CEFRACOR
CENTRE FRANÇAIS DE L'ANTICORROSION

Committee for Cathodic Protection and Associated Coatings

Recommendation for fault detection after backfill and repairs on coating of buried pipelines

DISCLAIMER: The present recommendation has been consensually established by the members of the committee "Cathodic protection and associated coatings" of CEFRACOR. It reflects the general opinion in the trade and might be used as such as a bases representing at the best the state of art at the date of issue. Nevertheless, it shall not commit in any manner the CEFRACOR and the committee members by whom it was established.

1.SCOPE:

The purpose of this document is to propose decision criteria related to the detection and repair of puncture flaws in anticorrosion coating applied on the steel of buried pipelines under cathodic protection.

Note : This recommendation does not address coating fault detection before back filling which is the scope of CEFRACOR 's Recommendation PCRA 003 " Recommendation for the inspection by electrical methods of faults in organic coating applied on steel".

2. CONTEXT:

The maturity and the increase in the use of coating fault detection techniques by electrical measurements at the ground surface are food for thought with respect to their aims and limits, starting from the major question:

- When and why carrying out a coating fault detection?

to this are added three complementary questions:

- Which detection methods to be used?
- Using which detection sensibility?
- In which cases defaults should be repaired?

This recommendation takes into account the characteristics of the current coatings, the performances of the coating fault detection methods, as well as the effectiveness of the applied cathodic protection.

As a matter of fact, the actual purpose is the protection of the structure against corrosion and not only the intergrity of its coating. This purpose is achieved by the coating of the steel and its cathodic protection; both means having demonstrated their complementarities.

3. COATING FAULT DETECTION METHODS

Two methods are addressed in this recommendation :

- The electromagnetic attenuation method which enables to assess the distribution of faults
- The potential gradients method (direct or alternative current) which enables accurate localization of faults

With the electromagnetic attenuation method, an alternative current is applied between the potential test point lead and a ground pin. Then at regular intervals in a range of a 100m to 1000m, the intensity of the electromagnetic field radiated by the pipeline is measured. The attenuation trend allows to identify areas with important loss of current due to the presence of large cumulated surfaces of coating faults. This method does not enable to detect small isolated coating faults. Its field of application is that of pipelines having a large number of coating faults; its sensibility is in the range of a 100m.

The potential gradient method, also referred to as "Pearson method" with alternative current or "DCVG" with direct current, consists in adding a signal on the current flowing in the pipeline and measuring, at regular intervals in the range of 1 meter, the potential gradients created in the soil by this current and that increase in the vicinity of a coating fault : the presence of a potential gradient indicates the presence of a fault, its magnitude enables to assess the extent of the bare surface. This method is suitable for the detection of isolated faults, even small ones with an accuracy in the range of decimeters; however in case of close faults or corroding faults (outgoing current), the interpretation of the measurement is complex and subject to errors; more embarrassing, this method gives poor results or is not even applicable when it is not possible to place the reference electrode right over the pipeline (wide river, pipeline in casings, insulating asphalt, rocky soil, bitumen..).

For the two gradient methods, one should always keep in mind, that the fault detection is performed by detecting the current flowing through this fault ; hence, a non cathodically protected coating fault (default under blister, local high resistivity…) will go undetected despite it might be corroding.

4. WHEN AND WHY A COATING FAULT DETECTION SHOULD BE CARRIED OUT?

Why? Where as in the case of a new pipeline the localization of faults could simply be carried out in order to repair them, for an existing structure, the answer is more complex. However, generally speaking, one could say that detection is not done for repairing but to know, analyse and decide how to act with regard to the coating, the steel or its cathodic protection.

During and just after the construction of the pipeline.

At the end of the construction of a new pipeline it appears to be good practice, particularity in the case of pipelines for hazardous fluids, to have carried out a detailed fault detection (gradients method). Besides the normal objective of obtaining a sound coating, this will be positively incentive all along the construction works. It may also reveal unknown damage to the metal. The established mapping will serve as a reference for subsequent inspection campaigns. It will be also useful to perform a global attenuation measurement (not very expensive).

A detailed search will be the more significant when being carried out several months after backfill so that the soil will have achieved its final settlement. However, the inconvenient may be the closure of the building site and the access tracks. The pipeline construction contractor should consider the possible interest of a first measurement during or just after the backfill.

During the life of a pipeline having a sound coating

For such pipelines, several objectives might be set for a fault detection:

- Detect, by comparison of subsequent mappings, mechanical aggressions occurred after the construction and which could have damaged , beyond the coating, also the metal.
- Verify the absence of aging of the different coating types applied (factory or on-site applied coatings, coating of girth welds, etc.…)

- Verify that third party works did not have any consequence for the structure by comparing detailed local mappings carried out before and after the third party works.

The first objective requires the performance of subsequent campaigns with the gradient method. The frequency of the campaigns will be determined depending on the environment of the structure or its sensitivity with regard to the risks according to criteria consistent with those developed for the repair. The method can be effective in cases of very low density of coating faults. The method is less relevant when the conditions are not similar between two subsequent measurements.

Note: This method does not allow to reveal mechanical stresses in the pipe (e.g. dents due to ground work engines….) without puncture of the coating.

The second objective, more theoretical, is achieved either by analysis of the trend of the measurements of the insulation or by analysis of the comparison of subsequent mappings of the coating faults. In case of significant change, the reasons should be elucidated, corrective actions or compensatory measures should be implemented if necessary (reinforcement of the CP equipment, increase of monitoring frequency,….....) .

During the life of a pipeline with decayed coating

When the density of coating faults is important, the aim of their detection cannot be to repair them all. One should focus on the implementation of an effective cathodic protection at all points and monitor it by suitable methods. The coating fault detection will neither have the objective to detect recent aggressions of the structure since the density of faults will render this analysis difficult. Possible objectives of periodic search campaigns are:

- The detection of coating faults that are susceptible to decrease the effectiveness of the cathodic protection (e.g. due to their size)
- Check the aging of the different coating types applied (factory or on-site applied coatings, coating of girth welds, etc….)

These two objectives can be achieved by carrying out a global campaign by the Attenuation method, completed, if necessary, with local detailed measurements by the gradients method in area that reveal a substantial decay. The frequency of the campaigns will be determined depending on the environment of the structure or its sensitivity with regard to the risks according to criteria consistent with those developed for the repair.

Related to a campaign of excavations for check-up

The gradients method will be used when one intends to check by direct assessment the state of the metal (absence or extent of corrosion) or the coating (cracks, blistering) at a certain location or during a systematic campaign, in order to select locations to be excavated and accurately determine their location.

Related to a campaign of close interval pipe to soil potential survey

Check-up measurements of the pipe to soil potential at close intervals (also referred to as CIPS – Close Interval Potential Survey) are expensive operations if carried out over the total length of the pipeline. The potential measurement may be difficult to interpret especially when stray currents are present and beyond the vicinity of a coating fault particularly with high resistive coating with a low flaw density.
During a CIPS campaign it may therefore be judicious, to pay particularly attention (or even exclusively) to points or areas identified for having coating faults, in order to verify that the cathodic protection ensures fully its complementary role to that of the coating. In case that a mapping of coating faults is not available, or in order to up-date it, the CIPS campaign should be preceded by a coating fault detection preferably by the detailed method (gradients method).

5. WHEN AND HOW TO TREAT A COATING FAULT?

The objective to repair (after backfill) all coating faults is illusory for several reasons:

- The detection methods are not exhaustive. There is a minimum detection threshold which may vary; the repeatability of the measurements is not a 100%. Certain faults are definitely not detectible due to their electrical environment
- The cost of repair of certain inaccessible faults or those scattered over too long distances is prohibitive compared to an enhancement of the cathodic protection, which is complementary to the coating in the struggle against corrosion

This observation leads to define classification rules for identified faults, or pipeline sections on which an unknown coating fault may subsist, and then define corrective or compensatory measures to implement in order to end up in a totally safe condition.

In order to carry out this classification, the pipeline operator may be guided by the criteria listed in the C4C Method given in annexe **"C4C: Criteria CONTEXT – CHARACTERISATION – COMPENSATION – CORRECTION"**

The resulting classification may be organized according to the actions to be taken:

- Faults that must be imperatively repaired
- Faults to be deeper investigated (e.g. suspicion of metal damage)
- Faults to be repaired or investigated in case of opportunity
- Faults to treat otherwise than by repair
- Faults to be monitored, without treatment, because they present no immediate risk of corrosion

6. CONCLUSIONS

It is important to periodically pay attention (and as soon as the pipeline is laid , if possible) to coating faults of an underground pipeline. The method of detection and its sensitivity should be adapted to the needs and one must remain aware of the limits of these types of measurements which cannot ensure an exhaustive result. The identified faults must be analyzed and classified: the classification criteria may be guided by the C4C Method (Criteria Context – Characterisation – Compensation – Correction).

This classification enables to define whether the faults should be repaired or if it is sufficient or preferable to choose for compensatory measures, or if merely its evolution should be monitored over the time. The first compensatory measure is obviously an effective adjustment of the cathodic protection, natural and indispensable complement of the coating in the struggle against corrosion.

7. REFERENCES

Guidelines GESIP 2000/01 "Méthodes de recherche de défauts et de réparations des canalisations de transport" (Methods for coating fault detection and repair of transmission pipelines)

Standard NF EN 13509 "Cathodic protection measurement techniques" , October 2003

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Annexe : Classification of coating faults – C4C Method

Criteria Context - Characteristics - Compensation – Correction

Indicative list of criteria to be taken into account:

CONTEXT of the fault

- Disturbed electrical environment
  - Proximity of an anode or an impressed current station, presence of stray currents
  - Proximity of HV power lines, close distance to pylons ...
  - Proximity of other underground networks, particularly in urban area
- Complex or evolving geographical environment
  - Density and type of houses
  - Possibility or difficulty of excavation
- Type and severity of the risks related to the pipeline

CHARACTERISTICS of the fault

- Physical characteristics
  - Size of the fault (note: important error margin; not directly related to the risk of corrosion)
  - Location of the fault (particular care is paid to risers)
  - Type of coating , risk of disbondment
- History of the fault
  - Origin (known or supposed)
    - Fault due to construction
    - Natural aging of the coating
    - Aggression of the structure (in which case a coating fault may be associated with a default of the pipe)
  - Possible evolution (by comparison of subsequent mapping of the faults)
  - Continuity of implementation of the cathodic protection

COMPENSATION of the fault

- Capability of the cathodic protection to protect the bare metal
  - Local soil resistivity, change of hygrometry
  - Power and range of the impressed current stations, related to the cumulated surface of coating faults
- Sufficient verifications and follow-up
  - Electrical measurements: check of the pipe to soil potential, check on simulated faults (metallic test probes)
  - Inspection by other methods (smart pigging,…..)
- Action on the environment
  - Drainage of currents, management of interference between structures
  - Distancing from electrical groundings, placing insulation in the soil (crossings, pylons,….)

CORRECTION of the fault

- Technical feasibility of the repair

  - Accurate localization of the fault
  - Accessibility of the pipeline
  - General conditions of the coating
- Comparison of the economics of the different acceptable solutions

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