The impact of corrosion on pipeline integrity

Corrosion represents the main threat for pipeline integrity. In North Sea for instance, DNV reports a total of 65 incidents occurred between year 1971 and 2001 which resulted in leakage (see figure here below): 26 accidents (40%) were related to corrosion (DNV RP F116 - Appendix A).

Internal corrosion prevails on external corrosion as cause of pipeline leakages, as shown in the figure below for leakages of pipelines in the North Sea and in the Gulf of Mexico.

Pipeline Direct Assessment

Direct Assessment (DA) is a methodology developed to verify the corrosion integrity status of a pipeline and the associated risk. Direct Assessment can anticipate or integrate inspections with intelligent pigs and hydraulic tests. In case of non-piggable pipeline, it represents a valuable alternative to In-Line Inspection. ISO 12747 Recommended Practice for Pipeline Life Extension explicitly considers Direct Assessment as a method for pipeline requalification and life extension.

Direct Assessment applies to subsea and on-land pipelines, with specific procedures for

- internal corrosion,
- external corrosion,
- stress corrosion cracking,
used by operators to identify critical issues and then to apply appropriate codes, like ASME B31G, RSTRENG, BS 7910, DNV RP F101, ANSI/API 579, for the verification of integrity and fitness for service activities (FFS).

Direct Assessment procedures developed by CESCOR are in accordance with NACE International Standards and incorporate in-house developed expertise for corrosion prediction and modelling, and for integrity assessment of pipeline defects.

NACE Standards for Direct Assessment


Procedure

The DA procedure consists of four steps as shown in the block diagram here below.

Step 1: Pre-Assessment

In this preliminary phase, for each pipeline all data and information, both current and historical, are gathered and reviewed, with the aim of identifying the pipeline homogeneous segment. Data to be collected are classified with a priority level according to the importance for the DA execution.
Step 2: Indirect Inspection

The execution of this phase is based on the choice of indirect inspection methods, including:

- Models for internal corrosion prediction: CO₂ corrosion; Microbial Induced Corrosion (MIC), Erosion-Corrosion, others
- Flow and hold up analysis
- External corrosion assessment (soil, seawater, under insulation).

Internal corrosivity is assessed by considering local changes of influencing parameters and calculating residual thickness values. The aims of this step are:

- to identify areas, denominated sub-regions, among the selected regions of the pre-assessment, where the most critical conditions for the integrity of the pipeline and the entire asset are expected
- to define the sites where to perform final inspections (MPL Most Probable Locations), according to the rules of the minimum points to be selected reported in NACE reference standard.

Step 3: Direct Examination

The inspection of the points selected in step 2 is carried out in detail at this stage, in the order of priority established by the expert, based on the results of the fluid dynamics and corrosion analysis. After performing thickness measurements in these areas structural integrity of the component under study is assessed. The aims of this step are as follows:

- to verify the presence and measure the depth of corrosion attacks in the selected points of indirect inspection step. For the execution of this phase, the NDE method of inspection more reliable and suitable to the present case shall be selected (LRUT, AUT, UT, other)
- to compare the results of the detected attacks with those predicted by the corrosion analysis. If the results differ over a range defined by reference NACE standard, the possibility to take corrective action for the evaluation performed in the phase of indirect inspection shall be considered
- to perform the analysis of the structural integrity of the pipeline based on the results of the indirect inspection and measurements, using methods recognized by international standards (ASME, API, DNV).

Excavation at most probable locations.

UT measurements at most probable locations.

To assess external corrosion risks, cathodic protection surveys are carried out including measurements at test posts as well as potential profiles on the total length of the pipeline or on representative length samples.
For on-land pipelines, the CIPS and TGM or DCGV methods are used.

For subsea pipelines, potential profiles are performed by instrumented ROV or, where applicable, by the trailing wire method.

Step 4: Post-Assessment

In this final step, by considering the results of the integrity assessment, the effectiveness of the entire procedure of Direct Assessment is verified. The aims of this step are as follows:
- Opinion of the subject-matter expert (SME) about DA effectiveness
- Identifying mechanisms and damage causes
- Remedial actions evaluation
- Estimating residual life
- Defining re-assessment period
- Defining inspection and maintenance plan.