PRESSURE PIPE CONDITION ASSESSMENT ACROSS NORTH CAROLINA

Brent Johnson, P.E.
CDM Smith

ABSTRACT

In the not too distant past municipalities in North Carolina simply operated their pressurized piping systems until the combination of frequency and cost of repairing breaks drove them to replace the mains. Typically the entire main would be replaced even though the breaks may be isolated to a certain section of piping. Improper bedding or backfilling that creates point loads, over deflection of the pipe, corrosive soils, stray current, defective pipe material and poor installation techniques can all diminish the design life of a piping system.

Advances in technologies have made it cost effective to perform condition assessment of existing pipes to aid in determining its remaining useful life. Therefore many municipalities have begun efforts to perform condition assessment of pressurized pipelines within their collection and distribution systems. We will discuss the pipe history and condition assessment technologies deployed for three different municipalities across North Carolina.

The first case study involves a municipality is located in the southern part of the state that utilized tethered electromagnetic and CCTV inspection on 42-inch and 48-inch PCCP transmission mains. The second case study is in the western part of the state where ultrasonic testing was used to determine the extents of replacement for a 14-inch DIP sewer force main. The last case study took place in the central part of the state where free swimming electromagnetic inspection was performed on 30-inch, 36-inch and 54-inch PCCP potable and raw water mains.

We will discuss the selection process for the technologies deployed, their associated costs, and the lessons learned during the condition assessment process. This paper will be of interest to many NC Utilities who are considering undertaking a pressurized piping condition assessment effort.

Project #1  PWC Fayetteville - P.O. Hoffer Transmission Main Assessment

In January of 2011 PWC experience a main break on a 48-inch section of PCCP transmission main. These pipes were installed in 1967 and there was some concern about the structural condition of the remaining pipe sections. Following a review of the transmission main piping materials and configuration at the P.O. Hoffer Water Treatment Facility (Hoffer) it was recommended that Pure Technologies (Pure) be employed as a specialty...
consultant to perform the condition assessment of the remaining transmission mains. The transmission mains that were inspected are prestressed concrete cylinder pipe (PCCP) materials and range in diameter from 24 inches to 48 inches. Several technologies were reviewed for the pipeline inspection and it was determined that Pure offered the best combination of multi sensor tools to perform a comprehensive inspection of the transmission mains.

The specific purpose of the assessment was to provide inspection services to identify, locate, and quantify broken prestressing wires in individual segments of the PCCP water main utilizing Pure’s patented electromagnetic inspection technology.

Hoffer’s transmission mains contain numerous butterfly valves ranging in size from 24 inches to 48 inches. While Pure has a free-swimming tool that can be used on pipelines while they remain in-service, this tool – PipeDiver – cannot easily negotiate butterfly valves less than 36-inches in diameter and as such, the risk of entanglement is high in the Hoffer mains.

Therefore for the assessment of the Hoffer pipelines, it was recommend to use a tethered robotic system capable of performing an internal visual inspection (high definition video when available), and an electromagnetic inspection for wire break assessment in PCCP. The robotic equipment can also navigate around horizontal and vertical bends as well as up and down slopes. Pure required the pipeline to be out of service during the inspection. The robotic equipment has some maneuverability at inline valves but this is limited to those greater than or equal to 36-inches in size (depending on the valve design and configuration). The minimum
size opening for the robotic equipment is 16-inches in diameter. In order to gain access to perform the inspection, TA Loving was subcontracted to remove two venture meters located in below ground concrete vaults. Due to the clarity of the potable water the CCTV video footage provided useful information, specifically the location of some construction debris that was left inside of the pipeline during the repair of the January break. This debris was prohibiting the robotic crawler from completing the inspection and had to be removed by the use of a jetter hose. Following removal of the debris the robotic crawler completed the inspection and produce data that showed that the remaining pipe was in good condition.

**Project Cost**

The completed project inspected nearly 2500 linear feet of transmission main ranging in size from 24-inch to 48-inch in diameter. This required the temporary removal of a 42-inch and a 48-inch venture meters. The change in pipe diameters required separate tooling and inspection runs by the robotic crawler. The total project cost came in around $220,000.

**Project #2  City of Brevard – Neely Road DIP Force Main**

**Background and Project Goals**

The wastewater force main from the Neely Road pump station was identified as a high priority project for improvements. The City has experienced six failures of the 14-inch DIP Neely Road force main resulting in sanitary sewer overflows (SSOs). The most recent failure occurred in December 2013. The force main failures have all occurred because of deterioration that has occurred in the invert (6 o’clock position) of the pipe. The majority of breaks have occurred on sections of the force main that are expected to empty by gravity and thus be dry when the pump station is not operating.

**Desktop Analysis**

A desktop analysis was performed of the force main profile and break locations. This analysis showed that the force main breaks all occurred along Old Hendersonville Hwy between stations 100+00 (Neely Road) and 60+00 (Osborn Road). The air release valves (ARV) for the force main were until recently inoperable for a period of around twenty years. The inability to release the trapped hydrogen sulfide
(H2S) gases from inside the force main would ultimately cause the formation of sulfuric acid (H2SO4), which would attack the pipe wall typically starting at the pipe crown but sometimes at the 2 o’clock and 10 o’clock positions. What is unusual in this case is that the corrosion is occurring at the pipe invert or 6 o’clock position. The Neely Road pump runtimes indicate a short cycle time between pump shutdown and restart meaning that any sulfuric acid formed in the crown of the pipe that could run down the pipe wall to the invert would soon be washed downstream by the force main flow.

Another possible explanation for this is erosion of the pipe invert due to lack of grit removal equipment at the Neely Road Pump Station. A large amount of grit or gravel moving slowly down the force main pipe is a condition called a “sliding bed”. This can cause deterioration of the pipe liner and ultimately erosion of the pipe wall. The Neely Road force main, however, has high velocities which should result in a more random erosion of the force main liner and pipe wall due to the solids having a more erratic movement around the interior of the pipe. The large amounts of grit and gravel required to erode the force main would also cause wear and impingement damage on the pump impellers at the pump station.

The Neely Road pump station receives typical residential/commercial wastewater flows from the collection system. There are no known industries discharging to the system that could add chemicals that would be caustic to the force main piping. Several times a day the county discharges leachate from their landfill directly into the Neely Road wet well from pumper trucks. Another theory was that the leachate
contained a chemical that was corrosive to the ductile iron pipe (DIP) force main. The leachate was pH tested and proved neutral and in theory any chemical that would be corrosive to the DIP force main would also be corrosive to the pump casings and impellers. No corrosion has been evident in the pump casings or impellers.

**Field Testing**

CDM Smith subcontracted with S&ME to perform ultrasonic thickness testing of the Neely Road force main. The field testing was conducted in March of 2014. Six sites were tested with two of the sites being in excavated pits and four of the sites being in existing ARV manholes. Prior to the testing City crews removed all washed stone from within the ARV manholes and prepped the force main exterior by removing any large scale or rust formations. S&ME crews took multiple thickness readings at the 12 o’clock, 3 o’clock, 6 o’clock, and 9 o’clock positions for each of the six sites. All of the six sites had consistent readings for the different clock positions indicating that the pipe wall was still uniform and not experiencing any deterioration of the pipe interior.

Readings from the Neely Road ARV manhole and from all ARV manholes and excavations downstream of Osborn Road were consistently between thickness values of 0.35 and 0.42 inches. Test site #5 (Old Hendersonville Hwy / Neely Road) stood out due to the fact that its clock position thickness readings were consistent with each other but when compared to the other five pipe sections were significantly thinner. Test site #5 had an average wall thickness of 0.28 inches. This measured thickness is also in line with thickness readings taken from the pipe samples removed during the six point repairs of the Neely Road force main breaks.

This leads to the conclusion that the section of force main between Sta 100+00 (Old Hendersonville Hwy/Neely Road) and Sta 60+00 (Osborn Road) has an average pipe wall thickness of 0.28 inches indicating that a lower pressure class piping (150 psi) was originally installed. This is most likely due to the fact that this section of the force main acts more like a gravity sewer and was installed at average depths which allows the opportunity to reduce capital cost by installing a thinner pipe. This thinner pipe section is now under attack by corrosive H2S gas and has less pipe wall material to resist and prevent breakage and subsequent overflows.

**Recommendation and Cost**

Due to the lack of break history and ultrasonic test results showing sufficient pipe thickness is present on the pipe sections from the Neely Road Pump Station to Sta 100+00 (Old Hendersonville Hwy/Neely Road) and from Sta 60+00 (Osborn Road) to the WWTP, CDM Smith recommended that those force
main sections remain in service. It was further recommended to conduct full replacement of the force main piping from Sta 100+00 (Old Hendersonville Hwy/Neely Road) and Sta 60+00 (Osborn Road). This section contains piping that has a thinner wall than the rest of the force main and remains empty when the pump station is not in operation. All six previous force main pipe breaks have occurred within this section.

It is our opinion that the force main piping is experiencing one or a combination of several of the following conditions. This section is steeper sloped than the remaining force main sections. This could concentrate any grit or gravel movement into the invert causing liner failure and pipe wall erosion. Secondly this section experiences wet/dry cycles during pump station operations which can accelerate H2S attack. Any gases formed inside the force main between the lift station and the top of the hill at the Old Hendersonville Hwy and Neely Road intersection would rise and gather at the ARV. If not properly vented this would cause sulfuric acid to be formed which could run downstream in the piping invert and cause deterioration of the pipe liner and corrosion of the pipe wall material. Thirdly, any caustic chemicals contained in the County landfill leachate could leave a residue behind between pump cycles. This residue could settle to the pipe invert causing deterioration of the pipe liner and corrosion of the pipe wall material.

Since the force main failures are attributed to a possible combination of mechanical and chemical forces, we are recommending that the replacement pipe material have properties of both scouring resistance and chemical inertness. Both polyvinyl chloride (PVC) and glass-reinforced polymer (GRP) pipe materials meet these criteria.

The additional advantages of PVC pipe is low cost, inertness to any corrosive or contaminated soils, and public utility personnel familiarity with installation and repair. PVC will not be affected by anything that can be normally found in sewerage effluent. However, if some illegal discharge is made then chemical attack of the rubber ring gasket (common to all modern pipe systems) could be a concern. Because of modern pollution controls on sewage discharges, PVC can be safely used in any municipal sewerage network including areas accepting industrial effluent. The estimated capital cost for a 4,000 linear foot section of 14-inch PVC pipe is $655,000.
The additional advantages of GRP pipe are high strengths that provide break resistance under surge conditions and a smooth, low friction bore that requires less pumping energy. GRP pipes have a service life of greater than 50 years and are compatible with other pipe materials. Disadvantages include the needed care in handling and installation practices to prevent damaging the pipe and lack of familiarity of city staff with this pipe material. External impact can induce star cracking of the barrier layer on the pipe bore with no apparent damage to the surface of the pipe. The installation cost for a 4,000 linear foot section of 14-inch GRP pipe is $740,000.

The cost for the ultrasonic testing was $3500. The City of Brevard provided all traffic control and excavated two pits, one in a grassy area and one in Old Hwy 64.

Project #3 City of Raleigh – Raw Water and Transmission Main PCCP Inspection

As part of the 2013 Sustainable Infrastructure / Asset Management Program Assistance project, all water mains have been given a condition and criticality rating representing the probability of failure and consequence of failure of these assets. In most cases, the condition rating of a given pipe segment is estimated from factors such as pipe material and age and the actual condition is not known. The purpose of this project is to determine the actual condition of critical pre-stressed concrete cylinder pipe (PCCP) water mains in the State Street area. The project will also include condition assessment of the City’s raw water mains from the Falls Lake raw water
pump station to the E.M. Johnson water treatment plant, as the raw water mains were also identified as critical to the City's water supply operations. The field condition assessment data will be used to develop a phased rehabilitation and replacement (R&R) plan to support the City's continuing assessment and rehabilitation program.

On-site condition assessment was conducted on the selected, critical water mains as described below:

- Hillsborough Street PCCP: 5,500 feet of 36-inch PCCP water main;
- Pullen PCCP: 4,000 feet of 24-inch PCCP water main;
- East Street PCCP: 11,200 feet of 30-inch PCCP on East Street;
- Raw Water Mains: Parallel 36- and 54-inch parallel EM Johnson raw water PCCP mains (36,000 linear feet);

All of the above mains will be tested utilizing Smartball and Pipediver technologies from Pure. No inspection data is available at the time of this report but updated project results will be made available during the conference presentation.