

Determining material properties through in-line inspection

ROSEN's RoMat PGS (pipe grade sensor) in-line inspection service is able to non-destructively determine the yield strength and ultimate tensile strength of each pipe joint along a pipeline. This offers a step change in the accessibility and granularity in the measurement of actual pipe properties, providing operators with a comprehensive and detailed picture of their pipeline.

Knowledge of the true material properties along a pipeline is essential for safe management of pipeline systems. Despite the criticality of this information, the complexity, diversity and variation in properties within a pipeline are often underestimated.

Operators may be forced to rely on records with varying levels of confidence and traceability, while records of post-construction diversions, replacements and repairs can be lost over time, or following transfers of ownership and staff changes (Fig. 1).

The extent to which this uncertainty is a problem depends partly on an operator's tolerance to risk for a given pipeline section, but also on the financial and practical barriers to mitigating these risks.

Previously, the barriers to assessing material properties were an order of magnitude higher than, for example, condition assessment, due to the requirement for digs to conduct mechanical testing. The RoMat PGS service lowers this barrier.

The technology

The RoMat PGS tool is based on eddy current technology coupled with pre-magnetisation of the pipe. This pre-magnetisation acts to increase the penetration depth and remove fluctuations in the eddy current response arising from remnant pipe magnetisation (from manufacture and/or previous ILI runs). The eddy current penetration depth is such that the effect of wall thickness on the tool measurement is negligible for wall thicknesses greater than 3–4 mm.

The tool response is a function of various components of pipe metallurgy, including chemical composition, grain size and proportions of different microstructural phases.

As these aspects are also key parameters that directly determine the material strength, algorithms can be applied to relate the tool

response to pipe strength. The overall accuracy is therefore defined both by sensor accuracy and the accuracy in relating eddy current response to pipe strength.

RoMat PGS achieves an accuracy of ± 6 ksi (41.4 MPa) at 80 per cent confidence, which has been demonstrated through in-ditch validation of RoMat PGS inspections on operational pipelines, as well as extensive off-line benchmarking.

While this accuracy is comparable to other in-ditch non-destructive strength measurements (such as instrumented indentation testing (IIT) or conversions from hardness values), the key advantages arise in establishing property values for each pipe joint as opposed to a smaller number of digs.

Applications

The RoMat PGS service can provide:

- grouping of pipes into populations with shared characteristics and grades
- discrepancy analysis, including under-strength or unexpected pipe joints and sections



Fig. 1: Factors increasing asset integrity risk over time.

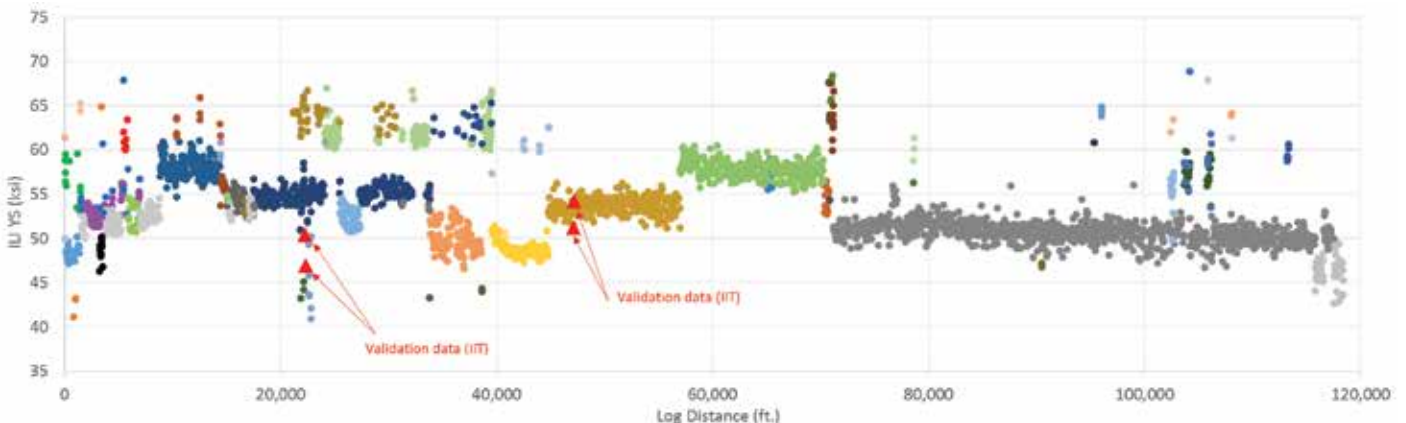


Fig. 2: Population analysis for a recent inspection.

INTEGRITY AND MAINTENANCE

- strength and grade determination in areas with no records
- verification of partially complete records
- inspection of areas that are inaccessible by excavation
- a further level of detail for fitness for purpose (FFP) assessments and maximum allowable operating pressure (MAOP) validation.

The tool is combined with RoCorr MFL-A and RoGeo XT to determine pipe strength in conjunction with multiple other data sets. Further value is extracted from the data by analysing these data sets in combination using a data integration process. This also allows pipes to be grouped into distinct ‘populations’, defined by a set of pipes with a single strength range and shared characteristics. This approach both reduces uncertainty compared with individually reported measurements, and allows statistical treatment in assigning grades and identifying outliers.

Case study – pipeline with partial records

For areas with missing or partial records, measuring the strength of each pipe provides an additional level of confidence compared with approaches that may fail to identify short sections or individual pipes with differences in properties, such as opportunistic or periodically spaced excavations.

An example of a recent RoMat PGS inspection for a pipeline with partial records is shown in Fig. 3, with identified pipe populations colour-coded, demonstrating the significant complexity that has arisen over time through a combination of post-construction diversions and replaced sections. Capturing the level of complexity in this line without an ILI solution would not realistically be possible.

Case study – FFP assessment

For integrity assessments such as FFP or MAOP validation, significant focus and resources are directed towards accurately defining the required inputs for these processes (see Fig. 2). Inspections can already determine wall thickness, diameter, pipe type, pipeline route and presence of defects for each joint along a pipeline, yet a single strength value is typically assumed across a large number of pipes based on a known or assumed SMYS. Determining strength for each pipe joint provides an extra level

of detail and confidence in these assessments.

An example of the value of RoMat PGS data in FFP assessments is illustrated in Fig. 4, and was presented at PPIM 2018¹. The inspected pipeline had recently experienced a failure at the indicated location. The RoMat PGS service reported yield strength values below the ‘known’ SMYS and these were subsequently verified by targeted excavations.

The FFP assessment identified a number of required immediate repairs, but the number differed significantly depending on the strength values considered. By applying statistically conservative inputs based on the RoMat PGS data for each pipe joint, instead of a single SMYS value across all pipes, the accuracy of the assessment was improved while removing unnecessary conservatism. **P**

1. S.Slater; O.Martinez, J.Cervantes Aguilar - State-of-the-Art ILI Services to Support Fitness-For-Service Assessments - PPIM 2018, Houston.

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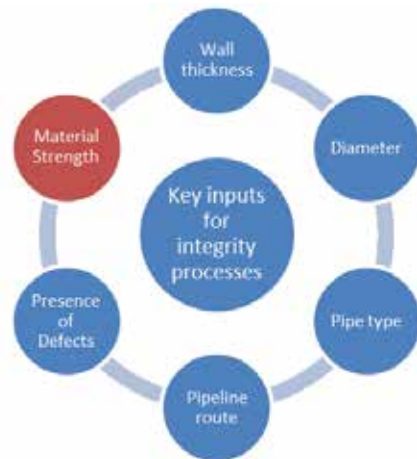


Fig. 3: Key inputs for integrity processes.

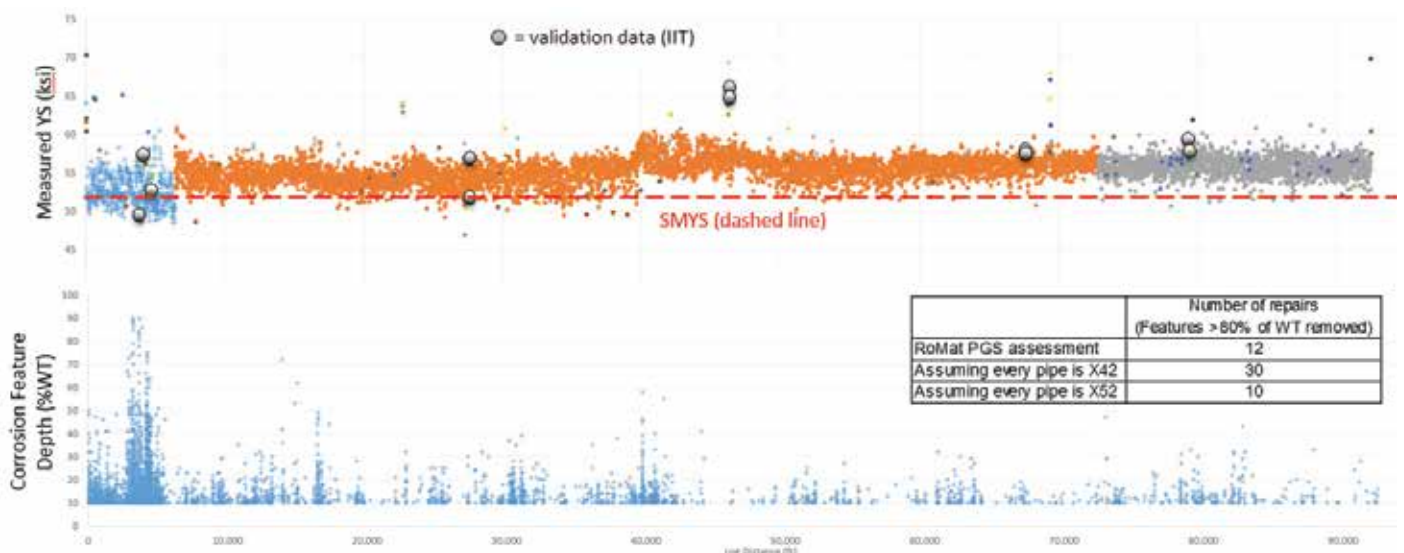


Fig. 4: The significance of pipe strength as an input to FFP assessments.