Detection of Minor Leakage in a Drinking Water Power Plant Pipeline

Project in the South Tyrolean community Mals in Italy

The final pressure test of a 2014 newly installed pipeline in a drinking water power plant in the South Tyrolean community Mals (Italy) showed a pressure loss out of range, which prevented the plant's commissioning. Thus the company MTA Messtechnik GmbH has been tasked to identify the reasons for the losses as quickly as possible using its newly developed pipeline inspection system Pipe-Inspector®. The decision for Pipe-Inspector was based on the ability of the system to inspect long pipeline sections wirelessly, both optically and acoustically, in a single pass. The contract was awarded in December 2014 at a time when low temperatures and extensive snowfalls are not uncommon at the site in over 2,000m above sea level, so that the time frame was very short to investigate and eliminate the potential damage in order to put the facility into operation as planned still in 2014.

The affected ductile cast iron pipeline, DN 200, is located outside the settlement area in mountain terrain at about 2,000 m above sea level. Access is possible only via unpaved paths. The newly constructed pipeline was designed to replace the existing potable water pipeline in need of renovation and to feed a newly built small hydropower plant. The total length of the pipeline section to be inspected with multiple 22° bends was 630 m, its operating pressure 30 bar. (**Figure 1**)

Negative pressure test prevents commissioning

The pressure test, mandatory in conjunction with the water rights order, serves as a verification of the pressure pipe's strength and tightness. For this purpose, the pressure in the pipe, filled with water, will be increased 1.5–2 times as high as the operational pressure, depending on the valid standard. This pressure is maintained and monitored during several hours.

A pressure protocol is created, which is presented to the authorities. Only then the pipeline will be approved for operation. Provisions for pressure testing are defined in the applicable regulations[1].

The reason for the order to inspect the pipeline was a negative pressure test with the result of a pressure drop exceeding the permissible limit values, which revealed a calculated water loss of 3.9 l/h and jeopardized the timely commissioning of the complete hydropower plant.

Condition assessment and evaluation of laid pipelines

The application range of wired CCTV inspection systems is limited due to their operating range. Starting from about 150 m cable length it becomes problematic, so that the pipeline's length of 630 m and its pressure of 30 bar required a cable-less inspection method right from the outset.

The customer finally chose Pipe-Inspector which allows the cable-less and complete optical and acoustic inspection of long pipeline sections up to 50 km length. During operation it overcomes 90° bends and is applicable in pipelines from DN 100 to DN 3000, regardless of the material, and even in hard-to-reach areas.

In the project was used a Pipe-Inspector DN 125 with a pressure resistance up to 40 bar (of max. 100 bar possible), equipped with a high-resolution HD camera unit including LED light ring for optimum illumination of the pipe interior during the inspection.

The recording of acoustic leakage signals was performed using a built-in high sensitive hydrophone. Only the continuous measurement of the distance traveled by

[1] Euronorm EN 805, Anforderungen an Wasserversorgungssysteme und deren Bauteile außerhalb von Gebäuden.

Figure 1: Site in over 2,000m above sea level

Figure 2: Pipe-Inspector® launch

Pipe-Inspector, based on the values of a built-in accelerometer, allows the assignment of the obtained optical and acoustic data to a particular point in the pipeline, indicating the distance measured from the inspection starting point.

The measurement data, which have been collected during the inspection, were stored locally in the device and via a USB port easily exported to a specially developed analysis software after the completed inspection process.

Conduct of the inspection

Since the pipeline was already divided and separated into separate sections for previous partial pressure tests, there was no additional expenditure for the inspection tool's introduction and removal. (**Figure 2**)

The Pipe-Inspector device was positioned at a defined starting point in the emptied pipeline and a special locking piece was mounted, furnished with a 90° upstanding water connection point. In a next step, the pipeline was filled with water at the end point of the pipeline section to be inspected and subsequently vented to prevent air pockets in the pipeline, which may reduce the quality of the optical inspection results. (**Figure 3**)

In order to perform the inspection under operating conditions, the pipeline was applied with 30 bar water pressure at the inspection start point, so that the Pipe-Inspector, driven by the media stream, began to move, and the inspection process was started. (**Figure 4**)

The flow rate regulation was achieved by partially opening a valve at the end point of the inspection route. (**Figure 5**)

After 28 min the device reached the end point of the 630 m long inspection section and was taken out after emptying the line. (**Figure 6**)

Structural damage

Apart from deposits also structural pipe damage, caused by material defects, planning or installation errors, may cause problems during commissioning, resulting even in the total failure of the power plant. The penstock's optical and acoustic inspection was decisively in this project to minimize these risks and identify the problematic points.

Figure 3: Starting point with water connection point

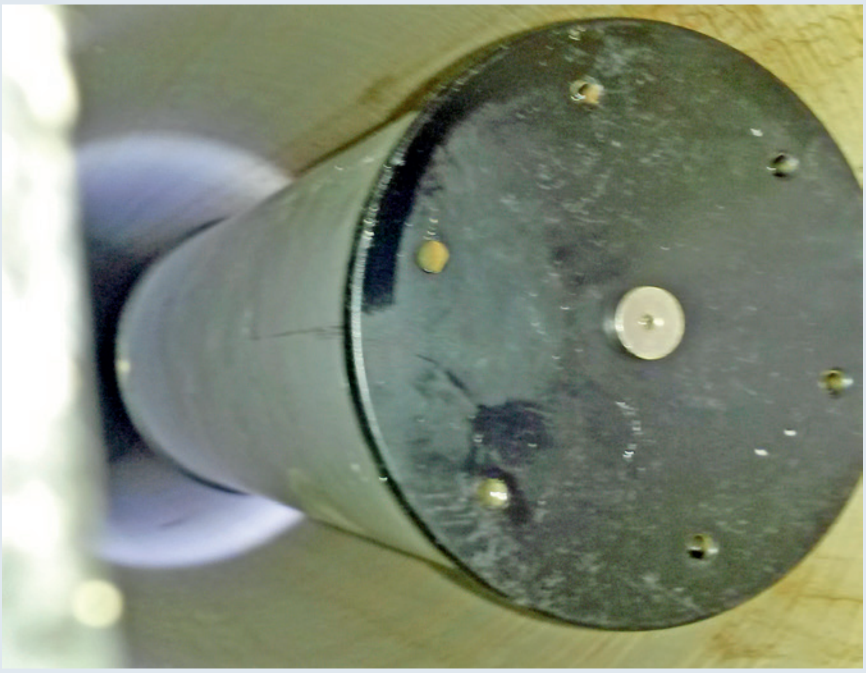

Figure 4: Pipe-Inspector® position at starting point

Detection of leakage sounds

Even minor leakage can cause a pressure drop during the pressure test. When water flows out in small amounts under high pressure, the occurring discharge sound is characterized by low amplitudes and high frequencies, resulting in a very low propagation along the pipeline. Thus, the boundaries of conventional acoustic leak detection methods, such as by means of correlators or geophones, are rather narrowly defined.

Another method, the leak detection using tracer gas, which is a hydrogen-nitrogen mixture, could not be applied in this project. The reasons were mainly the high financial cost, since for the 630 m long pipeline section with 30 bar pressure would need large amounts of gas. In addition, the safety effort is substantial and costly as well. (**Figure 7**)

Pipe-Inspector follows a different method approach, in which the recording of the sound leakage takes place directly in the interior of the pipeline. Thus also the detection of micro-leakages is possible, since the system is not depending on the specific structure-borne sound properties of the pipeline's material. (**Figure 8**)

Battery powered and cable-less, Pipe-Inspector floats freely in the media flow of the pipeline system. Therefore it necessarily passes each defect or leakage, recording discharge sounds directly on site. Because of this fact, the method is suitable especially for minor leakages in pipelines under high pressure. Thanks to the automatic operating pressure recording in the inspected pipeline section, it is possible to record real data for the first time.

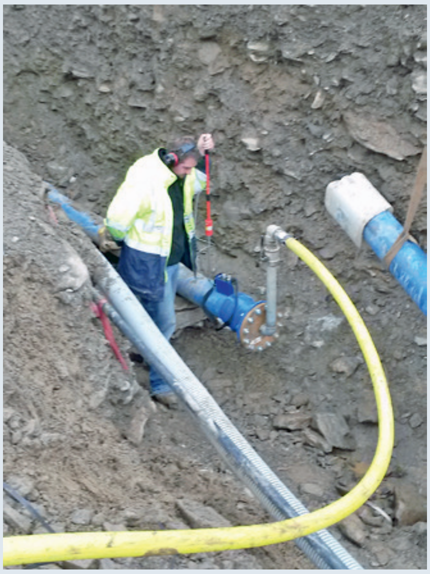

Figure 5: Inspection section end point

Figure 6: Pipe-Inspector® after retrieval

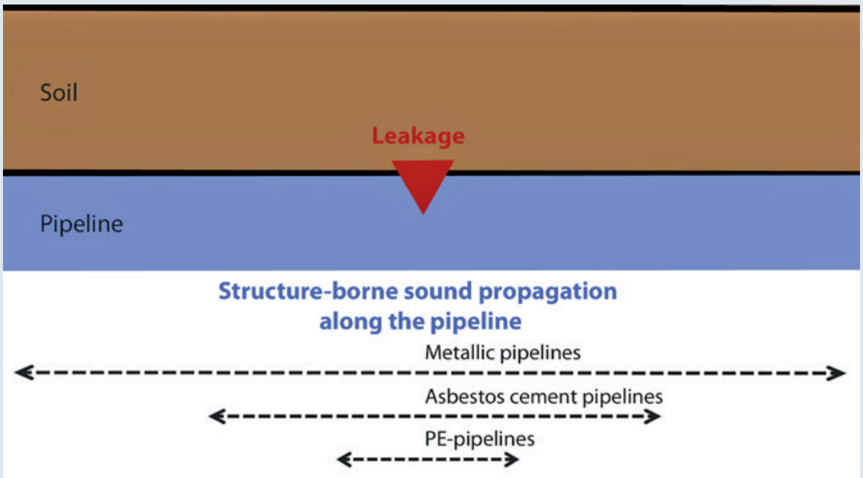

Figure 7: Structure-borne sound propagation

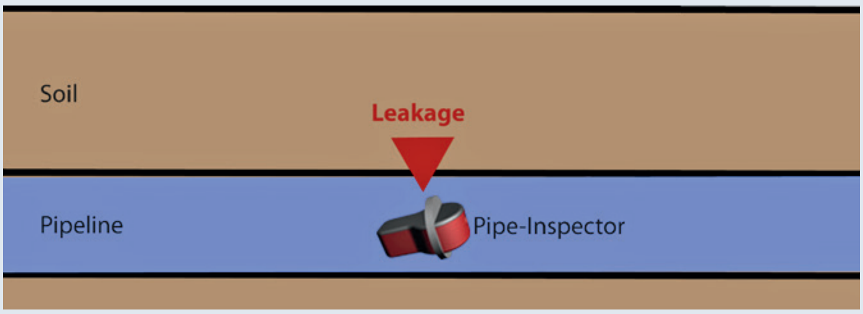

Figure 8: Leak detection by means of Pipe-Inspector®

Optical and acoustic inspection results

The measured data, taken from the pipeline interior and continuously recorded during the inspection, were made available to the customer by means of an inspection and damage protocol with exact information on the position of the detected damage.

Based on the pressure test results, a water loss of 3.9 l/h has been calculated already in the run-up. This value suggested itself, that imaging techniques wouldn't deliver significant results allowing the optical positioning at such low loss rates. The video data analysis finally confirmed this assumption. (**Figure 9**)

The acoustic analysis identified for instance a clear leak noise at position 317.7 m, although the corresponding images of the affected area yielded no visible evidence. (**Figure 9 and 10**)

A control inspection of the damaged area using geophone and correlator could not confirm the measurement results delivered by Pipe-Inspector. Once the damage protocol and video data have been sent to the customer, he arranged the excavation at the appropriate position. A subsequent visual pipeline inspection from the outside showed a 100 % hit accuracy of the acoustic Pipe-Inspector measurements. The cause of the leak noise finally was elicited as damaged gasket in a sleeve connection. Two other leaks that were identified during the evaluation of the acoustic data, also turned out to be pipe connection problems.

The time and financial cost of the excavation to expose the affected area could be kept to a minimum thanks to the exact lengths indicated by the Pipe-Inspector system. Due to the test results quality the necessary repair work could take place very quickly, which was the requirement for a repeated pressure test, necessary for the pipeline's commissioning. The total time frame from the arrival to the actual transmission of the evaluated inspection results to the customer was less than three working days.

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Figure 9: Video image pipe interior

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Datum:	Auftrag Nr.:	Operator:	Wetter:	Bericht Nr.:
2014-12-05		MTA-Messtechnik	bewölkt	201412031
Rohrleitungstyp: Kreisprofil	Pipe Inspector: Nr. 6	Gereinigt: nein	Referenzplan: Ground Plan of penstock	Seite 1/2

Ort:	Mals	Strang:	MO 18
Plz:	39024	Startschacht:	
Straße:		Endschacht:	S1
Lage:		Haltungslänge [m]:	630
		Rohrlänge [m]:	
Untersuchungsgrund:	Kleinstleckagen	Profil:	DN200
Leitungsartart:	Kraftwerksleitung	Material:	GG

Bemerkung:
Inspektion

Position [m]	Code	Beobachtung	Videoposition	Bild Nr.
0.00 m	001	Startpunkt	00:14:01	Item_1.jpg
18.60 m	037	Undichtigkeit	00:16:57	Item_2.jpg
317.70 m	037	Undichtigkeit	00:29:01	Item_3.jpg
610.30 m	037	Undichtigkeit	00:41:19	Item_4.jpg
630.00 m	002	Endpunkt	00:46:22	Item_5.jpg

Figure 10: Pipe-Inspector® Inspection protocol