



General practices for managing external corrosion on above ground gas facilities

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1. Introduction

Corrosion is the main threat to material degradation in aboveground facilities provided that the probability of third-party interference is very unlikely inside Natural Gas transmission facilities premises.

It presents itself in above ground facilities both in underground structures due to difference potential where material has lost its protection and on aboveground structures, where material is subject to atmospheric conditions which can produce corrosion of the components of the facility.

The most likely scenarios according to statistics

It can be concluded that due to external corrosion, a pinhole/crack is the dominant leak size, which can be managed using normal procedures as referred to in chapter 7 - "Consequences of failure" (p.67). If coating degenerates that severe over time the corrosion prevention by cathodic protection cannot be maintained, serious rehabilitation might be necessary and total replacement can be considered even.

Rupture is highly unlikely, but it cannot be neglected completely.

This paper first gives a high-level overview of legislation in Europe on managing the integrity of pipelines in general, and on the threat of external corrosion in particular. Then it focuses on the measures taken by transmission system operators (TSO's) to prevent corrosion leading to leakage, as well as the consequences of pipeline failure in general, including measures to manage those.

2. Applicable legislation

Any TSO must comply with legislation from national regulators. This legislation may differ among European countries, and may be influenced by cultural, historical and geographical factors, but the goal that the different legislations have in common is to prevent that construction and operation of gas transmission assets results in unacceptable risks to health, safety and the environment.

The national legislation usually is high-level and refers to technical rules and standards for specific technical requirements. The main difference between legislation, technical rules and standards is the character: it is either goal setting vs. prescriptive:

Legislation, technical rules and standards generally do not contain unambiguous and/or quantified acceptance criteria, especially not when they are goal setting. It is clear however, that no management system can exclude the occurrence of any leak completely. The small probability of a stable pinhole of hole is acceptable provided that such an incident is managed adequately.

A non-exhaustive list of specific standards to be met is:

- EN 12954. Cathodic protection of buried or immersed metallic structures. General principles and application for pipelines. Will be replaced by PNE – prEN 12954
- EN 13509. Cathodic protection measurement techniques
- EN 14505. Cathodic protection of complex structures
- NACE Standard RP0169: Control of external corrosion on underground or submerged metallic piping systems

- NACE Standard RP0286: Electrical isolation of cathodically protected pipelines
- NACE Standard RP0572: Design, installation, operation and maintenance of impressed current deep ground beds.

3. Overview of measures to manage external corrosion

Each TSO bases their integrity procedures according to their national regulation, and their best understanding of international standards.

Corrosion management systems involve several procedure levels, in which protection against corrosion is met during each phase of the life cycle of the asset: design, procurement, construction and maintenance:

- Design; both active and passive measures against corrosion must be considered during design.
- Procurement; components and accessories must meet the requirement established in design specifications.
- Construction; as-well, construction procedures must meet the requirements defined during design.
- Maintenance; during the operation lifetime of the asset, maintenance is essential to maintain the fitness for purpose of the asset.

The management of likelihood of external corrosion is categorized in three stages:

- Prevention; applying different measures to avoid corrosion
- Inspection; different inspection techniques must be used in order to assess the condition of the assets. These techniques include, but are not limited to, visual inspection, wall thickness measurements, CP measurements, etc.
- Repair and/or replacement of pipe segments, where and when necessary.

In practice, European TSO's have implemented a similar integrity approach of mitigating measures to manage external corrosion. All TSO's use all the measures described above; however, differences in legislation and cultural, historical and geographical factors, will result in a detailed difference in the implementation of these measures.

4. Prevention

External corrosion of the different elements of the facilities is prevented by passive and active measures:

- Pipeline and/or accessories coating is the most effective passive external corrosion prevention measure. Buried or underground accessories are coated by different material layers as explained in the WG-TP-72 document. Aboveground element coating is based on different painting layers to ensure proper bonding between paint and base material.

Applicable International Standards:

- EN ISO 8501 Corrosion Protection of Steel Structures by Painting

- Steel Structures Painting Council (SSPC) manuals
- EN ISO 1461 Hot dip galvanized coatings on fabricated iron and steel articles
- Cathodic protection of buried or underground accessories is the most effective active measure against external corrosion.

Different CP systems are fit to use in aboveground installations; impressed current or sacrificial anodes. The effectiveness of both of them is strictly bound to its design and the compliance of its specifications.

Aboveground facilities CP specification is covered by BS EN 14505 Cathodic protection of complex structures.

Prevention is the primary barrier to avoid external corrosion from happening and it's the best cost-effective measure.

5. Inspection

Assessing the actual condition of pipelines and accessories and their protection measures is a key point in order to assess the possibility of existing corrosion.

Hence, a variety of inspection techniques are used in order to evaluate the performance of the preventive measures and to assess if there is any ongoing corrosion mechanism.

These inspection measure include, but are not limited to:

- Visual inspection of the aboveground assessing the coating (paint) condition according to standard ISO 8501-1.
- Measuring the relative potential of the different buried elements with respect to a sulphur copper electrode gives an indication whether this given element is protected against corrosion in case there is a coating defect.
- Measuring the pipeline or accessories wall thickness to assess the remaining life-cycle of the measured element.
- Perform leak detection to detect corrosion pinholes;

These inspections allow maintenance staff to determine the suitability of the protections against external corrosion and whether or not there is already a defect in the pipelines or accessories. Technological developments will improve inspection techniques even further in the future, in both efficiency and effectiveness.

The different approaches for the definition of the maintenance plans is defined by each TSO with the inputs of:

- Legislative restrictions or defined inspection frequencies.
- Risk based inspections in order to optimize the inspection frequency.
- Arbitrary decisions based in the experience of the operator.

6. Repair and/or replace

When a defect is detected an assessment of the remaining integrity of the element is performed. The different defects that can be detected, may affect:

- Coating
- Pipeline base material
- Accessories

Depending on which element has been damaged the assessment has different approaches:

- If the coating is damaged, an assessment to its isolation capacity and its bonding effectiveness to the pipeline has to be performed.
- If the base material of the pipeline is detected, especially in aerial to buried transition segments, an assessment of the remaining strength based on ASME B31-G or ASME B31-G Modified is recommended.
- Accessories are rarely damaged, and their fitness for purpose, if corroded, is difficult to assess, if not impossible. Thus, if an accessory has an ongoing corrosion mechanism, repair or replacement is mandatory.

If a decision to repair a defect is made, the different options for each type of element are:

- For damaged coatings; depending on the size of the damaged section, patching or complete substitution of the affected area is the best solution.
- If the defect has happened on the base material or an accessory, the different options for the retrieval of the previous condition of the pipeline depend on the defect type, location, etc.

The best options for a repair are structural reinforcements, whether as metallic reinforcements (sleeves) or composite wraps.

In extreme situations, replacements are needed, nevertheless, the cost and the un-interruptibility advise against these type of actuations.

The decision upon which solution is selected depends on each TSO's standards.

7. Consequences of failure

In above ground facilities, a failure in the contention of natural gas may have severe implications if the defect takes place inside a confined space, the mere presence of gas can put life at risk by oxygen deprivation.

Consequently, a proper consequence analysis is required to prevent any hazardous situation from happening. The following categories have to be defined to evaluate the consequence of a leak of natural gas:

- Outflow: how much gas is released from the pipeline;
- Dispersion: where does the gas go;
- Ignition probability: where and how often will it ignite;
- Thermal radiation: how much radiation does the fire produce;
- Radiation effects: what impact does the radiation have on population and property.

There are several (national) standards and software packages available to determine the consequences of failure with the described approach. Typical parameters used in these calculations are population density near the facility, pressure, diameter and leak size.

8. Conclusion

This paper provides an overview of regulation, technical rules, standards and measures to manage the probability and consequences of failure due to external corrosion in natural gas above ground facilities. The legislation, technical rules and standards differ among European countries, and are influenced by cultural, historical and geographical factors; however, they focus on preventing unacceptable risks for health, safety and the environment during the construction and operation of gas transmission assets.

TSO's maintenance philosophy is similar across Europe, notwithstanding the differences which are reflected in the legislation, standards and technical rules. However, corrosion is one of the main threats to be faced.

Defects due to external corrosion are likely to occur, the most probable outcome is wall metal loss and the appearance of pinholes, with a small hazardous potential. Proper maintenance plans and design specifications are the prime barrier against these phenomena.

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