Backflow Prevention in Water Supply Systems (Part 1)

Water systems serving Laboratory and Animal Research Facilities (ARF) must be reliably safe and uncontaminated. Water supplies for domestic applications (e.g. clinical, administrative, food service, emergency fixtures, etc.) must be reliably potable. Yet complex piping systems in large biomedical research and clinical facilities can have hundreds of potential risks (cross connections) that must be anticipated and mitigated to ensure safe and reliable water supply. One of the greatest risks to maintaining safe and uncontaminated water supplies is "backflow"; when applying backflow protection, it is also crucial to consider facility flood prevention and protection. The NIH Design Requirements Manual (DRM) comprehensively addresses these issues.

What is Backflow?

Water piping systems can be subject to various forms of flow-reversals which may potentially result in chemical, pathogenic, or aesthetic contamination that renders the water supply non-potable and unfit for intended uses. The process that causes flow reversals is known as "backflow" and the physical condition that can facilitate backflow at a specific point in a piping system is known as a cross connection.

Backflow primarily occurs in two ways: back-siphonage and back-pressure. Back-pressure is a forced flow reversal, typically associated with a direct connection between a contaminated source and a lower pressure water system. There are many instances where this can occur, including make-up water supplies to pumped piping systems, cage wash equipment, and boilers. Water supply pressure does not need to be lost for a back-pressure backflow incident to occur; it only needs to be overcome at a given point in the system.

Back-siphonage is one of the most common causes of backflow and is caused by a negative (below atmospheric) pressure condition in a supply system. An unplanned service disruption, pipe break, or fire-fighting event is often implicated in back-siphonage by pressure losses and flow reversals. One hazardous example of backflow can occur in laboratories where aspirating devices or hoses are connected to faucets (or through emergency drench hoses) that do not include appropriate backflow protection. Static head in tall buildings can also result in flow reversals, and if there is a cross connection present, the contamination can siphon into the piping system. Process operations involving chemicals can therefore pose special risks. Lab vacuum systems, chemical cleaning, water treatment of piping systems, and even traditional faucets and drench hose eyewash fixtures can all result in cross connections that must be protected.

Impact of Backflow and Preventative Measures

The results of backflow events have ranged from aesthetic inconveniences (tastes and smells) and illnesses to far more serious problems where water supply systems were contaminated with pesticides, toxic chemicals, and pathogens. There are many documented cases of potable water contamination that occurred due to uncontrolled cross connections. From 1981 to 1998, the Centers for Disease Control (CDC) documented 57 waterborne disease outbreaks related to cross connections, resulting in 9,734 reported illnesses.[2] These included both microbiological and chemical contamination incidents; although well documented, these cases likely represent only a fraction of actual occurrences.

The DRM and major plumbing codes such as the International and Uniform Plumbing Codes (IPC and UPC, respectively) address minimum standards and protections to ensure clean and safe water supplies. In NIH facilities, the planning, tracking, and control of these issues requires careful attention, from initial facility design through operations and maintenance, due to the sheer quantity of potential risks. Strict control of the materials of construction and plumbing system design arrangements is necessary to ensure adequate water supply pressure and to avoid or mitigate contamination risks and cross connections. This includes proper selection and application of Back Flow Preventer (BFP) devices. Systems that are not constructed of approved materials suitable for potable water must not be interconnected with potable water supplies without appropriate backflow protection.

Part 2 of this article will discuss DRM requirements, examples of how and where they are to be applied, and the associated rationale.

Resources

1 NIH Design Requirements Manual (DRM) Revision 1.5: 03/26/2020

2 EPA white paper: Potential Contamination Due to Cross-Connections and Backflow and the Associated Health Risks (2001)

3 International Plumbing Code (2018)