Pipeline integrity management programmes have long relied on inline inspection (ILI) geometry tools to locate ovalities, dents and other damage. These same tools have been used to locate obstructions that could impede pig passage, and now they are also used to identify pipe diameter expansions caused during precommissioning activities, such as hydrostatic testing. Due to potential quality issues on previously manufactured high yield strength pipe, the US Pipeline and Hazardous Materials Safety Administration (PHMSA) has mandated the use of high resolution geometry technology for operators to inspect for steel that does not have the specified yield strength. Pipe expansion could result from hydrostatic testing if the steel has lower than specified strength properties.

El Paso Corporation recently constructed the Ruby Pipeline, a 680 mile, 42 in. line using eight construction spreads spanning from Opal, Wyoming, to Malin, Oregon. Spiral weld and straight seam pipe were used, and the line was designed under the alternative maximum allowable operating pressure (MAOP) rule (80% specified minimum yield strength design). As part of the alternative MAOP rule, PHMSA instructed through the ‘Interim Guidelines for Confirming Pipe Strength in Pipe Susceptible to Low Yield Strength’ dated 10th September 2009, that operators would perform a high resolution caliper inspection to address the threat of low
yield strength pipe. Further, PHMSA called for operators to identify all expansions greater than 0.6% for 42 in. pipe, as well as identify dents greater than 2% and dents that affect a weld.

The tool specifications required multi-finger sensors that contact the pipe inside diameter (ID) and have an accuracy of ±1% or less, to identify expanded pipe and dents. Ruby Pipeline personnel approached T.D. Williamson, Inc. (TDW) to discuss possible solutions to meet the PHMSA inspection and verification requirements. This necessitated running a high resolution caliper tool on the pipeline, post-hydrotest but pre-gas. The tool would have to be run with air, and Ruby Pipeline was required to report all findings to PHMSA. A minimum of two calibration digs was required per inspected segment. Any expansion identified as greater than 1% would be considered as a location for the calibration digs. In the event no expansion was identified above 1%, a minimum of two locations within the inspected segment would be selected for field verification inspections. Any expansion identified and confirmed to be greater than 1.5% would require pipe replacement. TDW was required to provide tool results and graphs of all expanded joints, as well as upstream and downstream joints for each identified expansion.

The inspection process
As shown in Figure 1, TDW developed a new tool to meet the customer requirements. A standard two-body deformation (DEF) tool was converted into a single body tool without sacrificing the high resolution capabilities for locating and characterising dents, ovalities and expansions. As a result of one of the early inspections, it was determined that the distance between cups needed to be greater than one pipe diameter to facilitate tool movement through valves and tee passages. Additional modifications were made, including the addition of a caliper cup on the front of the tool and the repackaging of all batteries and electronics into a single body canister.

DEF tools feature three primary characteristics that enable their use for accurate characterisation of dents, wrinkles, buckles and ovalities. Firstly, they feature mechanical measurement arms in direct contact with the pipe wall. Secondly, they feature a high circumferential channel count. Lastly, they feature high resolution sensors capable of detecting minute changes in pipe geometry. DEF tools are specifically designed to gauge pipe ID expansions as small as 0.25% of the nominal diameter, so they are well suited to locate expansions. Characterisation of expansions is further enhanced through use of sophisticated software tools developed for this purpose.

Ruby Pipeline contracted TDW to conduct inspections on 15 of the pipeline’s 30 total segments, for a total of 341 miles (50% of the Ruby Pipeline). The average inspection length was just a little less than 23 miles. The segments were broken at the test headers, with some permanent launchers and receivers used when applicable. The company dedicated two tools to this project.

TDW provided project management services throughout the inspection process. The project manager was onsite for all of the inspections and for the majority of the calibration digs. This project management service included co-ordination
with multiple contractors as well as Ruby Pipeline personnel. The company co-ordinated with the contractor to achieve appropriate air compression to run the multi-channel tool at a constant speed (avoiding starts and stops) (Figure 2). It was determined that running the tool with approximately 65 psig of air pressure worked well. Prepacking the line with pressure was a critical success factor. Through trial and error, it was determined that ten 1600 ft³/min. air compressors were sufficient to provide an average tool speed of about 2.5 mph. Once in use, tracking of the tool proved difficult due to weather conditions and terrain. Tool speed was monitored on the first few runs via tracking, but ultimately it was determined that tracking was not necessary to monitor tool speed, which was within specified limits given the limited air supply in use.

Data analysis and validation
With inspection data in hand, expansion graphs such as the one shown in Figure 3 were created. TDW analysts identified all locations with a calculated value greater than the specified threshold (in this case, expansions greater than 0.6%). All flagged locations were input into analysis software. Pipeline features such as tees, valves and manufactured bends impact ID measurements, but these were eliminated as potential expansions. The results of this analysis were reported as a differential value for each affected joint in inches and as a percent of nominal pipe size. A final list of joints with possible expansions was combined into a standard DEF inspection report.

Once this data analysis was complete, non-destructive evaluation (NDE) services were used to validate the inspection data. TDW provided Level II American Society for Nondestructive Testing (ASNT) technicians for the required expansion validation digs (two per tool run as required by PHMSA). This service was performed on the entire pipeline for all deformation tool runs, not just those miles inspected by the company. NDE work included measurement of the pipe outside diameter (OD) with Pi tape every foot; measurement of coating thickness at the 1:30, 4:30, 7:30 and 10:30 o’clock positions every foot; and measurement of wall thickness at the 1:30, 4:30, 7:30 and 10:30 o’clock positions every foot (or 12 wall thickness measurements, one at each o’clock position, if expansion was greater than 1%). Onsite, one to two digs were performed per day, with 55 digs performed in total.

Measurements were taken for the entire expanded joint and for 10 ft on either side of the adjacent joints. For example, on a 40 ft joint, 60 OD measurements were taken, 240 coating thickness measurements, and at least 240 wall thickness measurements. At least 540 measurements were taken per dig. Some digs were located at factory double length joints, which averaged 72 ft, resulting in a minimum of 828 measurements. These field measurements were then used to calculate an inner diameter of the pipe, which was then compared to the ID reported by the inspection tool to validate tool accuracy. Validation dig graphs such as the one shown in Figure 4 were created.

Prompt reporting of findings was critical to the customer due to a tight construction schedule. A preliminary report on dents and expansions was delivered within 48 hrs of completion of inspection, with a final report delivered in 15 days. The customer provided survey data of welds, with TDW matching this survey data to tool data in the final report. The survey data was tied to joint number, i.e., mill test data for each joint. The TDW data analyst worked closely with the customer to provide technical support in a timely manner. The customer reported that upon completion of the caliper inspections, there were no indications of low yield steel identified within the pipeline.

The inspection work carried out by TDW on the Ruby Pipeline is a good example of how inline inspection technologies (such as deformation) that have traditionally been used to identify restrictions or damage from external forces, can also be used to locate and size expansions from internal forces (such as hydrotesting). If pipe material concerns exist, even in newly constructed lines, use of an inspection tool and subsequent data analysis can be instrumental in identifying potential trouble spots before they become problematic.
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