Impacts of Cross-Connections in North American Water Supplies [Project #2611]

ORDER NUMBER:
90928
DATE AVAILABLE:
Winter 2002/2003
PRINCIPAL INVESTIGATORS:
J.J. Lee and Paul H. Schwartz
OBJECTIVES:
The first objective of this project was to assess the impacts, financial and otherwise, of cross-connections and cross-connection control in North American water supplies and to North American water purveyors. The project team also planned to create and use a computer model to simulate and demonstrate hydraulic changes in the transient state.
BACKGROUND:
For many years, cross-connections and backflow have been well understood. Programs to prevent unhealthy situations from happening have been in place for many years. However, a general and extensive study on their impacts, types of programs, incidents, and financial repercussions has not been conducted. Many computer models for steady state or quasi-steady state simulation exist, but applications for transient state simulation, especially demonstrating backflow incidents, have rarely been done.
HIGHLIGHTS:
Of the over 700 utilities surveyed, 91% were found to have a cross-connection control program. Survey data indicated 65% of cross-connections were indirect and 35% were direct. Sudden changes of water demands in piping networks can cause sub-atmospheric pressures within the systems resulting in backflow incidents. Systems with larger variances in ground elevations have the greater possibility of creating sub-atmospheric pressures as water demands in the systems change.
APPROACH:
In order to make an accurate assessment of the impacts of cross-connections in North America, primary data was necessary; therefore, a survey and a follow-up survey sent to water utilities across North America was the approach used. In order to demonstrate changes in hydraulic systems, a computer program for transient state simulation was performed for a large-sized piping network, a mid-sized water distribution network, and a small-sized piping network.
RESULTS/FINDINGS:
No geographic trends were found in North America in relation to the type of cross-connections being experienced. Indirect cross-connections accounted for 65% of cross-connections while 35% were direct cross-connections. Survey data suggested that the number of incidents per utility is not necessarily changing over time, but that reporting is becoming more prevalent as agencies develop cross-connection control programs. The overall average cost for all sizes of water utilities was $44,835 spent annually on administering the cross-connection control program. On the average, 3.65% of the agencies' operations and maintenance budget was directed towards cross-connection control. The data analysis demonstrated that those utilities with higher maximum elevation differences experienced a greater number of backflow incidents. Results from the computer modeling clearly indicated that sudden changes in the water demand, such as a hydrant opening, caused drastic transient flow conditions resulting in significant pressure loss and flow reversal in a network system of any size. Many examples demonstrated that the loss in pressure could reach below atmospheric pressure. The extent of the affected area cannot be generalized. It depended on spatial variations in network grids and scenarios of changes in water demand.
IMPACT:
The study provides a comprehensive assessment of the impact of cross-connections in North American Water Supplies. It also provides guidelines on the needed elements for an effective cross-connection control program for water utilities. The relative effectiveness of various elements in a comprehensive cross-connection control program have also been explored. Results from computer modeling clearly indicate that sudden changes in water demand, such as hydrant opening, cause significant transient flow conditions and flow reversal in a network of any size. Many examples demonstrate that pressure loss could reach below atmospheric pressure. Thus, appropriate plans to eliminate undesirable conditions within the distribution network should be made prior to potential disasters for water utilities. These plans should be made after careful studies of the response of the system to various scenarios.
PARTICIPANTS:
Eighteen utilities participated in this project.