

Project Focus

Pipes and pipelines: A challenging assessment at Ladybower Dam

Vital pipeline survey required at 70-year-old Severn Trent dam

Pipes beneath two draw-off towers presented access constraints

Electronic sensors established detailed picture of pipe risk



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Pipeline Condition Assessment within dams is essential, but very tricky says Adrian Davies-Jordan, pipelines engineer at MWH, outlining how he and the pipelines team tackled a recent project to survey the pipework in Severn Trent Water's (STW) 70 year old Ladybower Dam – immediately below the site of the historic training runs for the World War Two Dambuster pilots.

The risks associated with pipeline failures are generally described as being the product of 'the consequence of failure' and 'the likelihood of failure'. The consequence of failure is broadly seen as stemming from a combination of factors such as pipe diameter, pressure, and location. However, within the structure of a dam, if there should be any failure of large diameter pipework the consequences can be even more far reaching. Dams contain an array of pipes which can be used for a range of functions, varying from hydroelectric power generation through to water supply and reservoir level maintenance. The pipes are often located in confined spaces and may pass down shafts or through walls.

Drivers:

- *STW's pro-active approach to reservoir safety*
- *Long term security of supply*
- *Designing out the 'single point of failure'*
- *Health and safety of dam operatives*



Accessing the pipeline beneath the draw-off towers of the 70-year-old Ladybower Dam presented an unusual challenge

When MWH recently surveyed the pipe work within STW's Ladybower dam, the results were generally comforting. However, whatever the outcome, it is now accepted that such assessments will inevitably form a necessary part of managing one of the most critical assets types within the UK Water Industry. Indeed, Dams and Reservoirs Manager, Ian Hope, made clear that commissioning this pipework survey was part of STW's pro-active approach to reservoir safety. "We are not waiting to be confronted with imminent failure or indeed mandatory safety measures following a statutory inspection. The whole thrust of our approach is to better understand the condition and performance of our assets."

STW approached MWH with a specific brief: The clay core embankment dam featured two draw off towers with four draw off pipelines in each tower; one high-level pipeline, one mid-level pipeline, and two low-level pipelines (a bottom draw off and a scour line). The two low-level pipelines in each draw tower extended along below ground service tunnels, approximately 150m in length, delivering reservoir water to the downstream control houses on either side of the dam. From here the water was pumped into regional aqueducts. All pipelines had double isolation in the form of twin inline valves within the draw off towers. It was this arrangement of pipelines within the dam that presented the key areas for assessment.

The Key Issue

STW's principal concern was that a catastrophic pipe failure of any one of the four low-level pipelines within the below ground service tunnels, or at the base of the draw off towers, would result in flooding of one of the two service tunnels. Whilst, as a contingency, the actuated low-level valves could be operated from a dual source located in the adjoining tunnel, the concern was that a serious leak would cause significant damage and could compromise the electricity supply in the locality of the leak. The obvious consequence of such an event would initially be an uncontrolled release from the reservoir. In order to determine the likelihood of such an event occurring, MWH was asked to conduct a condition assessment survey of the pipework within the dam.

Perspectives

Severn Trent Water Dams and Reservoirs Manager Ian Hope: "Although access too many of the sites was both difficult and hazardous, careful risk assessment, planning, and preparation allowed a large amount of data to be collected safely. This meant MWH were able to provide us with a robust estimate of remaining asset life and identify an action plan to militate against catastrophic pipeline failure."

Access Constraints

The two key constraints were; how to obtain a comprehensive and robust assessment of the current pipe condition, and how to get the necessary access to the pipelines in order to achieve this.

MWH elected to use a broadband electro-magnetic (BEM) non-destructive testing (NDT) technique to determine the current condition of the pipework within the dam. BEM assessment involves coupling a sensor array to the side of the pipe and holding it there whilst an alternating current is passed through a transmitter coil at the surface of the pipe which generates an alternating magnetic field. This induces a voltage across the pipe, which creates eddy currents in the pipe wall, creating a secondary magnetic field. The wall thickness of the pipe is measured by detecting the attenuation and phase delay of an electromagnetic signal passing through the pipe wall.

The BEM output gives an average wall thickness over a 50mm by 50mm square sensor. The total assessment area was the entire pipe circumference over an axial distance of 900mm. This meant that localized areas of wall thinning could be detected as well as maximum and minimum thicknesses. In all, 10 such assessments were carried out in each tunnel giving an inspection frequency of approximately 1 in 30, so we were able to gain a detailed picture of the current pipe condition. Having determined the wall thickness it was a straightforward step to calculating the current pressure resistance capability.

Getting access to the pipes in order to conduct such comprehensive assessments proved tricky. Complete circumferential access to the service tunnel pipes was hampered by the fact that they were mounted some 1.5m above the ground on concrete plinths, the twin pipes being accessed along a narrow walkway suspended between the supporting plinths. MWH devised an ingenious method of getting to the complete circumference by using a custom-made saddle that could be wrapped around the pipe and rotated by 50mm increments using a reference line at the springer of the pipe (see figure 1). The saddle incorporated a Velcro fastened pocket which housed the sensor and held it securely against the wall of the pipe during the sensor readings.



A circular saddle was wrapped around the pipe so that its thickness could be monitored using the BEM sensor equipment. Lines on the saddle every 50mm indicated where measurements were taken.

Similar assessments were carried out on the flanged stub pipes that extended through the draw tower walls just upstream of the guard valves, as these were seen as the points of critical failure. Any burst here might not be contained until the water level in the reservoir had dropped below the level of the draw off pipe. The mid and high level draw off pipes were accessed by narrow platforms which could only be got to by descending steep ladders from the top of the draw off towers (see figure 2). This required a full confined space risk assessment and meant that at all times our operatives were in full rescue harnesses, with a rescue team and top man in attendance at all times. It also required the BEM equipment to be winched down to the platforms and set up at each location prior to sensor readings being taken. Despite the difficulties in conducting the assessment it was crucial to assess these pipes so as to provide sufficient information for the client to be confident that there was still significant remaining life in these assets.

Innovations

- *Access to the pipelines in the draw towers and the below floor area of the control houses was the most challenging aspect of the project.*
- *Designing of a custom made saddle to provide sensor access to the whole pipe circumference.*
- *Investigation of a remote, hydraulic valve closure method not susceptible to power failure.*

Pipeline Analysis

Having obtained a comprehensive set of wall thickness readings from pipes in the draw off towers, the service tunnels and the control houses (in total over 50 locations were assessed), the intended methodology was to use the wall thickness at installation, the current measured wall thickness, and the age of the pipelines, to determine the corrosion rate of the pipe walls.

This required finding out the age of the pipelines and the standard minimum wall thickness at installation. The cast iron pipes were all stamped, the socket/spigot pipes as class B, and the flanged pipes as Class D. The pipe material was known (vertically pit cast iron) and date stamped 1938 and 1942 respectively. Reference to the applicable standard (BS78:1938) gave minimum installation wall thicknesses of 25.5mm and 34.9mm respectively. The pressure ratings of the Class B and D pipes were significantly in excess of the maximum static head of the reservoir, and as the pipes were under no external loading, the primary task was to assess the current wall thickness and confirm that sufficient thickness remained for pressure containment. It was then possible to estimate the remaining time to minimum allowable wall thickness.

As the internal pressure was the crucial parameter in the remaining life methodology, we also undertook a comprehensive surge pressure analysis of the dam pipework, recommending the addition of air valves to guard against negative pressures in the service tunnel pipelines. A visual assessment of the 200 spigot/socket joints, and an analysis of remote manual methods for activating the bottom level guard valves in the event of an electrical failure completed the 'health check' of the pipework in the dam.

STW's Dams and Reservoirs Manager, Ian Hope commented; "Although access too many of the sites was both difficult and hazardous, careful risk assessment, planning, and preparation allowed a large amount of data to be collected safely. This meant MWH were able to provide us with a robust estimate of remaining asset life and identify an action plan to militate against catastrophic pipeline failure."

MWH Pipeline Engineer Adrian Davies-Jordan: "The results of MWH's recent survey of the pipe work within STW's Lady-bower dam were generally comforting. However whatever the outcome it is now accepted that such assessments will inevitably form a necessary part of managing one of the most critical assets types within the UK water industry."

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