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TECHNICAL ASSOCIATION
OF THE EUROPEAN NATURAL GAS INDUSTRY

Evaluation strategies for managing external corrosion on hard-to-pig pipelines

1. Introduction

The goal of this document is to provide a high-level overview of how external corrosion can be managed on underground pipelines that are hard to pig. This document is an extension of document of Marcogaz document WG_TP-72. In addition to WG_TP-72 "General practices for managing external corrosion on underground pipelines", this document provides a strategy for maintaining external corrosion on pipelines that are hard to pig.

In-line inspection (ILI) is an important tool for managing the impact of external corrosion when it can be used. However, many gas transmission system operator (TSO) has "hard to pig" pipelines, i.e. pipelines where the use of ILI tools is hard because of technical, operational and/or financial reasons. If so, another evaluation method can be used to conclude that the pipeline (system) is still fit to fulfil its duty.

2. High-level overview of general practices for managing external corrosion on underground pipelines

The Marcogaz document WG-TP-72 provides an overview of general practices for managing external corrosion on underground pipelines [1]. External corrosion is one of the threats to the integrity of pipeline infrastructure and the second most important initial cause of incidents, after external interference [10th EGIG report].

The three main barriers for preventing loss of containment due to external corrosion are: wall thickness, coating and cathodic protection (CP), of which only coating and CP are preventing external corrosion as such. There is a tendency among gas TSO's towards increasing the use of direct inspection techniques to verify the effectiveness of these barriers. ILI is an important and well-known direct inspection technique to determine the metal loss in the pipe wall (as % of the wall thickness or absolute) of a pipeline and thereby is an indicator of the performance of the barriers mentioned before. It should be noted that ILI results are not restricted to external metal loss due to external corrosion effects only. For example, internal metal loss anomalies and geometrical features usually can also be detected.

To a large extent, the effectiveness of the barriers to manage external corrosion is already determined during design and construction. During the design phase, the wall thickness is determined, the line pipe and field coating are specified and the CP system is designed. During fabrication, the line pipe coating is applied. During construction, the field coating is applied and the CP system is installed. Pipelines are designed according to relevant standards and TSO's audit engineering, procurement and construction (EPC) firms and material suppliers. This process ensures that the barrier effectiveness is according to relevant standards. In addition to what is achieved by design and construction, the effectiveness of these barriers shall be maintained and monitored when operating the pipeline.

3. Hard to pig pipelines

Each TSO has pipelines that cannot be or are not inspected with ILI, i.e. are not piggable. In general, all (relatively) new pipelines are designed and constructed to enable ILI. Older pipelines are not necessarily piggable. Each TSO has its own specific reasons for not pigging certain pipelines. These reasons include:

- Technical reasons, for example lacking launching and/or receiving facilities, obstructing parts, too small pipeline diameter, multiple pipe diameters or too sharp bends;

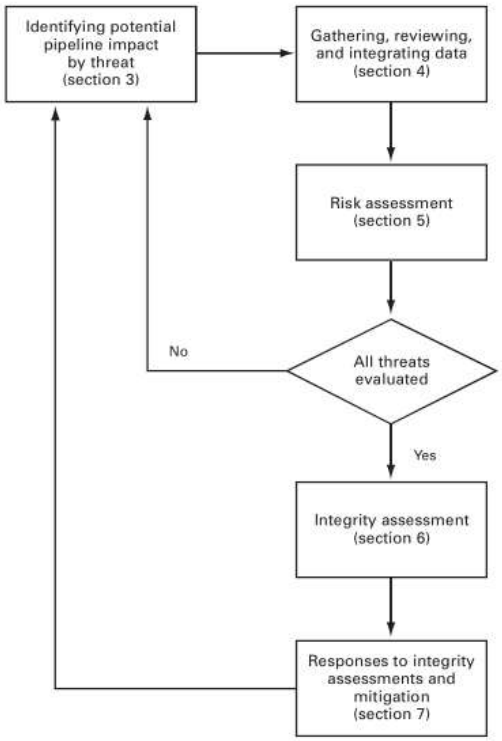
[1] MARCOGAZ: "General practices for managing external corrosion on underground pipelines", WG-TP-72, 2018

- Operational reasons, for example no back-up pipeline for gas supply or gas velocity is not within required range;
- Financial reasons, for example costs are too high for modifying a pipeline to enable ILI or short pipelines that have a relative high cost per pipeline length when inspected with ILI.

Pipelines that cannot or will not be inspected in-line will be referred to as "hard to pig" pipelines in this document.

4. Fitness for purpose of piggable vs. hard to pig pipelines

Figure 1 Process for Pipeline Integrity Management [2]



All TSO's follow a similar process for managing the integrity of pipelines, for example for external corrosion. Figure 1 shows a typical overview of a pipeline integrity management (PIM) process to maintain the fitness for purpose of pipelines [2]. Similar processes can be found in other codes and standards for pipeline integrity management and life-time extension, like EN 16348 and ISO/TS 12747 [3]. These codes and standards describe the same process: the condition of a pipeline shall be assessed based on threats that are relevant to the pipeline. An integrity assessment might have an additional goal that is to request permit from the regulator to operate a pipeline beyond its initial permitting period. The period for which a new permit is requested, can be determined by comparing the original design state with the actual pipeline condition, using data acquired during operations. Data relevant to the threats and condition of a pipeline shall be collected. This includes for example, pipeline characteristics, construction and operational data and data from previous inspections. The process of gathering relevant data and thereby creating the best available understanding of the pipeline condition, enables the best choice for selecting a method for determining the pipeline condition per specific pipeline. The codes and standards typically prescribe for external corrosion that as a minimum corrosion assessments results [what does this mean?] shall be evaluated, the condition of the coating and CP shall be assessed and identified anomalies shall be reviewed [what does this mean?].

For a piggable pipeline, it is possible to demonstrate its fitness for purpose with results from ILI, in combination with the effectiveness of the barriers coating and CP as is described in relevant pipeline standards.

There is a tendency towards increasing the use of direct inspection techniques, especially for managing corrosion, both at operators and some safety supervising authorities. However, ILI

[2] American Society of Mechanical Engineers: "Managing System Integrity of Gas Pipelines", ASME B31.8S, 2012
International Organization for Standardization: "Petroleum and natural gas industries -- Pipeline transportation systems -- Recommended practice for pipeline life extension", ISO/TS 12747:2011, 2011;
[3] CEN: "Gas infrastructure – Safety Management System (SMS) for gas transmission infrastructure and Pipeline Integrity Management System (PIMS) for gas transmission pipelines – Functional requirement", EN 16348, 2013;

is only one of the means to determine the fitness for purpose of the pipeline and thereby to determine the effectiveness of the wall thickness as first line of defence. It should not be considered indispensable.

For hard to pig pipelines an alternative strategy can be used. Without the possibility to use ILI, it is even more important to assess the effectiveness of the barriers "coating" and "Cathodic Protection system" that actually prevent external corrosion. Other possible measures are to investigate and if possible apply alternatives for ILI or apply additional barriers [what does this mean?]. Generally speaking, it is more difficult to demonstrate a pipeline's fitness for purpose without results from an ILI. Therefore, especially for these pipelines the data gathering and risks assessment steps of the PIM process are essential.

An alternative strategy for hard to pig pipelines will be discussed in the next section.

5. Possible strategies for managing external corrosion on hard to pig pipelines

Once it has been decided that ILI will not be used to assess the fitness for purpose of a pipeline, a strategy should be selected to manage external corrosion and thereby maintain the risk of external corrosion to acceptable levels. The basis of the alternative strategy lies in the data gathering and risk assessment steps from the PIM process, see figure 1. As an outcome of these steps, integrity assessments are defined. These integrity assessments give an indication of the effectiveness of each of the barriers to prevent loss of containment due to external corrosion. If ILI is not applied to determine the wall thickness, the role of other inspection techniques becomes more important:

1. Inspection of wall thickness:
    a. a hydro pressure test:. Hydro pressure testing is a well-known method that is required when constructing a new pipeline and that also can be used as an inspection method during operating a pipeline. It is for example used during operations in North-America. Several pipeline codes provide guidelines for performing a(n in-service) hydrotest, for example the PD 8010-1 [4]. Important disadvantages are large operational impact and the possibility that existing defects are aggravated without immediate failure.
    b. Visual inspection of the external pipe wall: local visual inspection of the external pipe wall after removing the coating during excavations. When indications of corrosion are found these are assessed (sizing, evaluation)
2. Inspection of coating condition:
    a. performing above-ground surveys to detect coating defects (DCVG or Pearson). An important standard is EN 13509 "Cathodic protection measurement techniques" ;
    b. In case of a coating defect detected by an above ground survey, Visual inspection of the coating: local visual inspection of the coating condition (adherence, disboundment,…) during excavations. The visual inspection can be extended with a spark test of the coating. Based on the evaluation of the coating condition a visual inspection of the pipe wall may be the next step.
3. Inspection of CP system:
    a. measuring the output current of rectifiers and pipe-to-soil potential at rectifiers and CP test poles An important standard is EN 13509 "Cathodic protection measurement techniques".
    b. periodic verification of corrosion coupons.
    c. performing above-ground surveys along the pipeline (CIPS or intensive measurement).

[4] British Standards Institution: "Pipeline Systems – part 1: Steel pipelines on land – Code of practice", PD 8010-1:2015+A1:2016.

4. Leak detection: since leaks due to corrosion are generally small [xxth EGIG report] these leaks are often not immediately detected. Therefore, a "leak detection program" may give an indication of the overall effectiveness of all barriers. It detects leaks and does not help to prevent leaks. An important standard is DVGW G-465-3 "Classification criteria for leaks in buried and not buried pipework in gas distribution systems", from which some principles can be applied for transmission systems too.

Ad 2. and 3.:

- In case of (possible) deviations or irregularities, coating and CP inspections require additional actions to investigate these deviations or irregularities. Some examples are inspection or maintenance of impressed current system or excavating the pipeline locally. This is similar to ILI where in some cases results from ILI may require excavations for an local inspection of the pipeline.
- External corrosion direct assessment (ECDA) is a structured process that defines/indicates locations where a pipeline will be physically examined. An important standard is NACE SP 0502-2010 "ECDA methodology".

All TSO's use (almost) all of these inspection techniques, but the combination varies and the criteria when to use them can be different. The strategies to manage external corrosion on hard to pig pipelines is influenced by cultural, historical and geographical factors. In some European countries, national legislation is applicable, that should be respected.

In addition to determining the effectiveness of the coating and CP, there are some new technologies available based on smart data to assess the condition of hard to pig pipelines. An example is that the condition of hard to pig pipelines can be statistically assessed based on the condition of piggable pipelines. Both piggable and hard to pig pipelines are protected by coating and CP. The condition of piggable pipelines is assessed with ILI. The condition of hard to pig pipelines can statistically be assessed by cross-referencing the CP of both piggable and hard to pig pipelines with the condition of piggable pipelines [5].

6. Conclusion

ILI is an increasingly important inspection method nowadays. However, not all pipelines are piggable. This paper provides an overview of how external corrosion can be managed on the hard to pig pipelines.

Each gas TSO applies its own strategy for hard to pig pipelines, based on national legislation, technical rules and standards. Their strategies differ due to cultural, historical and geographical factors.

Although there is a trend to increase the use of ILI, it is not the unique tool to effectively manage external corrosion and it is not always cost effective. In such cases, the overall operational safety level can be kept acceptable with a strategy using other inspection techniques. These techniques do focus on assessing the coating condition and the CP system. They will include risk assessments on (parts of the) pipeline and need adequate data. The right strategy based on other inspection techniques enables prevention of external corrosion and consequent pipeline failure caused by external corrosion.

Overall, it can be concluded that external corrosion and thereby the fitness for purpose of hard to pig pipelines can be managed and demonstrated when the described strategies are being applied, also without using ILI.

[5] R. Coster: "Empirical Potential-Dependent Corrosion Rate For Underground Pipelines", CEOCOR Luxembourg Congress, 2017.