

Backflow Prevention and Cross-Connection Control Recommended Practices

Fourth Edition



**American Water Works
Association**

Contents

List of Figures, v	
List of Tables, vii	
Preface, ix	
Acknowledgments, xi	
Dedication, xiii	
Metric Conversions, xv	
Chapter 1 Introduction	1
Purpose of Manual, 1	
Responsibilities, 2	
Health Aspects, 5	
Legal Aspects, 7	
Chapter 2 Backflow Prevention Principles	11
Basic Hydraulics, 11	
Types of Backflow, 13	
Assessing Degrees of Hazard, 18	
Assessing Other Risk Factors, 20	
Assessing the Effectiveness of Assemblies and Devices, 21	
Chapter 3 Program Administration	23
Developing a Cross-Connection Control Program, 24	
Types of Programs, 25	
Management Programs, 28	
Documentation, 33	
Human Resources, 33	
Program Administration, 35	
Chapter 4 Backflow Prevention Assembly Application, Installation, and Maintenance ...	41
Means of Preventing Backflow, 42	
Backflow Prevention Devices, 42	
Method for Controlling Backflow, 59	
Field Testing, 61	
Reference, 64	
Chapter 5 Conducting a Cross-Connection Control Survey	65
Authority and Responsibilities, 66	
Purpose of a Cross-Connection Control Survey, 66	
Assessing the Degree of Hazard, 67	
Survey Considerations and Concepts, 67	
Conducting the Survey, 69	
Reference, 74	
Chapter 6 Sample Hazards and Proper Protection	75
Typical Hazards, 76	
Hazards Posed by a Water Supplier, 84	
Protection for Specific Customers, 89	
References, 91	

Appendix A Example Notices and Letters, 93
Appendix B Testing Procedures or Methods, 99
Appendix C Industry Resources, 181
Appendix D Incidents Tables, 183
Glossary, 187
Index, 193
List of AWWA Manuals, 203

Introduction

For millennia, people have been concerned with obtaining and maintaining pure and safe water supplies. Archeological studies reveal that as early as 3000 BC, the ancient Egyptian State had a government official who was required to inspect the country's water supply every 10 days. With the widespread use of water closets in the 1800s came direct cross-connections with water mains. This brought into focus the problem that, as one nineteenth century authority stated, "foul matters may get into the pipes."^{*} Currently, many government and industry professionals are aware of the need to prevent contamination of potable water supplies through cross-connections. However, the water supplier goals and levels of involvement may vary.

PURPOSE OF MANUAL

This manual provides guidance to all professionals working with the potable water supply on the recommended procedures and practices for developing, operating, and maintaining an efficient and effective cross-connection control program. The manual also provides insight into the basic areas that should be addressed to ensure that public water system connections are made safely; that those connections will be operated and maintained to ensure water quality; and that public water suppliers have the basic knowledge needed to assist in this effort. The purpose of any such program is to reduce the risk of contamination or pollution of the public water system.

A cross-connection is an actual or potential connection between any part of a potable water system and an environment that would allow substances to enter the potable water system. Those substances could 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.

^{*} A.J. Keenan, C.S.I., B.C. Section AWWA Cross-Connection Control, September 1977.

RESPONSIBILITIES

The United States Safe Drinking Water Act (SDWA) became law in 1974. The purpose of the act is to protect public health by regulating all public drinking water supplies in the United States. SDWA was amended in 1986 and again in 1996. As amended, it requires protection of the public drinking water supply and its sources: both surface water and ground water. SDWA does not, however, regulate private wells serving fewer than 25 individuals and it also does not regulate systems having fewer than 15 service connections.

SDWA authorizes the United States Environmental Protection Agency (USEPA) to set national health-based standards for public drinking water. These standards have been established to protect against naturally occurring and man-made contaminants that may be found in our drinking water supply. Together the USEPA, state regulatory agencies, and water suppliers work to make sure these standards are monitored and followed.

In Canada, provincial governments have jurisdiction over the public health aspects of the drinking water supply. Local governments within a province (e.g., regional districts and municipalities), with the authority of the province, may impose other regulations or more stringent regulations not in conflict with provincial regulations.

Because there is a difference between the authority of the United States federal government and that of Canada, and between the different states and provinces, the following discussion, although referring to “federal and state,” illustrates the different regulations governing a public water supplier.

For US water utilities (public water suppliers), SDWA regulations govern PWSs. SDWA (see 42 U.S.C. 300f(4)(A)) states: “The term *public water system* [PWS] means a system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least fifteen service connections or regularly serves at least twenty-five individuals.”

The public water system includes any collection, treatment, storage, and distribution facilities under control of the operator of such system.

SDWA states that water suppliers are only responsible for the water quality delivered to the water consumer’s service connection. In many jurisdictions, this is commonly referred to as *point of entry* or *point of service*. The water supplier is not responsible for contaminants and/or pollutants that are added to the potable water by any circumstances under the control of the consumer beyond the public water supply water point of entry.

Currently, SDWA provides that the federal government may grant the state or local governments primacy for the administration and enforcement of the federal drinking water rules and regulations. Agencies that have been granted primary enforcement responsibilities must adopt drinking water regulations that are at least as stringent as the current federal drinking water rules and regulations.

In addition to adopting the federal drinking water rules and regulations, primacy agencies may adopt additional or more stringent drinking water rules or regulations as long as the rules or regulations are not in conflict with SDWA and/or other federal rules or regulations. Thus, in states that have primacy, cross-connection control rules are state adopted. Similarly, local government such as counties and cities, with the authority of the state, may also adopt additional or more stringent rules and regulations as long as the counties and cities are not in conflict with the state law or regulations.

Both federal and state/provincial governments regulate the public health aspects of drinking water in order to protect the health, safety, and welfare of the water consumer.

From the point of service/entry, federal, state, and local responsibilities to protect the health, safety, or welfare of the users of water are under the jurisdiction of agencies other than those regulating PWSs, and include, but are not limited to, the following:

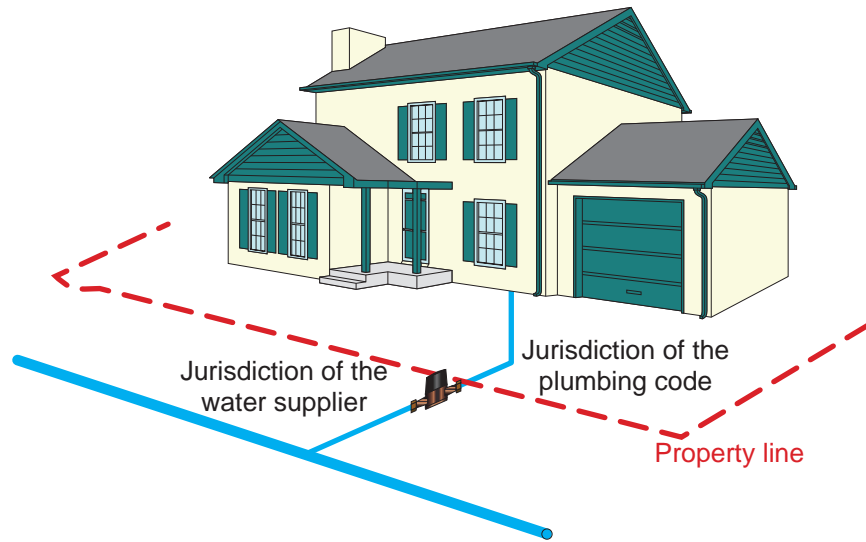
- Local plumbing and building officials who are responsible for enforcing all provisions of applicable plumbing and building codes relative to the installation, alteration, repair maintenance, or operation of all plumbing system devices and equipment including cross-connections on all new construction or any project that has plumbing or any building that has a construction, plumbing, or building permit open. In such cases, the local code official will make all the required inspections or they may accept reports of inspection by approved agencies or individuals. Plumbing codes provide for point-of-use backflow protection for potable water systems. The local code officials usually have limited or no jurisdiction over any pre-existing structures.
- Fire marshals who are responsible for regulating fire protection systems (e.g., fire sprinkler systems) downstream of the potable water system supply connection entering the premises.
- Safety inspectors (Occupational Safety and Health Administration [OSHA]; Workers' Compensation Board [WCB] [Canada]; Mine Safety and Health Administrators [MSHA]) who are responsible for inspecting potable water systems (plumbing) for workers' safety.
- Health officials who are responsible for inspecting restaurants and other food preparation facilities (e.g., dairies), health care facilities (e.g., nursing homes), etc.
- Agricultural inspectors who are responsible for the safe handling of chemicals (e.g., pesticides) used in growing and processing agricultural products.

These agencies have jurisdiction over work done on the customer's premises. Most have regulations that involve cross-connection control, and these different regulations may be in conflict with the procedures for cross-connection control recommended in this manual. The authority of these agencies over the water supplier's customers may be continuing or may be limited by the issuance of a final permit (e.g., for building occupancy) (see Figure 1-1).

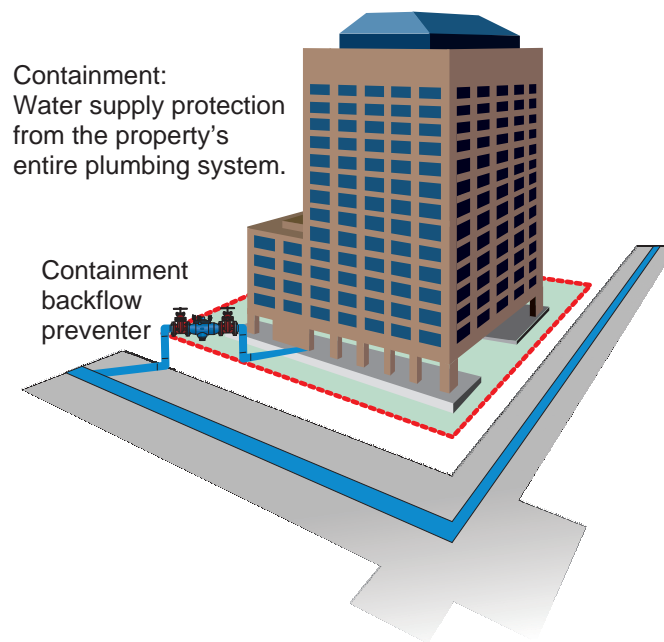
The implementation of a program for the effective control of cross-connections requires the cooperation of the water supplier, the primacy agency, plumbing/building officials, plumbers, the water consumer, and the backflow prevention assembly tester. Each has specific responsibilities and each must carry out their responsibilities in order to prevent pollution or contamination of the PWS.

Much confusion about cross-connection control exists due to a misunderstanding between many water suppliers, property owners, and code officials that under SDWA, the water suppliers are responsible for water quality to the last free-flowing tap. This confusion may result from some federal rules/regulations requiring water suppliers to monitor certain water quality parameters, such as maximum contaminant level (MCL) violations or necessary action levels for treatment techniques, which are measured at the tap and are reflective of the corrosivity of the water being supplied. Additional information can be obtained from the local authority having jurisdiction. However, this does not impose a responsibility on the water supplier for regulating plumbing. As stated in SDWA, "Maximum contaminant level means the maximum permissible level of a contaminant in water which is delivered to any user of a public water system."

Cross-connection control regulations provide water utilities a legal basis for reviewing water users for actual or potential cross-connections. More importantly, they impose requirements that adequately protect the PWS whenever a potential hazard is discovered.



A. Location on private side of property line



B. Location on public entity side of property line

Figure 1-1 Examples of backflow prevention equipment locations

Courtesy of Stuart F. Asay

HEALTH ASPECTS

Protection of drinking water for public health emphasizes preventing contamination. A multiple-barrier approach is used from the source to the tap. The following are major barriers established for PWSs:

- **Sources of supply:** Prevent human contaminants, such as pathogens (e.g., viruses and bacteria) or chemicals from entering the water supply through watershed control and wellhead protection programs.
- **Treatment techniques:** Remove or reduce natural and human contaminants to comply with maximum contaminant levels established by regulations, or otherwise provided by the system.
- **Chlorination:** Maintain chlorine residual in the water supply to control microbiological quality.
- **Storage:** Provide covered storage and prevent microbiological contamination through openings in reservoirs.
- **Distribution:** Comply with installation and material standards and provide minimum operating pressures to prevent contaminants from entering the system.
- **Cross-connection control:** Provide premises isolation (containment of service) or equivalent in-premises fixture protection to prevent contaminants from entering the water supplier's system.
- **Water quality monitoring:** Provide surveillance of system to detect contaminants in the water supply.
- **System operator:** Ensure that qualified personnel operate PWSs through operator certification.
- **Emergency plan:** Establish procedures for correcting problems detected in water quality monitoring or caused by natural disasters.

On the customer's premises, plumbing and health codes establish minimum design, installation, and operating requirements for public health protection. Major items in the plumbing codes are as follows:

- **Distribution:** Install approved materials and follow design requirements to ensure adequate pressure at fixtures.
- **Cross-connection control:** Provide backflow preventers at fixtures and appliances to prevent contaminants or pollutants from entering the potable water system.
- **Licensed plumber:** Require that a licensed plumber (with some exceptions, such as a landscape contractor or fire-sprinkler contractor) perform work that is plumbing code compliant.

These requirements are conservative. They include a high safety factor for system design (reliability) and for acceptable contaminant levels. For example, regulation of chemical contaminants may be based on a possible adverse health effect from the long-term (e.g., lifetime) consumption of two liters of water per day with a chemical at a level above the MCL.

Most SDWA requirements deal with possible chronic (long-term) health effects. Contamination of a water distribution system through a cross-connection may result in acute (immediate adverse) health effects that cause illness or death of one or more persons and/or financial losses. Although cross-connection control is only one of the multiple barriers to protect potable water quality, it is one of the most important. Without the water supplier's cross-connection control program, the distribution system may become the weak link in the multiple-barrier approach.

Potable water is water that does not contain objectionable pollutants or contaminants, and is considered satisfactory for drinking or culinary purposes. By this definition, potable water need not be sterile. Potable water may contain nonpathogenic organisms and other substances. For cross-connection control purposes, potable water is considered to be safe for human consumption, meaning it is free from harmful or objectionable materials, as described by the health authority. In assessing the degree of hazard, “safe for human consumption” or “free from harmful or objectionable materials” are not clearly defined parameters. A chemical toxin in high concentrations may cause no harm when consumed in low concentrations. In assessing the actual and potential degrees of hazard, microbiological, chemical, radiologic, and physical parameters must be considered. These parameters are described in the following sections.

Microbiological

Waterborne disease pathogens are the primary concern in cross-connection control. Waterborne diseases are caused by the following major groups: bacteria, virus, algae, fungi, protozoa, and parasitic. The risk to public health of a waterborne disease transmitted through the public water supply is exacerbated by the

- Large population that may be exposed to the contaminant.
- Ability to immediately detect contamination. The first indication may be a positive microbiological sample.
- Effectiveness in tracing the source. For example, *Giardia lamblia* cysts may enter the distribution system from a reservoir or through a cross-connection with an auxiliary supply.

The amount of the infectious organism ingested contributes to the difficulty of assessing the relative risk to public health from a microbiological contaminant. The health effect to an individual consuming a microbiological contaminant varies by the type of organism, the quantity ingested, and the strength of the person’s immune system. For example, water with a low level of the total coliform bacteria *Citrobacter freundii* presents little adverse health concern; however, this bacterium may colonize distribution system piping and could become a health risk. By comparison, the ingestion of only a few *Giardia lamblia* cysts may be infectious.

Although a microbiological contaminant may not be a pathogen or opportunistic pathogen (one that affects a person with a weak immune system), their presence in the water distribution system may be an indirect concern. Some microbiological contaminants may cause taste and odor problems or increase the chlorine demand. A coliform bacteria detected in the water supplier’s monitoring program may require mitigation measures from resampling to a boil-water order with an emergency water main flushing and disinfection program.

To assess the problem of bacteria entering the distribution system, the water supplier must consider the following issues:

- Poor-quality source water may enhance bacteria growth and regrowth in the distribution system. For example, source water with a high level of organic compounds provides a food source for bacteria that may enter the distribution system due to a backflow incident. Other quality concerns include water with high turbidity, sulfate-reducing bacteria, and iron and manganese that provide a biofilm (slime) or biomass (sediment) in water mains that facilitate bacterial regrowth.
- Distribution system piping that is in poor condition may aid bacteria growth. For example, corrosive water may cause tuberculation to form on old unlined cast-iron

and steel water mains. The tubercles provide a rough surface that shelters bacteria and a biofilm from the disinfectant.

Systems may have inadequate capacity to maintain pressure during peak water demand periods (e.g., fire flow, hot summer weather). Many old distribution systems have a relatively high frequency of breaks or leaks. Whenever there is a reduction or loss of pressure in the distribution system, there is the possibility that contaminants will flow back into the potable water system.

- Difficulty maintaining disinfectant residuals, such as chlorine, in the distribution system makes it possible for pathogens to survive.

Because each water system is different, the concerns about microbiological contamination are different for each water supplier.

Chemical

There are acute and chronic toxic effects that can occur from exposure to harmful chemicals.

The health effects of a toxic chemical vary by type of chemical and quantity ingested by the infected person. For most people, ingestion of water with a high copper level may likely cause nausea, diarrhea, abdominal pain, and/or headache. In the small portion of the population that is extremely sensitive to copper, the health effects may be poisonous, perhaps causing death.

Some chemicals have a low level of toxicity. However, when combined with the chemicals that are added to a water supply, a potentially more harmful chemical may form. Chemical contaminants may also react with the piping material in the plumbing or distribution system to leach toxic metals into the water. Because every water system treats its water differently, concerns about corrosive water are different.

Physical

There are few physical hazards that are not also chemical hazards. Examples of “pure” physical hazards include hot water and steam. Human contact with these hazards may result in burning of the skin, eyes, etc. In addition, physical hazards may also cause damage to the distribution system piping or materials.

LEGAL ASPECTS

Removing or controlling all cross-connections is a challenging task, one that could require resources beyond the financial capacity of many water systems, as well as public health and plumbing inspection departments. Frequently, property owners will modify a plumbing system, allowing uncontrolled cross-connections. Once contamination from a cross-connection occurs, it is likely that one or more persons will suffer some type of loss, e.g., a minor financial loss to cover the cost of flushing a plumbing system or serious injury or illness or death and resulting social and economic damages.

Government Statutes, Regulations, and Local Controls

Federal and state/provincial legislative bodies are heavily involved in adopting statutes that have a major impact on drinking water suppliers. Appropriate administrative agencies also promulgate regulations and periodic regulatory changes pursuant to their statutory authority. Local governments also may impose controls over water consumers through ordinances, regulations, rules, orders, and permits.

Once the statutes, local ordinances, regulations, and other administrative actions have been enacted, regulated entities are responsible for knowing and obeying these laws. Although most government agencies make an effort to notify affected parties of their newly established and ongoing obligations, contractors and builder groups should be involved in the process of enacting laws and developing regulations.

As previously stated, the primary federal statute governing the safety of PWSs in the United States is SDWA. Although major portions of SDWA are concerned with information gathering, the 1996 amendments recognized source water protection, operator training, funding for water system improvements, and public information as important new components for providing safe drinking water.

SDWA's reporting requirements may also apply to a backflow incident, whether it is the subject of enforcement or not. A variety of circumstances and events, such as failure to comply with the primary drinking water standards and other violations, must now be reported to those served by a PWS (see 42 U.S.C. 300g-3(c)). This type of required disclosure is a strong deterrent, even in the absence of civil penalties, because it exposes a water supplier to a third-party lawsuit under other statutory and common law.

Other laws and regulations that impact water suppliers and customers include

- Federal and state environmental and consumer protection regulations, including product liability laws (e.g., supply of tainted product: contaminated water)
- State requirements for the implementation of a cross-connection control program, testing of assemblies by certified testers, reporting of backflow incidents, records, etc.
- Plumbing codes and/or related industry standards (e.g., IPC, UPC, NFPA)

Water suppliers should remain aware of applicable state and local laws and regulations and consult qualified legal counsel concerning their possible application in the case of a backflow incident.

Common-Law Doctrines

Even though the water supplier has the responsibility for administration of a cross-connection control program, the building owner also plays a part in protection of the water supply within their facility. As such, all applicable building codes, fire sprinkler standards, and plumbing codes as well as any OSHA or Canadian Center for Occupational Health and Safety requirements need to be met. The building owner should also ensure that the necessary testing and maintenance of any backflow prevention equipment is conducted on their premises per requirements of the program administrator.

A common-law duty of every water supplier is to supply potable water to its customers. A water supplier's cross-connection control program should be designed to reasonably reduce the risk of contamination of the supplier's system and the water supplier's exposure to legal liability. If it is determined that a water supplier has failed to meet this duty, the water supplier could be held liable to its customers for damages proximately caused by the water supplier's breach of this duty. If other parties (contractors or other individuals) are at fault, their liability to any injured party may be determined in a similar manner, with any party found to have caused damage to another, assessed damages for some and possibly all injuries suffered.

Liability for supplying impure water has long been recognized as common law, most often for the incident of disease or poisoning that result from the violation, as well as for damage to machinery and goods suffered by commercial customers. Although case law varies from state to state, the general standard created by these cases is one of exercising reasonable or ordinary care to furnish pure water. Liability may result if this duty to

exercise reasonable care and diligence in supplying water is breached. However, other cases emphasize that water suppliers are not insurers or guarantors of the quality of water supplied by them.

With respect to damages, a customer has the burden of proving all “special” or specific damages, such as reasonable and necessary medical expenses that were incurred as a consequence of the asserted breach of duty. Property damage, lost market value to property, loss of income, court costs, and any other specific items of expense may also be claimed. In addition, a customer may seek an award of general damages, which are for pain, suffering, and discomfort, both physical and emotional. There is no precise formula for computing these kinds of damages, and unless a law is in place to limit damages, they are determined by a judge or jury after considering the evidence introduced in criminal or civil litigation.

If statutory performance standards such as those included in the SDWA are violated in connection with a backflow incident, the water supplier’s noncompliance with such standards will ease a claimant’s burden of proof. This, in turn, will allow a claim of negligence per se for having violated the standard but will still require a showing that a customer’s claimed damages were proximately caused by the instance of noncompliance. Because SDWA’s record-keeping and reporting requirements generate a large quantity of data on which such actions might be based, the implementation of backflow-prevention measures becomes imperative, rather than defend against government enforcement or third-party claims of damage.