CONDUCTING WATER SUPPLY TESTS

INTRODUCTION

The purpose of this section is to provide guidance on fire protection water testing. Thorough fire protection water supply testing:

- Provides the data required to analyze the overall adequacy of fire protection water supplies,
- Provides the data required to analyze individual water sources at the facility in question in regard to operation and reliability,
- Ensures there are no completely closed valves or valves with dropped gates in the distribution system,
- Flushes silt, rust and other small debris from water mains.

POSITION

The exact method used to test the water supply at any facility must be tailored specifically to the facility's fire protection systems. Generally, arrange tests to accurately demonstrate the volume and water pressure available at the point of greatest water demand or where pressure losses to the system being analyzed are the highest.

Use good judgment when choosing the test location. Conduct water tests as close to the property being analyzed as possible. If possible, make sure the test water discharge exceeds the combined demand for sprinklers and hose streams. Plotting results on $N^{1.85}$ graph paper can result in extrapolating a straight-line graph past the test data. The farther out along the flow axis the test point is, the more accurate the overall curve will be.

The point of analysis is usually referenced to the base of the sprinkler riser of the sprinkler system with the greatest water demand. Accurately note elevation changes, pipe size and distance to the analysis point when collecting water test results. When water supplies are analyzed, proper adjustments for elevation and friction must be made.

Prepare a test procedures before the work is started. Frequently, it is desirable to outline procedural items, such as test setup, data to be recorded, and sequence of valve operation, so that the results will be obtained accurately, efficiently, and safely.

Use the same test procedures each time the supplies are tested so that the results can be directly compared with previous tests. Changing these procedures may be advisable when previously used procedures are incomplete or revised procedures may reveal additional useful data.

Use AXA XL Risk Consulting's "RSVP" Impairment Tags, as discussed in PRC.1.1.0 and *OVERVIEW*, when any valves are operated, and make a careful inspection to confirm that all protection is restored when tests are completed.

DISCUSSION

Test Preparation

Conduct tests only when conditions are appropriate. Freezing and drought are examples of inappropriate conditions. However, test new supplies when completed regardless of the season. For fire pump testing see PRC.12.0.2 and PRC.14.2.1.1.

At least annually, check gauge calibration so that readings will be as accurate as possible. Avoid freezing or mechanical damage to the gauges.

Study the facility insurance diagram and determine the sequence of valve operation necessary to complete the testing in a thorough and efficient manner. Make sure that the sequence tests all paths through the underground system. For testing looped systems see PRC.14.1.2.3.

For complex systems, write out a brief procedure that includes all valve sequencing. This procedure could be the basis for planning future tests.

Notify all necessary parties, such as the water department, fire department, and alarm companies that tests are to be conducted. Brief parties regarding their duties and the time and number of people required.

Make sure the following materials are available for the tests:

- Pitot tube with gauge, 0 psi – 100 psi (0 bar – 6.9 bar).
- Hydrant cap assembly with National Standard Threads or threads or fittings to match the hydrants being used. It should have a petcock to vent the cap and hold the gauge, generally 0 psi – 200 psi (0 bar – 13.8 bar).
- Ruler, tape measure, or other measuring device.
- A means of determining flow rates, such as the AXA XL Risk Consulting Hydraulic Calculator (See PRC.14.1.2.1.2).
- AXA XL Risk Consulting Impairment Tags and valve seals.
- Forms to record test information.
- Wrenches for operating hydrants and curb-box valves.
- Test nozzles, preferably Underwriter's playpipes. The number of nozzles are based on the flow requirement. When a standard Underwriter's playpipe is used without a nozzle tip, about 500 gpm (1890 L/min) can be flowed; with a nozzle tip, the rate is about 250 gpm (945 L/min).
- Communication equipment, if necessary.

Record these test measurements:

- **Static Pressure** - The stabilized system pressure when no water is flowing from test apparatus.
- **Residual Pressure** - The stabilized system pressure reached while a uniform flow is maintained.
- **Pitot Pressure (dynamic pressure)** - The pressure taken at the center of an orifice of known diameter while a uniform flow is maintained through the orifice.
- **Flow Orifice** - The opening of a known or measured diameter. Confirm the size of the discharge opening to the nearest !/16 in. (1.59 mm). A small change in orifice diameter can result in a big change in flow.
- **Orifice Discharge Coefficient**, C_d -The hydraulic loss due to orifice friction. The orifice discharge coefficient for an Underwriter's playpipe is 0.98. The AXA XL Risk Consulting

Hydraulic Calculator is based on a 0.98 coefficient for sizes consistent with Underwriter's playpipes and 0.90 for hydrant butts with smooth rounded outlets. When pitot readings are taken at hydrant butts, the coefficient can vary because of the shape of the hydrant butt outlet. To ensure accuracy, use the proper outlet coefficient shown on the AXA XL Risk Consulting Hydraulic Calculator.

Carefully consider where water will be discharged during the tests. It is sometimes possible to return water used in the test back to private water supplies, such as ponds or tanks, to conserve water and ease periods of reduced water capacity. Avoid damage to lawns or plants, roadways, rail sidings, parked vehicles, buildings, or their contents. Do not allow water to enter open windows or doors.

Do not select test locations that are susceptible to water damage unless they are essential for the water supply analysis. When water damage susceptibility is possible, ensure susceptible areas are protected.

Testing without hose is preferred. If hose is used, confirm it is in good condition to avoid water damage and personal injury. Secure hoses and nozzles so they do not flail during testing.

Flow readings from Underwriter's playpipes are the most accurate. If it is not practical to use playpipes, open hydrant butts may be used. Be sure to apply the proper discharge coefficient.

If the flow from a large diameter hydrant outlet fails to completely fill the outlet port, test results will be inaccurate. When the flow stream is not solid, use multiple small diameter hydrant butts or multiple Underwriters' playpipe streams.

Take residual pressure readings as close to the point of analysis as possible. The point where the actual pressure reading is taken is called the "common hydraulic point." It is the point at which the gauge connection meets flowing water during the test. The length of the connection from the common point to the gauge is inconsequential.

Occasionally, a check valve may be located in the lateral feed or in the sprinkler riser itself to trap pressure between the gauge connection and the common hydraulic point. The trapped pressure can be relieved by cracking open the system drain on the riser. The pressure will drain off so that the true static and residual readings can be obtained. Trapped pressure may occur in the entire private underground if a jockey pump is used to maintain an elevated pressure.

If residual readings are taken at the supply side of the flow hydrant, the test results are valid for the point at which the readings were taken. If residual and static readings are taken beyond the point of flow, the point of test is the hydrant at which the flow measurements are made.

Finding a location to take static pressure readings in rural or residential areas can sometimes be difficult. This is especially true when conducting preliminary water tests for proposed building sites. Pressure gauges can be attached to any devices connected to the same water supply. It is sometimes helpful to have a brass garden hose connection with a pipe fitting adapter and reducers so that a test gauge can be connected to a sillcock. Due to the small size of most domestic piping, make sure that there is no domestic water usage during the test, and look for the presence of meters, check valves or other devices in the line that may affect the test results.

When taking pressure readings with other than fire protection devices, be sure the domestic and fire protection water mains branch off where expected. Otherwise, the true common hydraulic point may be misrepresented.

A residual reading at the same hydrant used for flow is not very accurate because of turbulence. But when no other location for static and residual readings is available, the same hydrant can be used for an approximation. The residual pressure in the main will be about 3 psi (0.21 bar) greater than the residual gauge reading because of friction loss in the hydrant barrel.

Do not allow the residual pressure to drop to a dangerously low level, usually 20 psi (1.38 bar). When the terrain is not flat, pipe collapse is possible if a sufficient partial vacuum is pulled at the higher elevations. Under these conditions it may take awhile for the residual pressure to stabilize.

Test each water supply individually to determine the flow and pressure available. Periodic fire pump testing is described in PRC.12.0.2; however, water measurement techniques are described in the water measurement section that follows. Use RSVP Impairment tags if the valves are shut.

Test public water connections using private hydrants or pump headers, if available. Where two or more connections exist, test each individually first, then test all of them together. Try to discharge the minimum demand for that risk.

If there are no private hydrants, test the supply using public hydrants. Where neither public nor private hydrants are available, estimate the water supply from the drain test results using PRC.14.1.2.2.

After ensuring that the water level is normal; test elevated supplies, such as tanks, reservoirs, standpipes and gravity supplies, the same way as public water supplies. Because water from nonpotable sources may contain sediment, periodic flushing and cleaning is necessary. Check facilities that replenish water for adequacy. Examine and flush heating systems so that efficient heating of the water is maintained in cold weather.

Pressure tanks are usually of limited capacity. Conduct drain tests to ensure the waterways are clear and check valves are not obstructed.

When checking the adequacy of protection, it is sometimes desirable to test near the point of analysis with all normal water supplies in operation. Testing can involve municipal and on-site gravity and pumping supplies. If such testing is not possible, test each water supply individually and correct the results to the point being analyzed. On $N^{1.85}$ graph paper, plot a pressure or volume curve for each supply. The total flow can be determined by algebraically adding the incremental flow from each water supply connection to the underground. Start at the most remote connection and work towards the analysis point. Make the necessary friction and elevation corrections.

Two notes of caution:

- Do not combine the discharge from a booster pump with flow test data of the municipal supply from which the pump draws.
- Do not include water supplies intended for redundancy with primary supplies when the adequacy of protection is being evaluated.

Water systems with static pressures that change or fluctuate greatly could be of concern. These pressure fluctuations may be caused by:

- Impaired water utility. Local storage tanks or part of the total pump capacity may be impaired.
- Multiple municipal pumps. Municipal pump operations are sometimes staggered. If additional pumps begin operating during the test, the recorded results may be erroneous. Record which pumps were operating during the test. If pumps are manually operated, confirm operating personnel are available around the clock.
- Seasonal changes. Unusually high runoff in the spring or drought in the summer can affect the water supply.
- Industry demand. Increasing daily demand, over time, may cause normal consumption to draw down the overall static pressure.
- Sporadic high demand during test. A commercial laundry, or possibly a fire, a broken main, or another water test could occur close to the test area.

Accurate Water Measurement

Carefully select where static and residual pressures are to be taken. The gauge may be attached to a hydrant, a lower gauge port on an alarm valve, or a water gauge port on a dry system. Place the gauge as close to the point of analysis as possible. Water must flow past the point of analysis so that the test data will record conditions at a useful common hydraulic point.

If a hydrant is selected, it is a good practice to flush the hydrant before attaching hose caps and gauges. On a frost-proof hydrant, open the first few turns quickly so the open frost-proof drain can close quickly and prevent undermining the hydrant.

Do not stand in front of any hydrant discharge port. The caps have been known to blow off if not securely tightened or if damaged by cold weather or severe mechanical impact. Similar precautions also pertain to valves with exposed valve bonnets that may have accumulated water prior to freezing.

Reclose the hydrant slowly to avoid water hammer. Place the hydrant cap assembly on the hydrant and open the hydrant fully. Expel air from the hydrant cap assembly by operating the vent port. Attach the pressure gauge to the hydrant cap assembly and open the gauge petcock. Record the static pressure reading.

After taking the initial static pressure reading, open the flow hydrant fully. Do not throttle hydrants or hydrant gate valves during the test. Allow the water pressure to stabilize and be clear of debris before the pitot tube is inserted into the water stream to take the pitot reading.

Hold the pitot tube firmly with the gauge connection between the second and third fingers. Insert the pitot tube opening into the center of the stream facing the flow and allow the blade to rest against the edge of the orifice, parallel to the nozzle opening. Elevate the air chamber at the end of the pitot tube to the 2 o’clock or 10 o’clock position. The Jones Improved Pitot Tube (used by AXA XL Risk Consulting) has indicator position marks for standard playpipes to ensure correct positioning at the center of the stream. The maximum velocity pressure is at the center of the flow stream. Record the reading from the gauge. Allow the chamber of the pitot tube to empty after taking each reading.

To get more accurate pitot readings, ensure that the pressure readings are above 10 psi (0.69 bar). A rapidly oscillating needle is probably due to needle vibration, or possibly high pressure and nonuniform flow. Check to see that all water has drained from the pitot tube air chamber. If this does not remedy the problem alter the size or number of flow outlets.

A needle moving up and down slowly is probably due to water pressure fluctuations; if so, record the lower reading.

To determine the amount of water flowing, refer to the “Quick Reference Flow Tables” on the AXA XL Risk Consulting Hydraulic Calculator or use Equation No. 1. This equation was derived in PRC.12.0.1.

When pitot pressure measurements are too high, or nozzle sizes are not those shown on the “Quick Reference Flow Tables” of the AXA XL Risk Consulting Hydraulic Calculator, the flow through an orifice can be determined by one of two methods. The first is to solve the equation for flow, using the measured variables, such as the orifice size, discharge coefficient, and the dynamic or pitot pressure. The equation is as follows:

English units:

$$Q = 29.85\, C_d\, D^2 \sqrt{P} \qquad \text{(1 E)}$$

Where

$Q =$ Flow (gpm)

$C_d =$ Discharge coefficient

$D =$ Orifice diameter (in.)

$P =$ Pitot pressure (psi)

SI units:

$$Q = 0.00666\ C_d\ D^2 \sqrt{P} \tag{1 S}$$

Where

$Q =$ Flow (L/min)

$C_d =$ Discharge coefficient

$D =$ Orifice diameter (mm)

$P =$ Pitot pressure (bar)

The second method uses selected entries from tables to determine flow when the actual pitot pressures or orifice diameters are not found in these tables. For pitot pressures not found in the AXA XL Risk Consulting Hydraulic Calculator or other reference tables, keep the orifice diameter on Equation 1 constant, and set up a flow ratio as follows:

$$Q = \left(\frac{\sqrt{P}}{\sqrt{P_t}} \right) Q_t \tag{2}$$

Where

$Q =$ Flow (actual)

$Q_t =$ Flow (table value corresponding to P_t)

$P =$ Pitot pressure (actual)

$P_t =$ Pitot pressure (selected table value)

For orifice diameters not found in tables or the calculator, keep the pitot pressure in Equation 1 constant, and set up a flow ratio as follows:

$$Q = \left(\frac{D^2}{{D_t}^2} \right) Q_t \tag{3}$$

Where

$Q =$ Flow (actual)

$Q_t =$ Flow (table value corresponding to D_t)

$D =$ Orifice diameter (actual)

$D_t =$ Orifice diameter (selected table value)

When flowing multiple outlets, determine each flow separately; then add the flows together to determine the total flow.

Take the residual pressure readings for each flow. Close the hydrant at which flow measurements are made and reconfirm the static pressure.

Record lengths of pipe runs and elevation of static and residual readings so proper adjustments can be made when analyzing the water supply.

At the completion of the test, carefully inspect the protection to make sure that all valves are open.

Compare water test results with previous test results. Investigate deviations.