3° Congreso de Integridad en Instalaciones en el Upstream y Downstream de Petróleo y Gas

The use of RoMat PGS ILI technology and Pipeline DNA process to determine the populations of undocumented pipeline sections

Abstract

PHMSA advisory bulletins and proposed rule-making has focused on producing and establishing appropriate documentation on pipeline materials to justify maximum allowable operating pressure (MAOP). In-line inspection (ILI) can support the documentation and data integration process and therefore meet multiple integrity and regulatory requirements. This can be achieved by extracting additional value from existing data and utilizing new technologies. ILI is traditionally used to detect, identify, and size pipeline anomalies. However, ILI technologies can also be used to satisfy the industry's need to verify and complete pipeline-property documentation as well as the "data gathering and integration" requirements specified in CFR §192.917 (d). Inappropriate pipeline-property and material documentation may be considered a derivative of the construction and manufacturing threat, and - as in the case of external corrosion - ILI can be used for integrity assessment. This paper describes how recent developments in ILI technology provide state-of-the-art sensor technology and data analytics to establish an as-built pipeline record that is reliable, verifiable, traceable, and complete.

ROSEN has developed a solution to define pipe properties based on data from the RoMat PGS ILI service in combination with existing documentation and historical pipe manufacturing data, to characterize the pipe properties. The RoMat PGS service can be deployed in combination with other ILI services. This solution provides the Operator with a characteristic 'DNA' that is used to describe the types of pipe within any given pipeline. This solution has two key benefits; the first and most transparent benefit is the non-destructive determination of essential pipe properties: wall thickness, outer diameter, and now the yield strength and ultimate tensile strength for each joint. This in itself addresses a significant part of ongoing PHMSA initiatives and can be used to identify potential integrity concerns such as pipe with strength values below that expected and other outliers. The second benefit is the ability to accurately identify the pipe populations based on a wide range of attributes, including length, wall thickness, etc. This allows the operator to target specific excavation locations in order to ensure that a) the pipeline is robustly characterized and b) the number of excavations required may be reduced by using a smart approach to determining excavation locations. This analytical approach by ROSEN is called Pipeline DNA.

The aim of this paper is to present the ROSEN RoMat PGS ILI service and Pipeline DNA assessment process. It will also discuss how the process is applied in ongoing integrity assessment plans in response to the recently published DOT NPRM publication. The Pipeline DNA process will be illustrated using a collection of the ILI data and a presentation of the data on the basis of a worked-example demonstration.

Introduction

Although many operators have records of the original pipeline material, a full understanding of the pipeline history in terms of modifications, repairs, diversions or replacements might not be available. Often there is poor traceability and it is possible that pipes, pups or components were installed without the necessary degree of traceability. Confidence in historical records can easily reduce over time as operating companies get bought and sold, move offices, loose key staff, convert from paper records to digital records and from changes to the assets. This is illustrated in Figure 1 and highlights that aging assets are likely to pose the greatest risk to integrity with regards to undocumented materials.

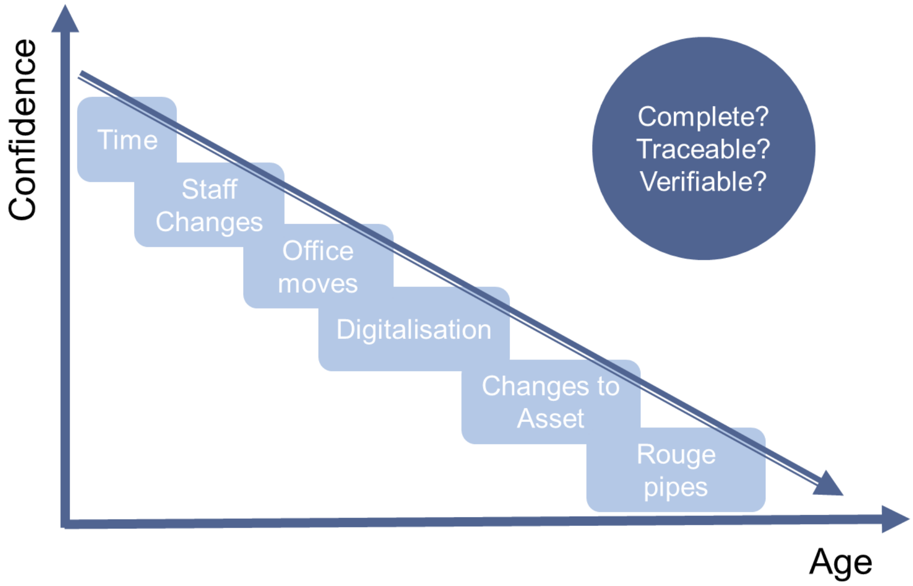

Figure 1 A reduction in confidence as a function in pipeline age

The regulatory requirements imposed on pipeline operators vary Worldwide and within Europe, but there is a clear common requirement that, as far as reasonably practicable, pipelines shall not operate beyond safe operating limits, be designed correctly, be constructed using suitable materials and be proven to be fit for purpose.

Compliance with this requirement cannot be demonstrated without verifiable, traceable and complete records (VTC). This language is currently being referenced in the US following the issue of the notice of proposed rulemaking by PHMSA [1]. Defining what constitutes VTC requires interpretation. In reality, most records of pipeline materials are likely to be somewhere between completely unknown or completely known, as shown in Figure 2. In between these two extremes various levels of material verification activities may be required to address underlying risks.

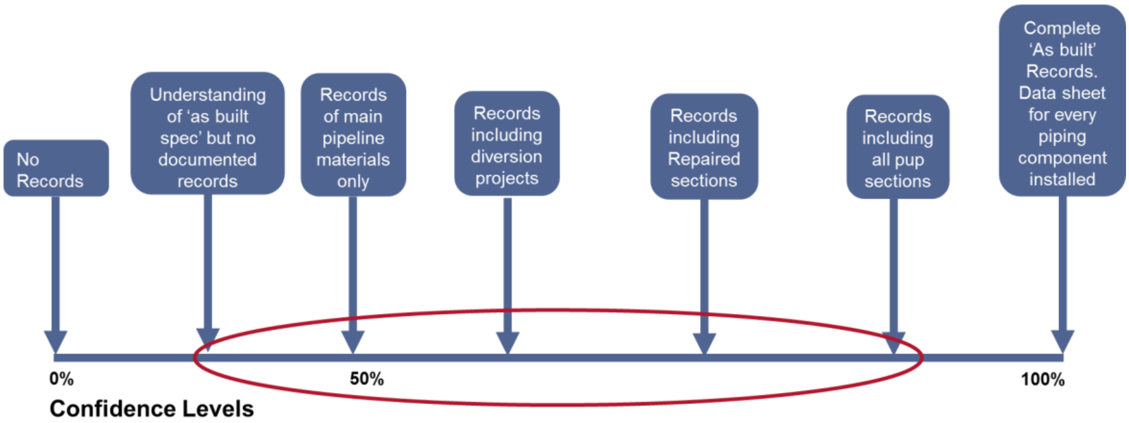

Figure 2 – Illustration of confidence levels in pipeline material documentation

A proven track record of safe operation can result in operators implementing a 'grandfather' assumption that the asset was designed and constructed using appropriate materials. Where the grandfather assumption has been made compliance can often not be clearly demonstrated, posing the question ‘what else could be done which is reasonably practicable?’. Currently, if material records are uncertain, yet 50 years of safe operating data indicates that there are no significant issues, the high costs to thoroughly verify and document material records may not be considered reasonable for an operator with a robust track record of safe operation.

The role of ILI

A traditional approach to verification may involve opportunistic excavations or excavations in random locations, both of which are inadequate in terms of developing a robust approach that covers high risk locations or statistically relevant data.

In-line inspection (ILI) can provide a practical approach for verification of properties however. Operators can already verify wall thickness, diameter, seam type, location, and joint lengths using ILI. These inspections commonly find discrepancies, confirming that pipeline records are not always completely accurate and that previous assumptions may be incorrect.

Yet currently pipe strength and grade data is taken from existing documentation or assumptions and used in engineering integrity management processes. Strength data can be verified through non-destructive testing or destructive testing of sections removed from service testing, both of which require the expense of performing excavations, which naturally limits the degree of verification that can be performed.

ROSEN’s new RoMat Pipe Grade Sensor (PGS) inspection service provides operators with a practical way of verifying the strength of every pipe spool along a pipeline (Figure 3). It can be implemented to support operators with the verification of existing documentation and confirmation of assumptions used in the integrity management system. Furthermore, the data can be used in the risk management process to identify outliers or threats and could be used to support modern approaches for the validation of Maximum Allowable Operating Pressure (MAOP).

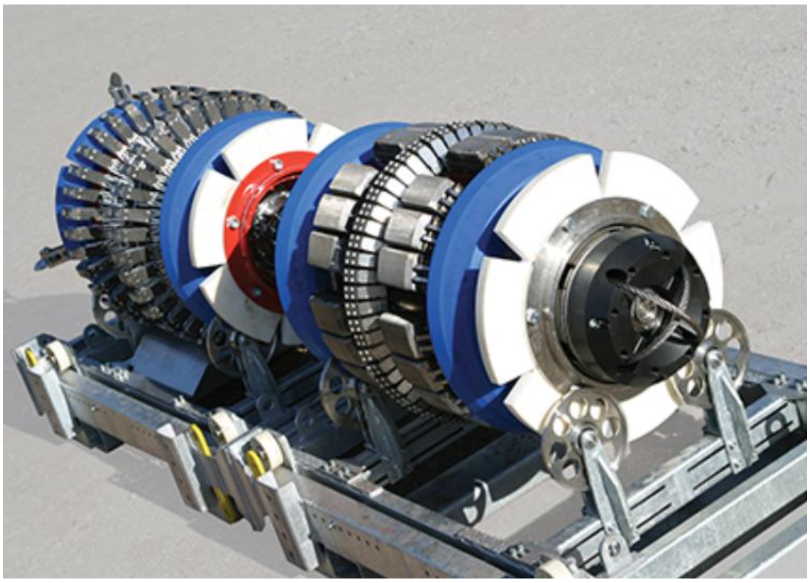

Figure 3 ROSEN RoMat Pipe Grade Sensor Inspection Tool

A holistic Approach to Material Verification

The material verification approach developed within ROSEN combines multiple In-Line Inspection (ILI) services, engineering assessment of multiple data sets and in-situ verification activities to assist operators along the path of material property verification.

ILI Technology

ILI is traditionally used to detect, identify and size pipeline anomalies, however ROSEN has now developed a technology that provides an estimation of Yield Strength (YS) and Ultimate Tensile Strength (UTS) for each pipe joint along a pipeline. An example showing the YS as a function of log distance is presented in Figure 4. The RoMat PGS tool can be combined with other ILI services, meaning multiple data sets can be collected in one ILI run. For example the RoMat PGS tool can be combined with RoCorr MFL-A, RoGeo XT and RoGeo XYZ.

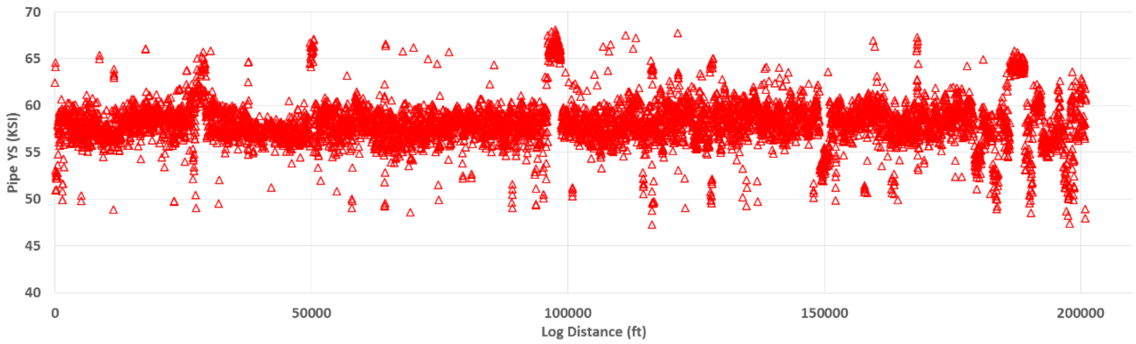

Figure 4 YS along the pipeline

The RoMat PGS output of YS and UTS data can be used as stand-alone values to update material records or as an input to the integrity management system, however the true power of the data is realised when the RoMat PGS output is used in combination with other ILI data as discussed below.

The DNA Approach for Data Analysis

The DNA assessment is the process in which all measurable and available pipe parameters are used to create groups and populations of the different types of pipes within a pipeline system.

The ILI data, namely wall thickness, individual pipe length, YS and UTS, pipe location and pipe type in terms of whether it is welded or seamless pipe is analysed in tandem to establish trends in the data and determine the groups of pipes that share common properties. The different variables are analysed in significant detail and an iterative approach is taken to drill down into the data, using the results from each iteration to refine the assessment and identify unique populations with a high level of confidence. An example of how the populations are defined is presented as a function of YS and log distance in Figure 5. This example illustrates how each population described by a unique set of variables. Using the data presented as a function of log distance means that areas such as replacement sections or diversions can easily be identified.

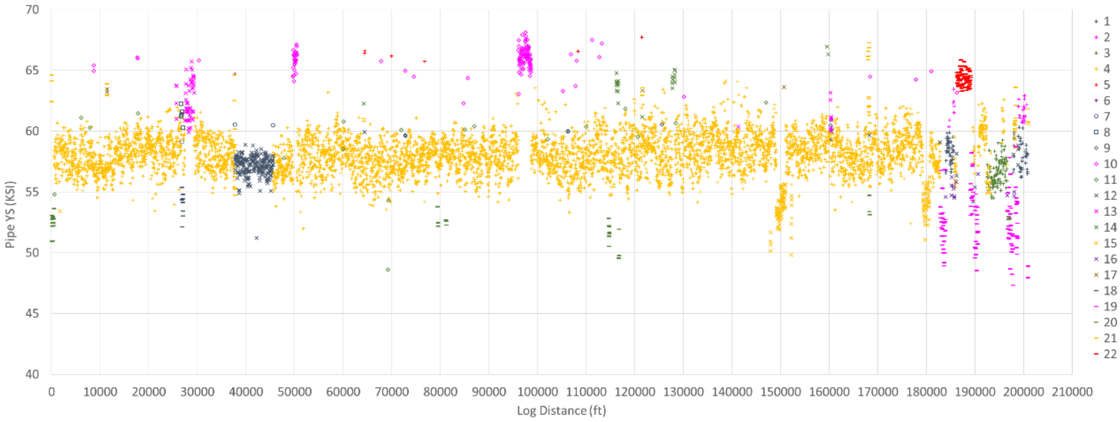

Figure 5 First iteration of the DNA process identifying the different groups of pipes

This population based approach is teaching us that pipelines are often more complicated than initially realized or expected. Particularly where pipelines have been operated for a number of decades though developing urban environments, the history of pipe modifications, repairs, diversions etc. leads to large numbers of different pipe types being used on a single pipeline.

Each pipe has a reported strength, but once the initial populations have been identified, it is possible to assign each population with an assigned grade related to the strength range reported by RoMat PGS. This allows the populations to be considered as distinct parts in integrity management. A schematic of this approach is shown for one population (with data from RoMat PGS) in Figure 6. In this example the data points highlighted in red all have YS values above the SMYS for API 5L grade X52 but a number of the pipes only meet the requirements of X46 [2]. Therefore all the pipes in the population are assigned as X46. This is consistent with what you would expect purchasing pipe today, where the pipes would all meet the SMYS of the grade ordered but a significant amount of the pipes will have YS values above the SMYS of higher grades. This example provides a demonstration of the repeatability of the RoMat PGS service, which is critical to help define accurate populations.

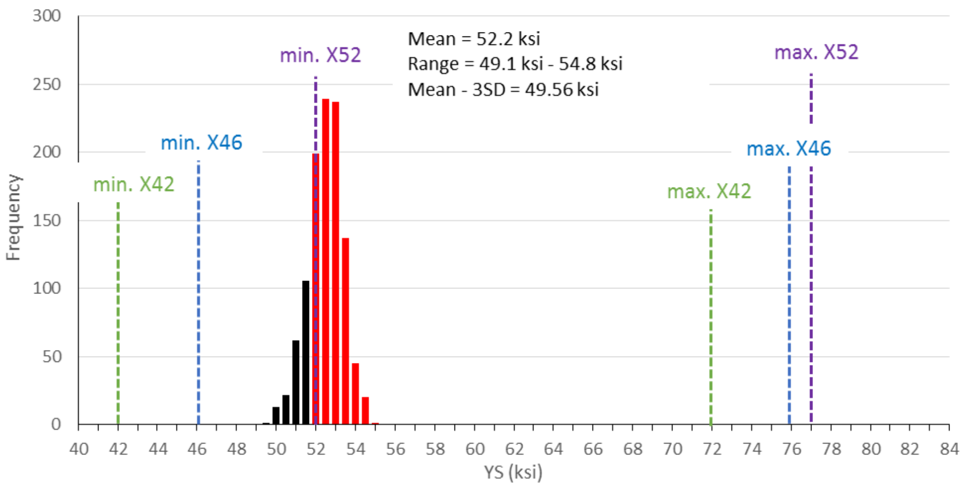

Figure 6 Schematic showing the allocation of grade for a given normal distribution

Identification of areas of High Risk

The RoMat PGS inspection data and subsequent DNA analysis provides an opportunity to qualitatively appraise the risk presented to pipeline operation from pipeline materials.

Using the collected data, areas of high risk can be identified, for example:

Gaps in data
Discrepancies with the original pipeline design
Discrepancies with operator records and material records
Lower bound values and outliers such as pipes with much higher strength than expected
Secondary factors such as **neighboring** buildings, road crossings etc.
Correlation with other ILI data such as corrosion, cracking etc.

Using this risk profile, a strategy for completing verification of material data can be progressed. This can include in-situ testing focused in areas with elevated risks are present and additional confidence is required.

An example of high risk areas would be where strength values or wall thickness are found to be below those documented in operator records. Examples of a discrepancy analysis in the material verification process for wall thickness and yield strength are shown in Figure 7 and Figure 8.

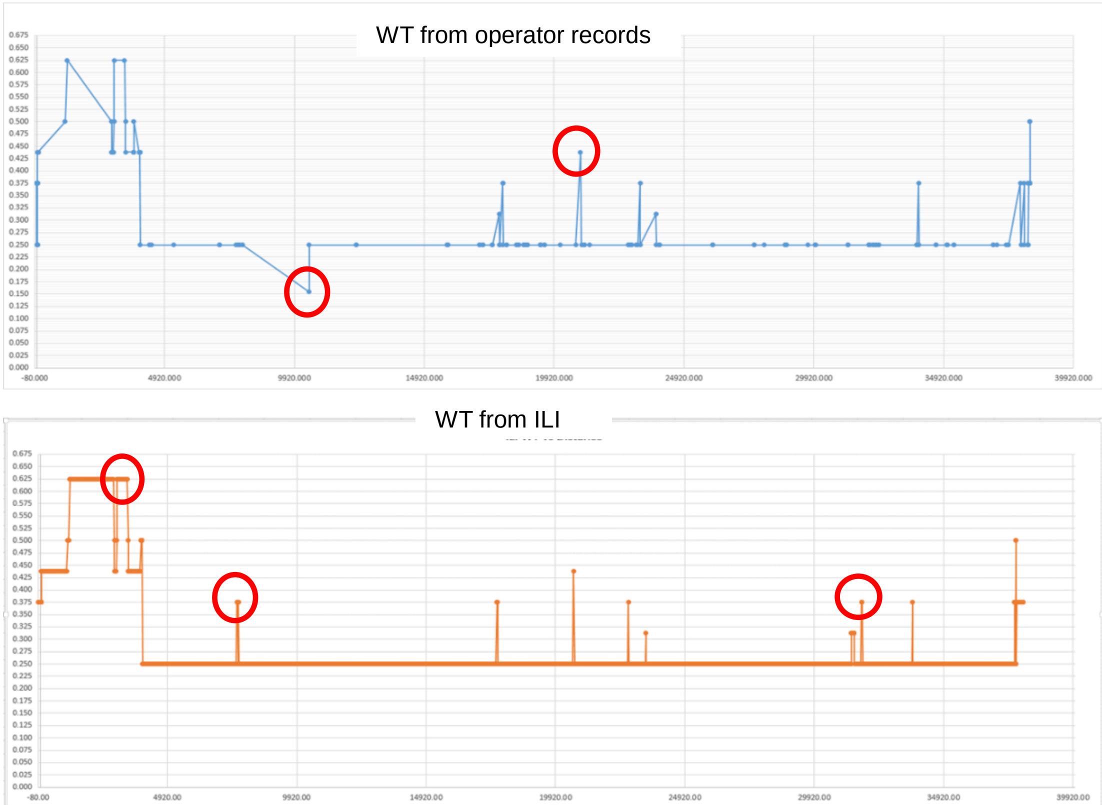

Figure 7 Wall Thickness Discrepancy Analysis

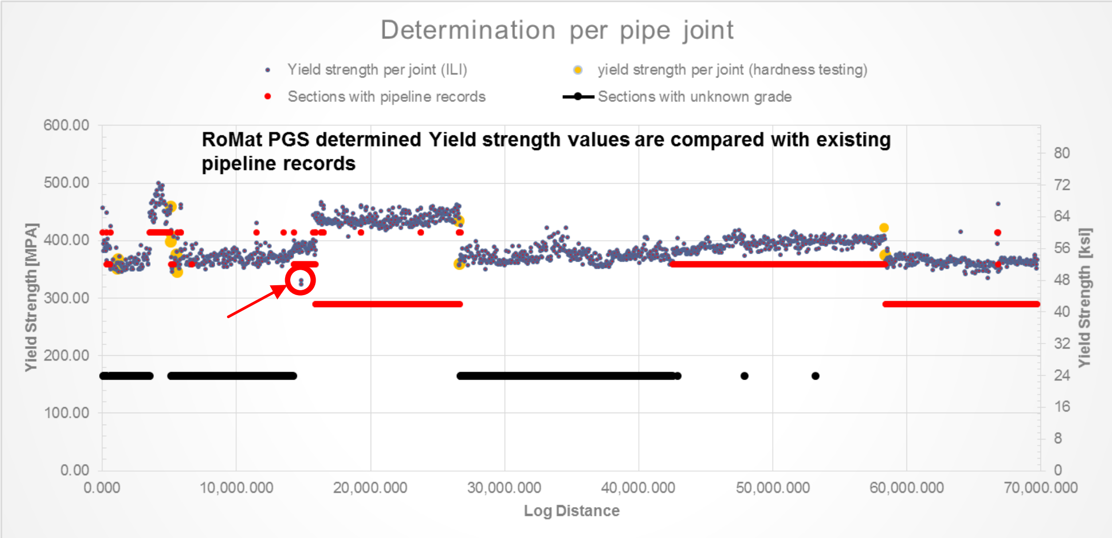

Figure 8 Yield Strength Discrepancy Analysis

In-situ Material Verification

The in-situ material verification process incorporates visual inspection to determine such things as weld type, presence of cracking, coating type and general condition of the pipe. Non-destructive testing of the pipe wall thickness is performed along with chemical analysis. To provide verification data, industry accepted techniques such as Instrumented Indentation Testing (IIT) and hardness testing can be used to identify the strength of pipes. The activities for in-situ verification (Figure 9) are covered in a bespoke procedure that has been developed by ROSEN. This is a prescriptive procedure that has been introduced to ensure consistent and robust data is collected from all excavations using industry standards and best practice, and is aligned with the standard verification approach defined in API 1163 [3].

Figure 9 In-situ testing

The material verification process is a long term activity. By continually reviewing the data collected at each verification, the process can be optimized iteratively with the data related back to existing documentation to provide more confidence to the verification process. Furthermore, long term activities should include destructive testing to compliment the non-destructive techniques discussed throughout this paper.

Engineering Integrity - MAOP Validation

Following completion of material verification, the potential exists to use this newly recorded comprehensive data set in new ways. Many assessments use material strength data and currently use assumed values and large safety factors, ultimately leading to defining a MAOP. Defining or validating the MAOP of a pipeline is a very complex process which needs to consider a wide range of technical risks and potential consequences. This process, although varies dependent on the local regulatory framework, is well established and will follow the general framework provided in Figure 10.

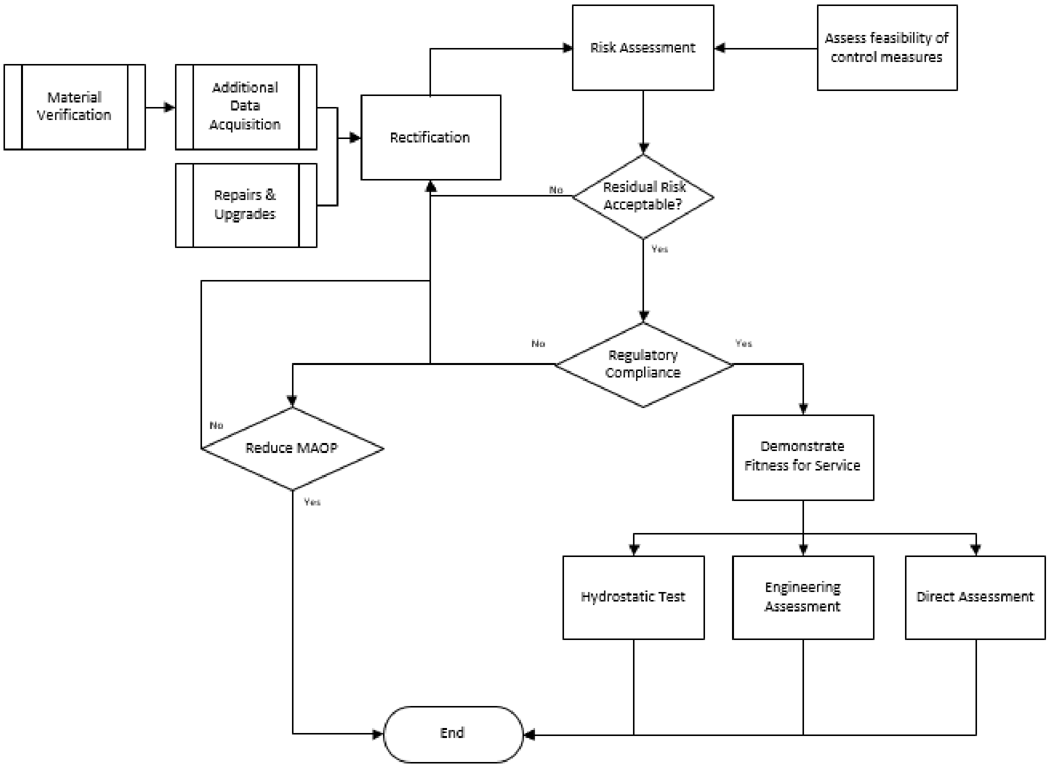

Figure 10 General Approach to MAOP Validation

By capturing material information on every single piping component along the pipeline, this does however raise the potential to challenge this approach. A complete and verified data set will allow the risk assessment process to be redefined, potentially demonstrating lower risk levels, or highlighting new risks not previously considered. Many parameters are considered as part of the risk assessment process but material strength is a common parameter in assessing the extent of risk for most threats considered during a MAOP risk assessment.

The goal of any change to the MAOP process would be to reduce the need to perform hydro testing. Mandatory regulatory requirements and specific technical risks will mean that MAOP validation will often still require hydro-testing, however in some circumstances the need for hydro-testing could be challenged.

The primary purpose of a hydro test is to verify a pipe is fit for service at a given pressure. ROSEN's approach would be to collect material information for every pipeline component to a known calibrated accuracy, verified with field and destructive test data and therefore demonstrate that further hydro testing may not provide any additional benefit.

Summary

ROSEN believes that operators now have technologies available to them to allow them to proactively investigate and understand their own pipeline assets in far more detail. This information has the potential to support operators to better demonstrate regulatory compliance, reduce operating risk, optimize asset performance and extend asset life.

ROSEN has developed a holistic approach to the material verification process that includes the following key activities:
Using combined ILI services including the RoMat PGS service to measure YS and UTS.
Advanced data analysis (pipeline DNA assessment) of the ILI information to accurately determine the populations of different pipes within the full pipeline length.
Prioritization of the excavation locations for subsequent verification activities.
In-situ testing procedures to characterize the pipe properties and verify the RoMat PGS technology.
An iterative approach to material verification, using the information from successive excavations to optimize the verification process.

The above combination of ILI, DNA assessment and a robust in-situ verification provides the industry solution for material verification.

References

[1] PHMSA 49 CFR Parts 191 and 192 RIN 2137-AE72 Notice of proposed rulemaking.
[2] API 5L Specification for Line Pipe.
[3] API 1163 In-line Inspection Systems Qualification.

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Cargo actual en la empresa:
Intl. Operations Manager being responsible for the implementation of new services in the ROSEN Group inline inspection (ILI) business in the following areas: Geometry & Mapping, Metal Loss, Leak Detection, Visual Inspection and Material Properties Determination.