

A real-time matrix based corrosion monitoring system

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ABSTRACT

A real-time and online corrosion monitoring system that provides reliable wall thickness data is presented. The system has monitored a weld for four years on a wet gas pipeline, and the operator has used this data as part of their risk-based integrity management strategy. The monitoring system is based on the well-established ultrasound pulse-echo technique. As the sensors are installed directly on the pipe outer wall, and measure wall thickness as a function of time, it provides high resolution data on material wall loss and corrosion rate. The system is modular in terms of number of sensors, and the ultrasound sensors can be installed in a ring on straight pipe, on top of the weld, or any matrix that the operator finds necessary to obtain sufficient information about the corrosion mechanisms.

We present field data and correlate with flow rates and flow temperature to demonstrate the strength of the systems performance.

INTRODUCTION

Pipeline integrity management and practices have been systemized through standards⁽¹⁾, and one important aspect in integrity management is corrosion monitoring. Corrosion monitoring by using permanently installed equipment has increased in the past years⁽²⁾. By using permanently installed ultrasound transducer (UT) sensors and automating signal processing and communication, a more cost-efficient corrosion management program can be obtained. Ultrasound techniques have been developed to complement traditional inspection with monitoring to improve cost efficiency of pipeline integrity management. Permanently installed ultrasound sensors can be retrofitted without interfering with production, which leads to a low threshold for using this type of equipment. It has low costs involved, and with an easy installation procedure the effort of installing this kind of equipment is low. In addition, retrofitted ultrasound sensors can be a substitute for corrosion monitoring by corrosion coupons and corrosion probes, as these intrusive techniques pose risk to HSE, increased work and planning. There are several publications discussing how corrosion monitoring should be performed in the most efficient way^{(3), (4)}.

Inspection programs with manual UT, together with probes and coupons, have been the choice of many corrosion monitoring programs⁽⁶⁾. Manual UT inspection is strongly influenced by human factors⁽⁷⁾, and

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therefore a permanently installed ultrasound sensor will have orders of magnitude increased repeatability. Probes and coupons are efficient and have the potential of high repeatability. The drawback with these techniques is that they need to be periodically replaced and are intrusive. In addition, newly replaced probes in an old pipeline may not have the same conditions as the old pipeline that have undergone with years of wear and tear and may have residual material on the pipe wall.

The corrosion monitoring tool used in this article is an ultrasonic erosion and corrosion monitoring tool which provides real-time and online wall thickness data for onshore and topside piping and pipelines. It is non-intrusive and is installed and operated without interfering with production. The system's ability to provide fast and accurate erosion and corrosion rates makes it an effective tool for real-time feedback of corrosion inhibitor programs. The sensor arrays are retrofittable and installed simply by strapping them on to the pipe. No gluing or welding is required as the ultrasound pulse is coupled into the pipe by using a fatty grease. Each sensor array has numerous ultrasound transducers providing reliable high precision ultrasonic wall thickness measurements at the selected locations. It is based on the well-established ultrasonic pulse-echo method. Being retrofittable, the sensor arrays can be removed or relocated.

Two systems were installed in ATEX zone 1 on a gas plant in the North Sea in 2017. Twelve (12) transducers spread around the pipe were installed on the outside of the pipe and the wall thickness was measured four (4) times a day, and data was automatically transferred via TCP/IP to a Graphical Display Software (SW). The operator can log on to this display and review the corrosion rates and status of the integrity of the pipe. In addition, data can be exported to Excel for further detailed analysis.

EXPERIMENTAL PROCEDURE

The test environment is a wet gas piping system where there has been signs of selective girth weld corrosion, and the operator is looking for a high-resolution UT monitoring system to monitor the integrity development of the piping.

Two corrosion monitoring systems are installed on girth welds, and the installation sites and conditions for the two locations are summarized in Table 1. Each station consists of twelve (12) transducers in a circumferential ring and all transducers were placed on the center of the weld. The weld cap was removed by manual grinding on each location where the transducers were located. The reason for removing the weld cap was to ensure sufficient contact between the transducer and the pipe steel wall.

Table 1. Summary of installation site and test conditions.

Instr ID	Pipe ID	Wall Thickness	Location	Pipe material	Pipe temperature
1	14"	16-17 mm	on weld	Carbon steel	~50 degC
2	7"	16-17 mm	on weld	Carbon steel	~20 degC

One system is placed before the cooler and the other system is placed after the cooler, see Figure 1 for details. The reason for the selected locations is to monitor the corrosion rates on these two spots. The system before the cooler is installed where the pipe has horizontal orientation. The client expects that bottom of line is more exposed to corrosion on this location, and more sensors are therefore installed at the bottom as can be seen from the sketch. The second system, which is located after the cooler, is installed where the pipe has a vertical direction. No specific spot on the circumference on the pipe is suspected to have more corrosion than the other, and therefore the sensors are equally distributed around the pipe, as can be seen from Figure 1.

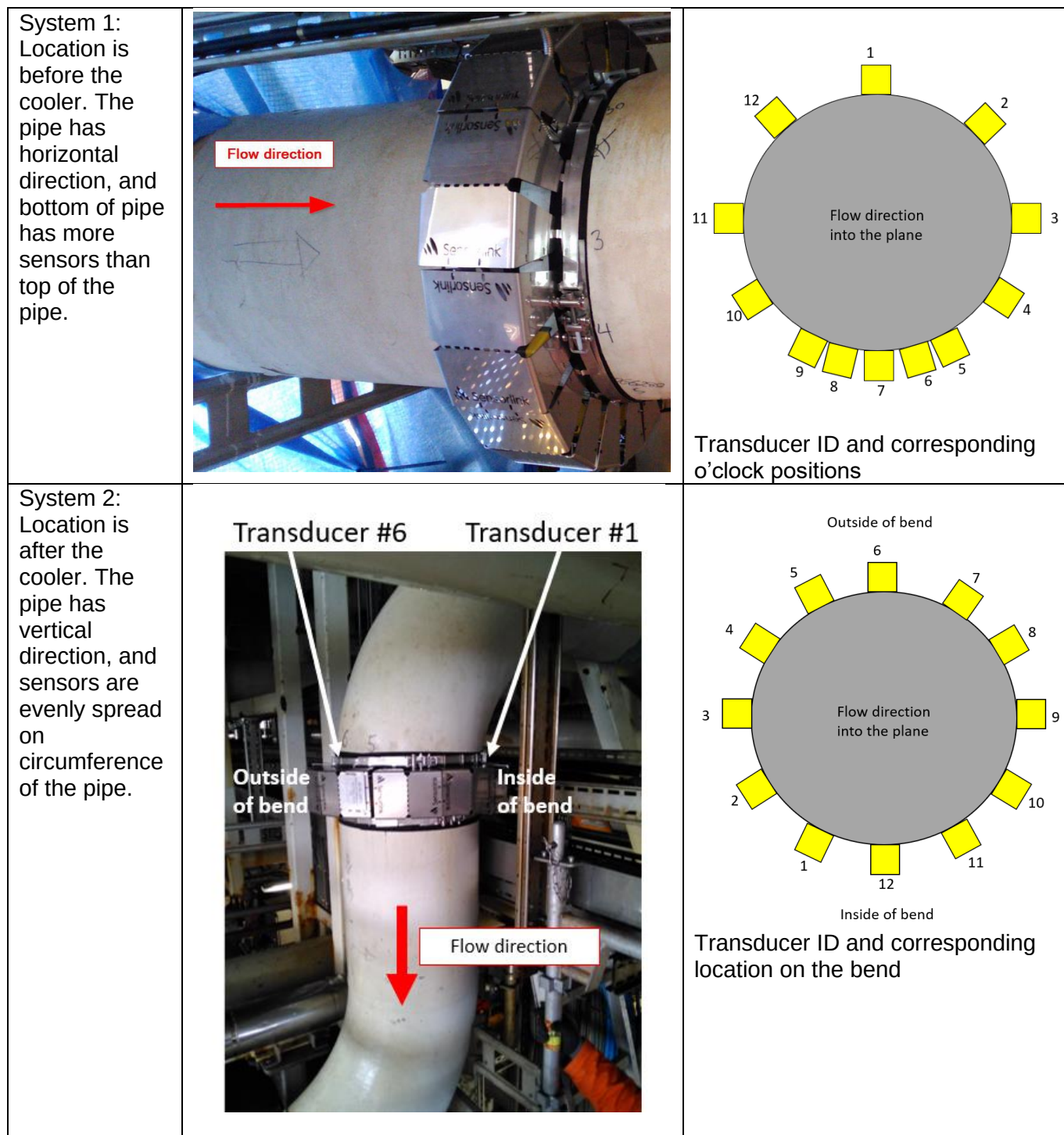


Figure 1. Installation configuration of the two systems.

The system configuration is shown in Figure 2. The system is configured to measure wall thickness four times per day and the data is automatically transferred to the Graphical Display SW for calculation to of wall thicknesses and corrosion rates. Both offshore and onshore personnel can log into the Graphical Display SW via a web service on their intranet. Data from all instruments are included in the same graphical user interface, and this graphical interface includes data from other platforms as well.

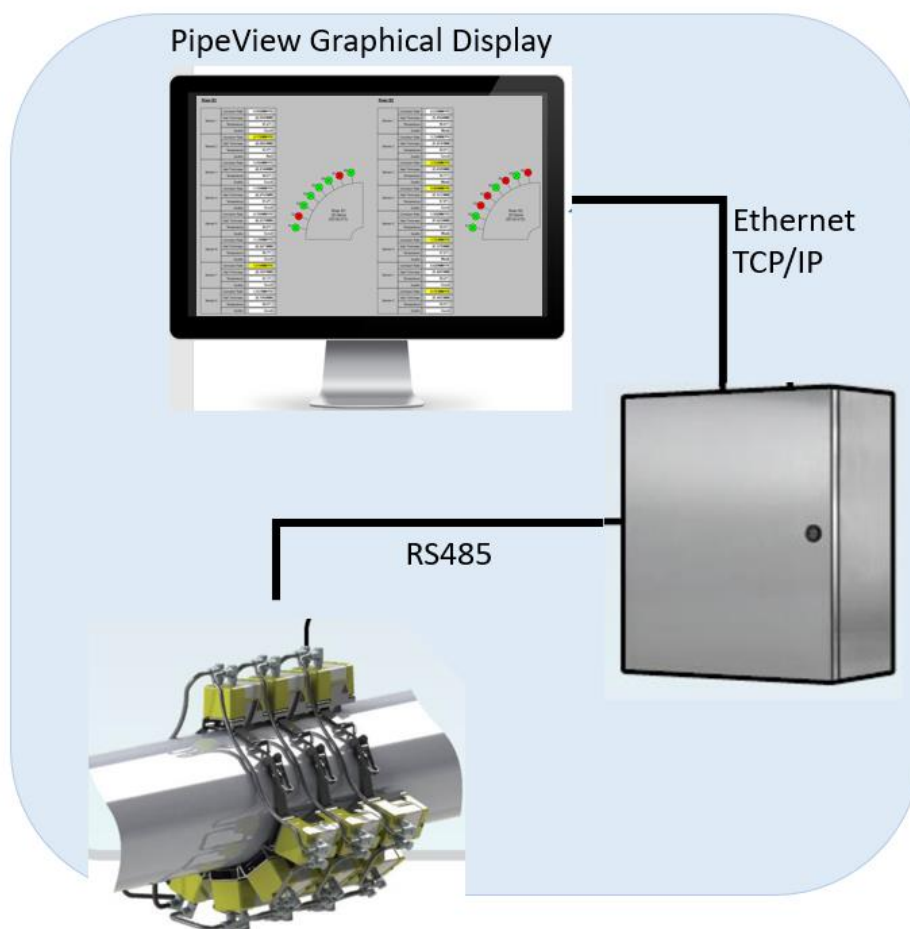


Figure 2. Configuration of sensor, datalogger and data transfer.