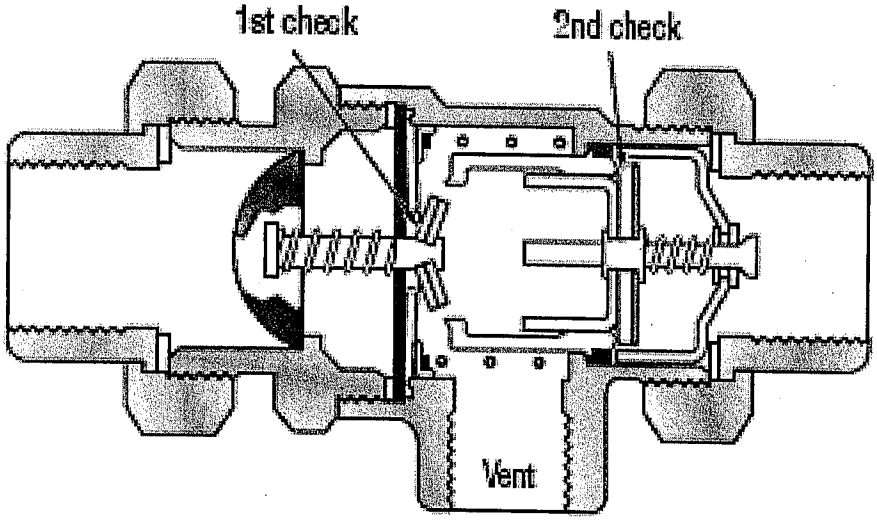

Figure 3.10: DUAL CHECK WITH ATMOSPHERIC VENT

In a backpressure condition, the increased pressure at the outlet will cause the second check valve to close. If the check does not close, the increased pressure will flow across the second check and cause the vent valve to open as it is subjected to backpressure. In a backsiphonage condition, the inlet pressure will be reduced to a sub atmospheric pressure and cause the check valves to close.

Backflow devices cannot be substituted for applications that require backflow assemblies. Standards for devices and assemblies differ, with various standards describing different performance requirements.

CHAPTER – 4

ASSIGNMENT & DUTIES

WORK ASSIGNMENT AND JOB DUTIES

The principal purpose of the Cross-Connection Control program to keep the City of Houston distribution system protected from contaminant or pollutant sources could be accomplished with the primary approach of conducting field surveys or inspections through water systems of the industrial and commercial facilities. The procedural method of conducting the field inspections follows a systematic rule that includes various details related to the survey. They are namely,

1. *Identifying survey locations*
2. *Prioritizing customer's category & data gathering*
3. *Preparation of the daily survey itinerary*
4. *Conducting the field survey or inspection*
5. *Updating survey / inspection findings and actions*
6. *Conducting resurvey inspections*
7. *Proper filing of the incoming backflow prevention assembly test & maintenance reports*
8. *Dealing with customer noncompliance*

The work assignment also includes assisting the supervisor in special projects and reports.

CHAPTER – 5

ACCOMPLISHMENTS

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The skills that a student intern gains from the above mentioned work assignment include

- Hands-on experience on the usage of Cross-Connection Control Application package.
- Judgmental experience and applications of chemical engineering concepts in the selection of backflow prevention assembly based on the degree of hazard.
- Practical knowledge on the concepts of Fluid Mechanics, Piping Hydraulics and Unit Operation Equipment such as boilers, heat exchangers, and cooling systems.
- General awareness on the standard rules and regulations of USEPA, AWWA and TCEQ.
- General knowledge on City of Houston's various other departmental activities such as the control of traffic signals, customer compliance, treatment of wastewater in the distribution system, construction of roads and bridges, during site visits.

The School-To-Work Program also provides an excellent opportunity to develop the communication and inter-personal skills by allowing participation in the public speaking classes.

CHAPTER – 6

CONCLUSION

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Cross-connection in the water lines can be eliminated by conducting the survey thoroughly by evaluating the customer's water system through tracing the water lines, and any branches of it, to the end uses. It is also very important to document the most apparent cross-connections using notes, sketches, and photographs, as required. In the event that city water is being supplied to the customer by way of a holding tank, it must be made clear that the holding tank needs to be equipped with proper backflow prevention method, which would be an adequate air gap separation in this case. It's also required that there is no bypass existing before the tank inlet, in which case, the bypass line must be disconnected and capped off or the customer needs to be instructed to install the suitable backflow prevention device on the bypass line. Looking for auxiliary water systems at each and every location to make sure that no obvious cross-connection exist with the City of Houston potable water supply.

Any cross-connection if located need to be classified based on the degree of hazard and respective type of backflow prevention control method need to be installed to protect the distribution system. Entering the survey/inspection reports in the Cross-connection control database and keeping regular track of the activities at every particular location helps improve the program to achieve better results.

Thus, Cross-Connection Control program serves the purpose of providing safe and healthy water to the public from dangers or hazard by protecting the City's distribution system by meeting all the above-mentioned specifications.

REFERENCES

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8. www.abpa.org
9. www.usc.edu/dept/fccchr/ccvlib

APPENDIX

1. AWWA – American Water Works Association
2. USEPA – United States Environmental Protection Agency
3. TCEQ – Texas Commission on Environmental Quality
4. ABPA – American Backflow Prevention Association
5. AVB – Atmospheric Vacuum Breaker
6. SVB – Spill-Resistant Vacuum Breaker
7. RP – Reduced-Pressure Principle
8. RPDA – Reduced Pressure Detector Assembly