uThukela Water taking the first step towards **proactive pipeline integrity management**

uThukela Water (Pty) Ltd recently completed a series of investigations as part of a programme to assess the condition of two critical raw water supply pipelines

Kobus Prinsloo
SSIS Sahara (Pty) Ltd
kobus.prinsloo@ssis.co.za

Hannelie Hickley
uThukela Water (Pty) Ltd
hannelie.hickley@uthukelawater.co.za

THE NTSHINGWAYO DAM (previously known as the Chelmsford Dam) was completed in 1961 to supply the town of Newcastle in KwaZulu-Natal, as well as the ESKOM thermal power station and surrounding industries and farms. Two gravity pipelines were built from the dam. The then Department of Water Affairs and Forestry constructed a pre-stressed concrete pipeline (PCP) to supply the Ngagane Water Treatment Works (WTW) that supply potable water to Newcastle and its surrounding communities. A second steel pipeline was built by ESKOM to supply water to the Ingagane Power Station, which was mothballed in 1990 and subsequently decommissioned. A fibre-cement (FC) pipeline was built between the power station and the Ngagane WTW to augment the capacity of the pre-stressed concrete pipeline and to utilise the existing steel pipeline after decommissioning of the power station to increase capacity and provide redundancy.

Both raw water pipelines have been in service for almost 50 years. The two pipelines are strategically important in that they supply the largest portion of raw water to the Ngagane works for treatment. The raw water supply system experienced significant water losses, raising concerns about the condition and structural integrity of the pipelines. Water requirements are such that neither pipeline can be taken out of service for extended periods. In-service inspection technologies were therefore required. The investigations, which involved a number of survey techniques and technologies, were performed by SSIS Sahara (Pty) Ltd.

SSIS implemented a phased approach to assess the integrity of the pipelines. Apart from being more appealing when budgets are limited, this approach also ensures that the outcome of each inspection builds on the previous results and is scrutinised before implementing further investigations simply to drive revenue. The following investigations were performed as part of this appointment:

- Site survey and desktop study
- Tethered non-disruptive in-line leak detection survey using the Sahara® system
- Transient pressure monitoring
- Coating integrity and corrosion potential survey on the steel pipeline.

INVESTIGATION FINDINGS

Site survey and desktop study

Very little design and construction records of the pipelines still exist. SSIS was therefore reliant on field surveys to confirm the route and the design details of the pipelines. The site investigation found that the majority of pipeline components (air valves, isolating valves and scour valves) were in a poor condition (see Figure 1). This is unfortunately a common observation on many bulk water supply pipelines in South Africa and is certainly not unique to uThukela Water.

Leak detection survey

A combined pipe length of almost 38 km was successfully inspected on the pre-stressed concrete, steel and fibre-cement pipelines using the Sahara® inspection system. Sahara® is a proven system that is being used worldwide to accurately pinpoint the location, and to estimate the magnitude of leaks in water pipelines of any material type. Because leaks in pipelines are directly associated with the structural integrity of the pipe wall and the joints or steel welds, Sahara® is an ideal non-destructive, real-time pipeline condition assessment tool. It is deployed while the pipeline remains in service, allowing for uninterrupted water service delivery to customers while inspections are performed.

Figure 1: Condition of isolating valve on the pre-stressed concrete pipeline – a familiar site on South African bulk water infrastructure

Six leaks were found on the PCP, while five leaks were detected on the Steel/FC pipeline. Interestingly, eight of the leaks were found at pipeline components like air valves, scour valves and isolating valves, with only one and two leaks detected on the main pipe barrel of the PCP and the Steel/FC pipelines respectively, which is indicative of the condition of the main pipe barrels.

Large volumes of moving or stationary air were also detected in both pipelines. Excessive air entrainment could increase internal corrosion or adversely affect the hydraulic capacity of a pipeline.

Transient pressure monitoring

Transient pressure surges can result in severe damage or even failure of pipelines.

Aged pipelines are especially susceptible to surge-related damage. Remote Transient Pressure Monitoring (RTPM) on both pipelines found that end-line valve closures result in pressure surges (see Figure 2). Although not excessive, mitigating measures were recommended to reduce pressure surges even more.

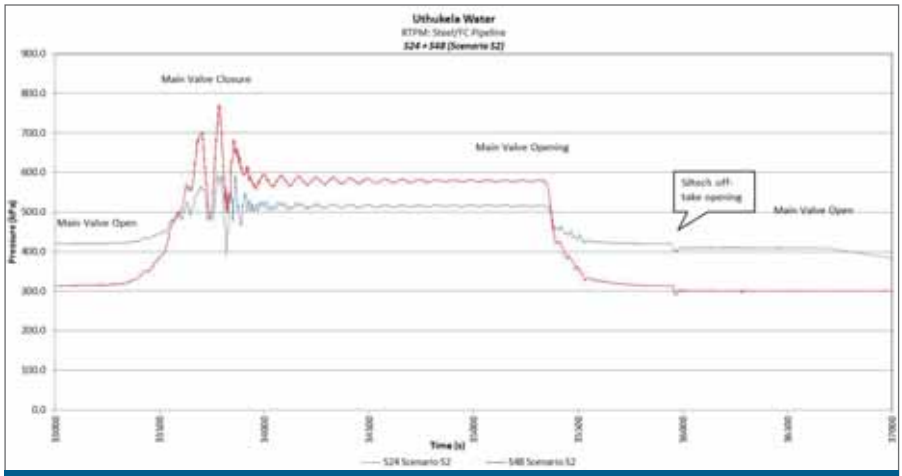

Figure 2: Pressure monitoring of the steel pipeline to confirm its hydraulic behaviour and magnitude of induced pressure transients

Figure 3: Partially closed in-line isolating valve (photo courtesy FJ Olivier)

Figure 4: Internal condition of a PCP barrel after approximately fifty years of service (photo courtesy FJ Olivier)

The hydraulic modelling of both pipelines yielded interesting results. Whereas the hydraulic performance of the Steel/FC pipeline was as expected, the hydraulic analysis of the PCP produced results that were not representative of the expected condition of the main pipe barrel. Entrapped air, the presence of some large leaks along the pipeline and an isolating valve that was stuck in an almost closed position (see Figure 3) are the most likely causes of the anomalous hydraulic behaviour of the pipeline.

The hydraulic assessment confirmed the theoretical hydraulic capacity of both pipelines, which is important from a master planning point of view.

External coating integrity survey

The external corrosion potential and coating integrity surveys confirmed that more than half of the steel pipeline is located in areas characterised by corrosive soils, while significant stray current interference is experienced due to the location of the pipelines near high-voltage transmission mains and a major railway crossing. The cathodic protection system was not providing adequate corrosion protection, and some coating defects were detected that would require further investigation and repair.

Recommendations

Based on the findings of the surveys performed on the PCP and Steel/FC pipelines, and given the relatively low operating pressures that the pipelines are exposed to, it is believed that rehabilitation or selective repair methods could be a cost-effective alternative to overall pipeline replacement. This was confirmed when sections of the PCP were removed to install a by-pass connection, offering the opportunity to inspect the internal condition of the pipeline and finding it to be in better than expected condition after almost fifty years of service (see Figure 4).

Additional investigations were recommended to inform the decision-making process going forward and build on the information gathered to date. A number of the recommended actions are currently being implemented.

PRO-ACTIVE PIPELINE INTEGRITY MANAGEMENT

Water utilities simply do not have sufficient capital funding to indiscriminately replace bulk pipelines any longer. The alternative solution is to either do nothing

(and then react to failures through costly and inefficient emergency repairs) or to better understand the condition of the existing infrastructure and perform proactive maintenance, thereby managing the integrity of the infrastructure.

Based on extensive international experience, only a small portion of a pipeline typically requires repair or replacement, while the rest of the pipeline may still be in a good condition. Pro-active pipeline integrity management, based on appropriate condition assessment inspections and targeted repairs, typically costs between 5% and 15% of the capital replacement value, giving utilities the reliability of a new pipeline in terms of performance and safety at a fraction of the cost of capital replacement.

CONCLUDING REMARKS

This project highlights the value of implementing a comprehensive and proactive pipeline condition assessment programme. uThukela Water originally faced the prospect of full infrastructure replacement at significant capital cost, based on pipe age and water loss as its only indicators. The investigations performed to date, however, indicate that rehabilitation or selective repair methods could be a cost-effective alternative to pipe replacement. Further investigations will be required, but with the baseline now set, uThukela Water can continue to implement a proactive approach to the management of its bulk infrastructure, setting an example for other utilities faced with similar challenges in South Africa. □

FACT BOX

Client uThukela Water (Pty) Ltd
Project Integrity survey of two raw water mains from Ntshingwayo Dam to the Ngagane Water Treatment Plant
Region KwaZulu-Natal
Inspection distance 38 km
Project duration January to December 2011
Pipeline description Steel, fibre-cement and pre-stressed concrete pipelines of 600 and 700 mm ND

Key project outcomes

- Discovered 11 leaks of varying sizes
- Assessed and documented the condition of pipeline components, such as air valves, scour valves and isolating valves
- Assessed the hydraulic performance of both pipelines
- Performed external corrosion potential and coating integrity surveys
- Established a baseline for the condition of the pipelines, against which future inspections can be measured to assess trends and decisions can be made on the most appropriate way forward
- Improved understanding of the condition and operation of the system enabling pro-active management and more focused maintenance interventions

Source:
http://www.saice.org.za/downloads/monthly_publications/2012/2012-Civil-Engineering-June/#/0