Developing an Approach to Diagnosing & Correcting Capacity Problems on Distribution Infrastructure

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Water distribution capacity problems on existing transmission mains are often easy to correct but difficult to troubleshoot and diagnose. This is usually the case because water distribution systems are looped, allowing water to feed from multiple directions. The aim of this article is to provide a general guide to field practitioners for correcting water distribution problems on existing infrastructure.

Usually, the first indication of capacity problems arises from several customers complaining of low water pressure. In addressing these problems, we have implemented a procedure to systematically investigate, analyze, and correct these problems. To illustrate this procedure, here is an actual example:

The City of Riviera Beach Utility District contracted the installation of approximately 9,000 feet of 16-inch ductile iron pipe (DIP) water main. The project included directional drilling under the C-17 canal and under Interstate Highway 95. The directional drilling included the installation of 16-inch HDPE pipe. This new 16-inch water main was expected to provide additional capacity to the district's distribution division located the 11 butterfly valves on the 16-inch pipe line and ensured that the valves were all in the open position. The procedure usually employed to verify the state of the valve includes closing back three turns and then re-opening the valve. District staff proceeded by installing pressure gauges at the air relief valves by using a T-fitting to retain the functionality of the air relief valve and minimize the number of taps required on the pipe. After the gauges were installed, staff members isolated the 16-inch main from one end and conducted a series of fire flow tests. The purpose of isolating the line from one end was to ensure that no looping condition would exist—a necessary constraint to determine the actual conveyance capacity of the pipe system.

With the water treatment plant at a steady state, District staff members examined the field report and drill log for the C-17 directional drill. We found that the project specifications had maximum allowable entry and exit angles of 15 degrees for the HDPE pipe. According to the drill log, the drilling contractor had at times exceeded 25 degrees. The utility staff theorized that the pipe had possibly buckled due to the tighter entry and exit angles, but we knew that an actual inspection had to be conducted to be conclusive about the transmission problems. The HDPE pipe was scheduled for an inspection, and the staff proceeded by removing one of the valves to insert a camera. Upon inspection of the valve assembly, we discovered that the contractor had installed the 16-inch butterfly valve following the DIP fusion to the HDPE pipe. This valve installation problem proved to be the transmission problem, thankfully, no buckling had occurred as initially theorized.

In essence, a butterfly valve opens inside the pipe diameter. Since the inner diameter of the 16-inch HDPE pipe is 14.75 inches and the valve was sized for a true 16-inch DIP pipe, the butterfly valve, which depends on the inner pipe diameter for its successful operation, was only partially functional. This problem was not initially recognized by our water distribution staff because the valve actually had free working turns available out of the full 32 turns for a full open or close state. Staff members were not able to find this valve problem because they only closed back three turns on the valve to determine whether the valve was actually in the open status and assumed everything else was acceptable. The same valve problems were found at the HDPE I-95 crossing. We corrected these problems by simply changing the butterfly valves to gate valves.

When the solution was fairly simple, the problem was extremely difficult to pinpoint for an entire run of 9,000 feet of pipe. Obviously, it would be uneconomical to inspect or camera all 9,000 feet, and this is where the use of a hydraulic model made a significant difference in troubleshooting the measured field conditions in comparison to the calculated conditions. The valve having only five working turns out of 32 was also extremely abnormal and unexpected. The contractor installing butterfly valves where the pipe diameter changed

Figure 1

Figure 2

Table 1: Procedure for Troubleshooting Field Problems

1. Install pressure gauges along the pipe. Rather than installing new taps, the utility worker can install at the AFRs using a “T” fitting.
2. Isolate one end of the pipeline to ensure flow in only one direction.
3. Under static conditions, account for all elevation changes by reading the pressure gauges.
4. Extract a determined flow rate from a fire hydrant. If the pipe is greater than 12 inches, staff members should use two distributors to generate sufficient flow to stress the line.
5. After Step 4 is in a steady-state condition, record the residual pressures along the pipe system.
6. Plot the residual pressures versus the gauge distances as illustrated in Figure 1.
7. Use an engineering table or a hydraulic model to determine calculated residual pressures and compare to the measured values from Step 5.
8. Once the problem has been pinpointed, cut the pipeline and inspect with the traditional tools. If the pipe segment in question is too long, the user should tap the pipe and install gauges to close in on the problem as needed.