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Not So Fast!
Close Hydrants Slowly

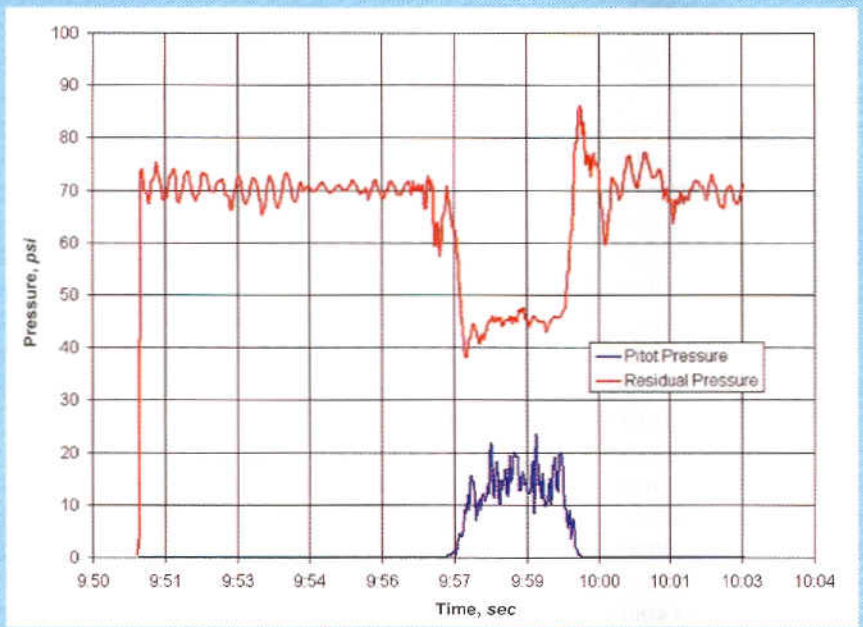
Increasing hydrant-closing time can make a dramatic difference in pressure surges in distribution system pipes. BY THOMAS M. WALSKI

BEFORE MOST NEW distribution system operators go into the field to operate hydrants, they're usually admonished to close the hydrants slowly to avoid damage to distribution pipes. If an operator asks why, the explanation usually includes something about water hammer, also known as hydraulic transients or pressure surges. But why does distribution system pressure spike when flow is changed?

When a fluid's momentum changes, a pressure wave is created, and opening or closing hydrants changes momentum and pressure. Although most pipes can withstand pressure in excess of their normal working pressures, water hammer pressures can exceed a pipe's strength, causing the pipe to rupture. Even if a pipe doesn't burst, water hammer pressure can separate joints—especially near bends—resulting in leaks.

Hydraulic transients are inevitable because the momentum of water in a distribution system constantly changes, and hydrant operation can be a major cause of momentum changes. Transient pressures can't be eliminated, but they can be managed by reducing momentum changes. That means slowly changing hydrant flow.

Figure 1. Actual Pressure Surges
A flow test revealed residual and Pitot pressures weren't excessive during a routine hydrant shutdown because the operators closed the hydrant slowly (15 psi is roughly 650 gpm).



PHOTOGRAPH AND CHARTS: BENTLEY SYSTEMS

FIELD DATA OBSERVATIONS

The magnitude of a transient pressure surge is directly related to the speed with which a hydrant is opened or closed. A pressure gauge at the residual hydrant can document the surge during a hydrant flow test. The gauge needle will fluctuate when the hydrant is opened or closed. The faster the hydrant

Close hydrants slowly to minimize pressure surges that can burst pipes and separate joints.

is closed, the greater the fluctuation. Digital data loggers allow the magnitude of pressure transients to be more easily observed. Actual pressure surges can be plotted during hydrant flow tests (Figure 1). High, yet not excessive, pressures resulted from operators closing the hydrant slowly during shutdown.

One way utilities can analyze the effects of a hydrant's closing speed on pressure surges is simply to slam the hydrant shut and record the pressure wave. However, the risk of serious damage to the distribution system makes this method ill advised.

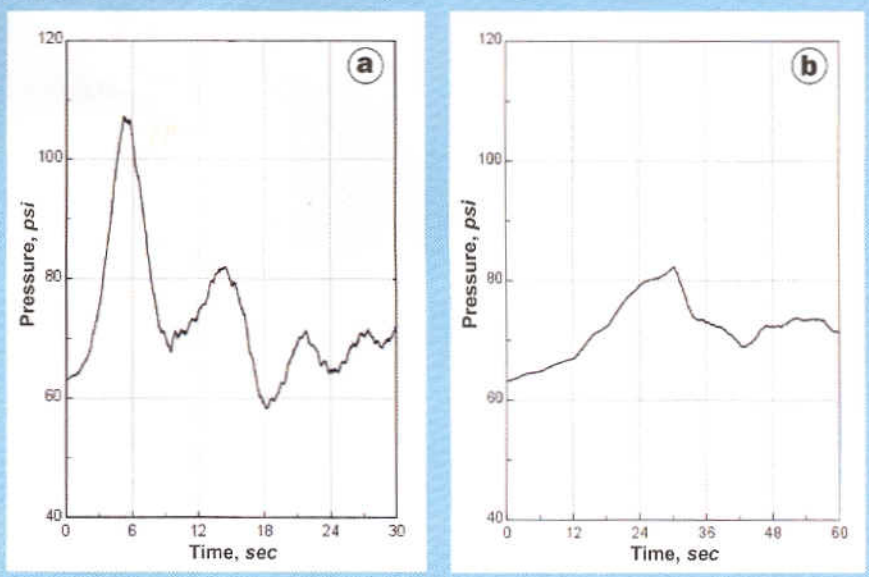
MODELING TRANSIENTS

Fortunately, it's possible to use a computer model to simulate the effect of hydrant operation on distribution system pressure. This procedure is much like placing pressure data loggers on all the hydrants in the system but at a fraction of the cost. These models also have excellent graphical capabilities to display flow-test results. It's also possible to determine pressure at locations where attaching a pressure logger isn't feasible.

A model of a medium-size town illustrates the effect of hydrant operation speed on pressures. Two hydrant closing and opening speeds were used—5 sec, representing fast closing, and 30 sec, representing conservative closing. When a hydrant is being closed, flow doesn't decrease linearly with time. The first few turns of the hydrant cause little change in flow, but the last few turns change flow dramatically.

Figures 2a and 2b. Hydrant Shutdown Results

The pressure peak for a 5-sec shutdown (a) is significantly higher than the peak for a 30-sec shutdown (b).



A computer model provides valuable insight about the magnitude and extent of transient pressures caused by operating hydrants quickly.

Pressure Plots. Computer modeling software was used to determine pressures and flow throughout a distribution system for 5-sec and 30-sec hydrant shutdowns (Figures 2a and 2b, page 15). For the 5-sec shutdown, notice that the pressure peak (about 110 psi) is significantly higher than the 30-sec pressure, which peaked at 81 psi. It may have been possible to generate this pressure graph using a pressure data logger, but the model allows users to view the pressure plot at many other points in the system.

Pressure surge is dampened out as distance from the hydrant increases. In this case (Figures 3a and 3b), the location is roughly 2 mi away and within a few hundred feet of a tank. Notice that the pressure surge has died off dramatically by this point, even for the 5-sec closure. In general, distance and tanks have a dampening effect on transient pressure waves in a distribution system.

Transient Profiles. Another way transient pressure was analyzed was to view the envelope of minimum and maximum hydraulic grade line elevations occurring during the event along some path from hydrant to source. The envelope of hydraulic grade was larger for the 5-sec shutdown, and the magnitude of the pressure envelope decreased as one moved away from the hydrant.

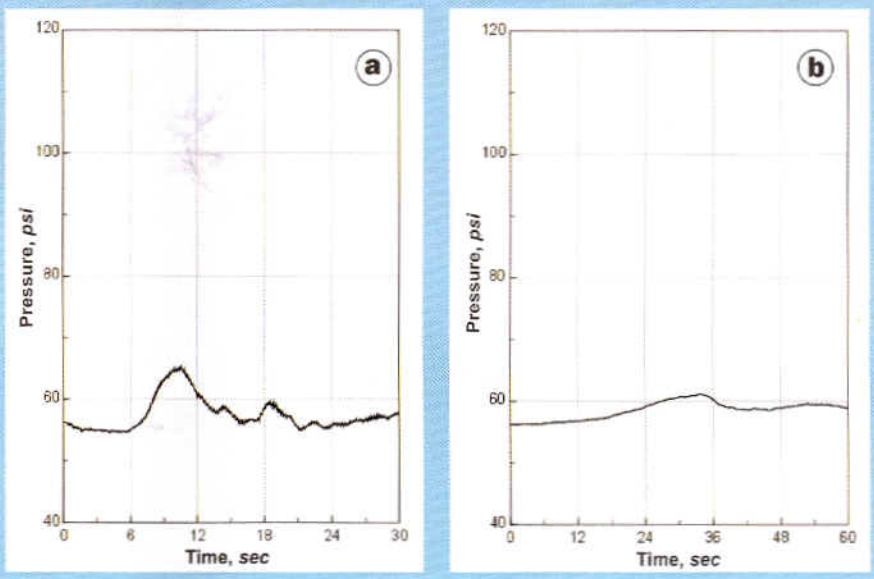
Mapping Transients. By color coding the distribution system map, Figures 4a and 4b show the maximum pressure during the transient event. The closed hydrant is in the northwest portion of this system.

The red lines represent pipes that experienced pressures greater than 100 psi; the magenta lines are pipes that experienced pressures of 90–100 psi; and the blue lines represent pipes that experienced pressures of 70–90 psi. The cyan lines represent pipes in which pressure didn't exceed 70 psi. These maps illustrate the large extent of transient effects.

Transients on Opening. A similar but usually less dramatic and inverted set of transients occurs when a hydrant is opened quickly. Instead of large positive pressures, a significant drop in pressure can occur if a hydrant is opened too fast. If the pressure drops below zero and leaks exist in the area, the distribution system could experience groundwater intrusion.

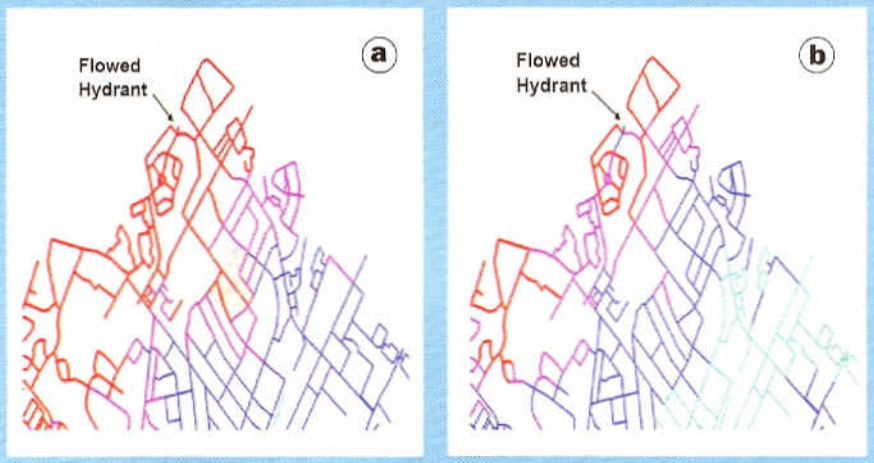
Figures 3a and 3b. Dampened Pressure Surge

Pressure surge diminishes as distance from a hydrant increases, whether a hydrant is closed in 5 sec (a) or 30 sec (b).



Figures 4a and 4b. Color-Coded Pressure Surge Results

A color-coded distribution system map is another way to view surge pressure for a 5-sec (a) and 30-sec (b) shutdown.



TAKE IT SLOWLY

A computer model provides valuable insight about the magnitude and extent of transient pressures caused by operating hydrants quickly. Increasing hydrant closing time from 5 sec to 30 sec can have dramatic results, greatly decreasing the impacts of hydrant closure.