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ECDA's experience within Fluxys

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ABSTRACT

External Corrosion Direct Assessment, as described in the NACE 2002 (The National Association of Corrosion Engineers) Standard Recommended Practice RP0502-2002, is a structured and continuous improvement process that is intended to improve safety by assessing and reducing the impact of external corrosion on pipeline integrity. This methodology has not yet been “validated” on Fluxys network.

Note that ECDA does not detect corrosion, but it gives a probability on the risk of corrosion.

ECDA consists of a four-step process:

1. **Pre-Assessment**, historical and current data are collected and analyzed to determine whether it is possible to use the ECDA process. Assuming it is feasible, ECDA regions of equal corrosion probability are defined, and indirect inspection tools are selected.

2. **Indirect Inspections**, above ground surveys are conducted, using sophisticated instrumentation to detect and quantify the severity of coating faults and the effectiveness of cathodic protection at those locations. The Standard recommends to apply two or more indirect Inspection tools.

3. **Direct Examination**, the results from the indirect inspections are analyzed, and specific sites are selected for direct examination of the exterior surface of the piping. Following excavation, the condition of the coating is assessed, and where necessary, pipeline repairs and corrosion mitigation are implemented.

4. **Post-Assessment**, the data collected from the previous three steps is evaluated to determine the effectiveness of the process and to determine the appropriate time interval before the next pipeline assessment.

In order to validate the methodology, Fluxys applied it on a test case. The document will illustrate the results and the specific concerns such as :

- The difficulty to collect a significant historic of the pipeline integrity.
- The need to handle a huge amount of data.

INTRODUCTION

Fluxys s.a., the Belgian natural gas transport company, operates a pipeline network of about 3800 km length. Next to this operational network some pipelines are no more used but still under Fluxys responsibility. As a cautious operator, Fluxys needs to assess the integrity of all those pipelines and in particularly in terms of effective protection against corrosion.

Since the seventies, MFL (Magnetic Flux Leakage) pigging tools have gained acceptance by the gas-transmission industry and have become the most widely used and effective tools available in order to assess integrity of gas transmission pipelines. However many pipelines are not suited to this type of inspection due to physical restrictions such as variable internal diameters, sharp bends, branch connections, no launch/receiving traps, short sections, … All those technical limitation can normally be solved but it should result in a long and costly process.

Possible alternative techniques to this technique MFL are available: pressure and tight testing, excavation and visual examination of the pipeline, coatings defect detection (combined CIPS/DCVG, Pearson)… Due to business continuity imperative, non intrusive techniques will have undoubtly the favor of pipeline operators.

It is not possible to assess integrity of the pipeline against corrosion based on the result of one of those alternative techniques. But combining them and processing the collected data's could lead to a realistic methodology of assessment of external corrosion. That's the main idea of "External Corrosion Direct Assessment "so called ECDA. This structured process, was standardized in 2002 by the NACE (National Association of Corrosion Engineers). Note that external corrosion is more critical concern for dry gas transport industry than internal corrosion.

In order to validate this methodology, Fluxys decided to apply it on a test case. The aim of this paper is to present to CeoCor's members a first explanation of the methodology illustrating the theory by the first Fluxys outfindings.

ECDA METHODOLOGY OVERVIEW

The External Corrosion Direct Assessment methodology is a four-step process that combines pre-assessment, indirect inspection, direct examinations, and post assessment, to threats the pipeline integrity due to external corrosion. IT aims to improve the safety by assessing and reducing the impact of external corrosion on pipeline integrity.

In the Pre-Assessment step, historical and current data are collected and analyzed to determine whether it is possible to use the ECDA process. Assuming it is feasible, ECDA regions of similar corrosion likelihood are defined, and indirect inspection tools are selected.

In the Indirect Inspections step, above ground surveys are conducted, using sophisticated instrumentation to detect and quantify the severity of coating faults and the effectiveness of cathodic protection at those locations. According to the NACE recommended practice, two different indirect and complementary inspection tools must be used to survey the entire length of a pipeline through each ECDA region.

In the Direct Examination step, the results from the indirect inspections are analyzed, and specific sites are selected for direct examination of the exterior surface of the piping. Following excavation, the condition of the coating is assessed, and where necessary, pipeline repairs and corrosion mitigation are implemented.

In the Post-Assessment step, the data collected from the previous three steps is evaluated to determine the effectiveness of the process and to determine the appropriate time interval before the next pipeline assessment.

ECDA is a continuous improvement and iterative process. Previous assessment results should be used to improve subsequent assessments and enhance system integrity.

FIRST STEP: PRE-ASSESSMENT

OBJECTIVES

The aims of the Pre-Assessment are:

- to determine whether ECDA is feasible for the pipeline to be evaluated
- to identify ECDA regions
- to select indirect inspection tools.

A scoring list for each parameter has to be done. The result of the pre-assessment will depend of the score that the operator has defined. Pipeline information may change permanently, a way to save them in continuous and to analyze them anytime have to be find. As each data has a score, region of equal probability of corrosion will result the assessment.

ECDA FEASABILITY

Pre-assessment requires a sufficient amount of data's to be collected. A first global analysis will determine if it is possible to find those data's and consequently to apply the ECDA process on the concerned pipeline

Next to this ECDA includes above ground detection techniques, some specific design can make this unfeasible. Let's think at direction drillings. It's thus necessary to identify those sections for an efficient corrosion management.

ECDA REGIONS

This step will include the collection of significant data's, the development of a scoring model and definition of regions by applying the scoring model.

Collection of significant data's

The NACE Standard recommends that the pipeline operator shall:

- *Define minimum data requirements based on the history and condition of the pipeline segment.*

A minimum of pipeline integrity related data's and their historic have to be collected. Normally of course the more data's, the more the methodology results will be meaningful. E.g.: "What kinds of coatings are applied on this pipe? How old are they? How was applied the coating on girth weld? Have external corrosion already been observed? Which level of CP potential was applied? …"

Finding in the archive significant historic of the pipeline is a real key factor to the success and a challenging one as well. It may result in revision of internal procedures concerning data's storage.

- *Identify data elements that are critical to the success of ECDA process.*

The collected data's will be integrated and analysed in order to determine witch parameters could be used for further evaluation (e.g. data's haven't been validated by qualified personnel, data's are not enough representative of the section,...). Moreover even if all type of data's can be used, the operator has to find out which are the more critical concerning external corrosion. The quality of pipeline steel (e.g. API 5L X60) will not have the same influence on the results as the type of the coating (bitumen, polyethylene).

- *Include as a minimum data's related to five categories: pipe-related, construction-related, soils/environmental, corrosion control and operational data.*

Those five categories have been defined in order to be sure all aspects related to external corrosion are covered.

Development of a pertinent scoring model

Useful data's are now collected and critical parameters are defined. For each of these parameters, the operator will assign a scoring value as parameters will not influence the analysis in the same way. For example, the thickness of the pipeline will not have the same importance as the type of coating for the ECDA. All those scoring will be then integrated in a global scoring model.

For each parameter a scoring table will be then defined according to the possible values (more likely range of values) of the data's. Each table is based on algorithms dependent on operator specific pipeline and environmental attributes, historical results from previous assessment carried out on the pipeline, published data's recognized by regulatory bodies, operator's experiences.

The global scoring model calculates the total risk of external corrosion associated with each region relative to all other regions in the system.

The global scoring model has to be pertinent. It means it will define a reasonable and practical number of regions of equal risk concerning external corrosion. Otherwise data's treatment may be useless and time consuming. It will also lead to useless expenses because a minimum of one visual control will have to be done in each region.

The NACE standard recommends the above mentioned 5 categories with 44 sub-categories and more or less 100 sub-sub-categories to score. Fortunately all parameters do not have to be taken into the model but only the most significant ones according to the pipeline.

An example of a score for each category is presented in Table *1*:

CATEGORIES		
1	PIPE-RELATED	10
2	CONSTRUCTION-RELATED	10
3	SOILS/ENVIRONMENTAL	20
4	CORROSION CONTROL	35
5	OPERATIONAL DATA	25
		100

Table 1 – Categories scoring

In this example, the operator wants to emphase that corrosion control category has the highest influence on the evaluation of the risk of external corrosion (weight of 35). It's the only parameter under control and it affects directly and strongly the risk of corrosion.

The CP survey data parameter is one of the sub-categories of Corrosion Control. The following scoring of CP survey data can be applied:

$$\text{CP survey data} = 0.4\ \text{Availability} + 0.6\ \text{Potential value}$$

Where:

Availability: it's the historical availability (report) of the potential value on one measuring point since the laying of the pipe. This parameter has the follow score:

Report	Score
All	0
> 50%	0,3
< 50%	0,7
None	1

Potential value: it's the highest potential value measured and reported since the laying of the pipe, on one measuring point. Those score are apply:

E_{ON} (V CSE)	Score
> 0	1
0 > E_{ON} ≥ - 0,6	0,8
- 0,6 > E_{ON} ≥ - 0,95	0,4
- 0,95 < E_{ON}	0

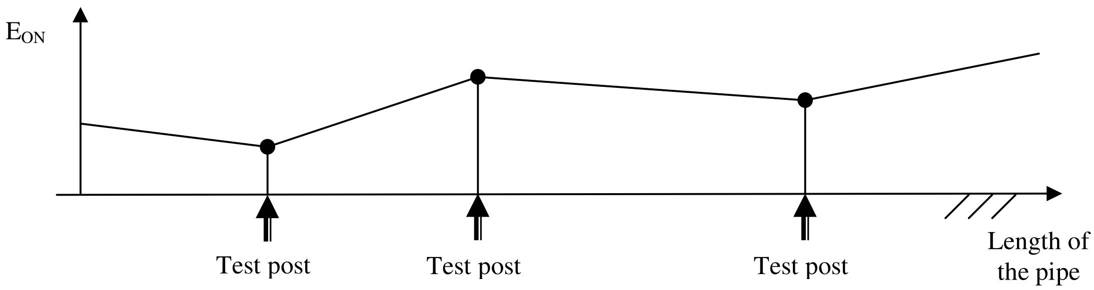
-0.6 V has been choosing because it's the value of the natural potential of the underground steel. And -0.95V is the limit of no risk of MIC corrosion.

Each score is between 0 and 1; the bigger is the risk, the higher is the score.

As example:

- If all report since the laying are available and no potential value has exceeded -0.95V, the score will be 0 (= 0,4 x *0* + 0,6 x *0*).
- If you have 75% of the report, and that you have register one value of -0.62V on one point, the score will be 0.36 (= 0,4 x *0,3* + 0,6 x *0,4*).

A rule needs to be defined in order to evaluate the score on the all length of the pipeline. As example a linear evolution of the score between two measuring points can be considered.



Definition of regions applying the scoring model

Huge amount of data

The ECDA processes need to handle a huge amount of data. Moreover, for each parameter, new data's are created almost every day. They have to be collected and treated efficiently. Sources of data's are also located in distinct departments. Centralization process is thus very critical. Those reasons make the use of software like PIMT almost mandatory.

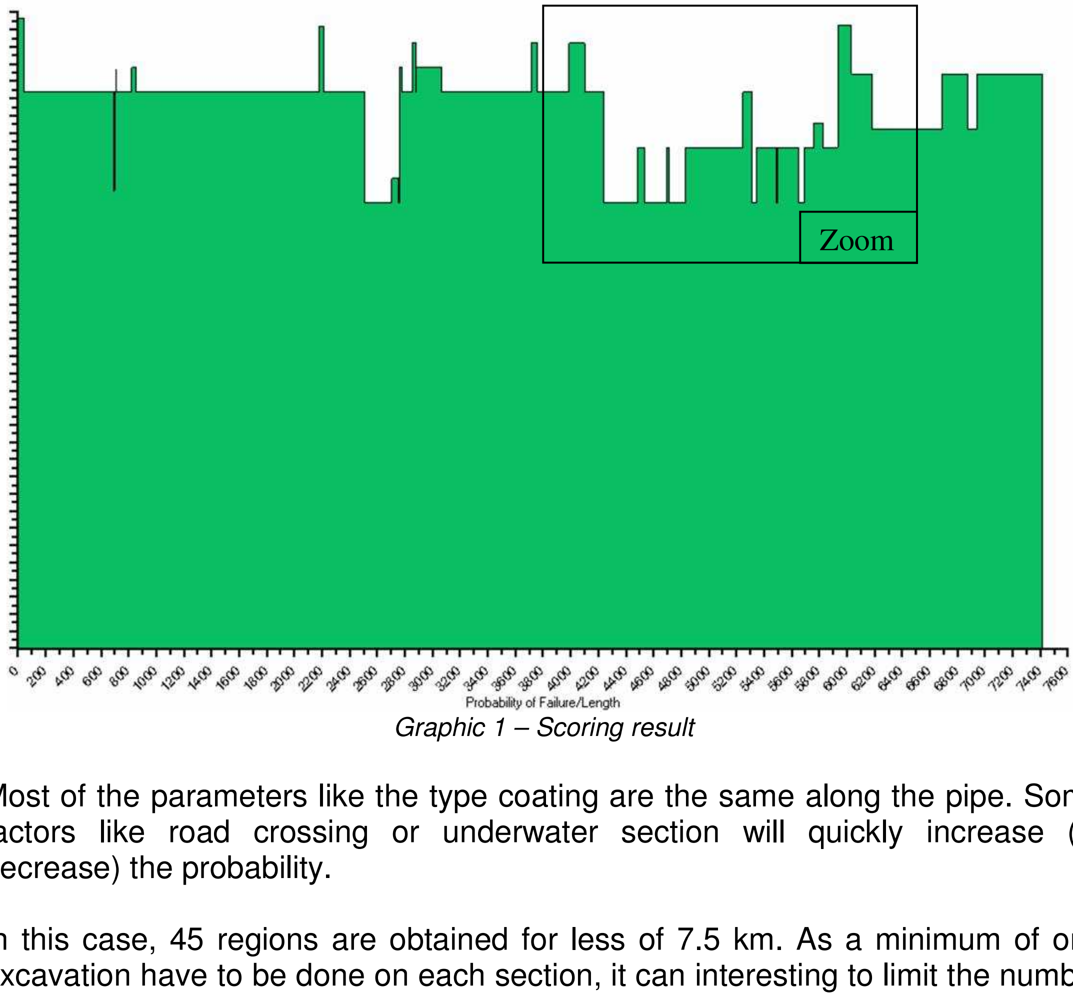
PIMT

Pipe Integrity Management Tool is a software consisting of several modules that enables users to perform risk of failure assessment, evaluate risk, generate integrity management plans, perform defect assessments, perform corrosion growth evaluations, and generate what-if scenarios for cost benefit analysis.

ECDA can efficiently be applied by using PIMT software. The scoring model with the algorithms has to be introduced.

ECDA regions

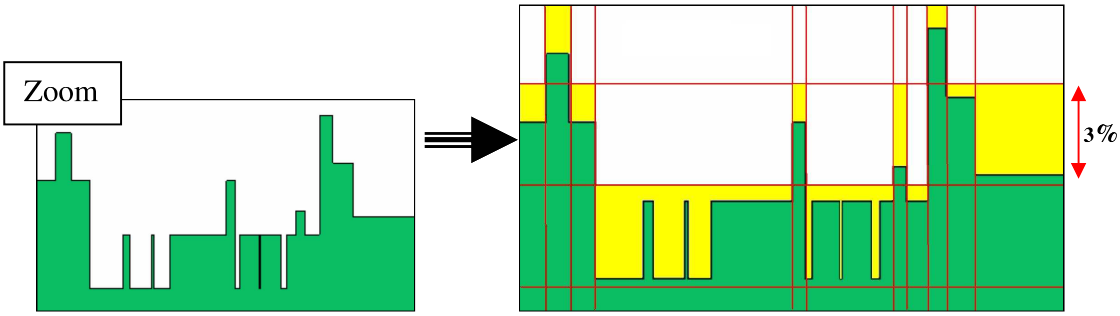
After having introduced the data in the software, all the scores are added together. *Graphic 1* shows the result of the pre-assessment on a pipeline.



Graphic 1 – Scoring result

Most of the parameters like the type coating are the same along the pipe. Some factors like road crossing or underwater section will quickly increase (or decrease) the probability.

In this case, 45 regions are obtained for less of 7.5 km. As a minimum of one excavation have to be done on each section, it can interesting to limit the number of regions. A way of doing is to consider a range of percentage to define a region. For example with an interval of 3%, 21 regions are defined.



21 ECDA regions *11 ECDA regions*

INDIRECT INSPECTION TOOLS SELECTION

The pipeline operator shall select a minimum of two indirect inspection tools on each region where ECDA is feasible along the pipeline. The selection has to be complementary, such that the strengths of one tool compensate for the limitations of another. The same indirect inspection tools should not be necessary the same on all locations along the pipeline segment.

The NACE standard provides a guidance table on selecting indirect inspection tools and specifically addresses conditions under which some indirect inspection tools may not be practical or reliable.

CONCLUSION

As the Pre-assessment is the first step of ECDA methodology, the operator should evaluate the feasibility of the study on the entirely pipeline.

All the significant historic and integrity data collected have to be scored according to the scoring model. The scoring is one of the most important key of the ECDA methodology. The result of this will be regions of same probability of corrosion. The database must be continuously completed and updated, which implies huge amount of data. An informatics tool as the PIMT can be an efficient tool for a proper management.

Pre-assessment is the first step, and one of the most important to obtain good result of ECDA methodology.

SECOND STEP: INDIRECT INSPECTION

OBJECTIVES

The objective of the Indirect Inspection step is to improve on each region the evaluation on external corrosion risk.

According to the operator's experience and result of the first step, operator will select two Inline Inspections for each region. In this step, above ground surveys are conducted, using sophisticated instrumentation to detect and quantify the severity of coating faults and the effectiveness of cathodic protection at those locations. This second step collects some information on the pipelines that are more focused and exhaustive at the time of the study than in the first step. These types of inspection are also easy to perform and not expensive related to pigging for example.

The Standard recommends as tools:

- Close Interval Potential Survey (CIPS)
- Current Voltage Gradient Surveys (DCVG)
- Pearson
- Electromagnetic
- AC Current Attenuation surveys

In the test case for the validation of the methodology, Fluxys has applied CIPS, DCVG test on field.

CLOSE INTERVAL POTENTIAL SURVEY

CIPS method

The continuous potential measurement is carried out with a purpose-built microprocessor-based data logger appliance. The measurement configuration can be seen in *Figure 1*.

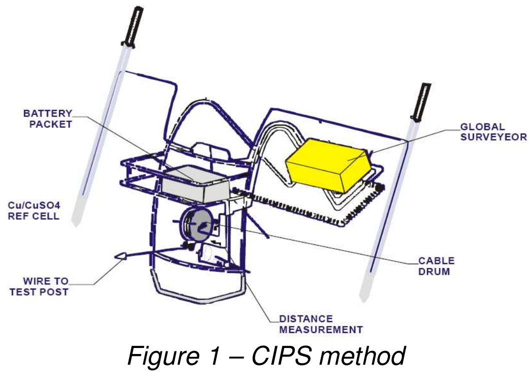


Figure 1 – CIPS method

The measurement itself happens by connecting a thin but very strong wire to the pipe to be measured. The connection may be done at the test posts or at any metal object being in metallic connection with the pipe (for example valves). The wire rolls down from a drum that allows distance measurement, also. The person carrying out the measurement has a $Cu/CuS0_4$ electrode in both hands and places them onto the soil after each stride.

The gathering and storing of measured data happens independently on the human so non-subjective. Besides the pipe-to-soil and polarised potentials and the measurement of distance from the starting point other information can be entered into the data logger, such as:

- Depth of pipe
- Coating defect location data
- Foreign objects
- Any data deemed to be necessary

The data can be entered by the 4 individual data channels or by the keyboard. A very important characteristic is the programmability of the data logger. Considering the local features of measurement the following values may be varied in 0.1 steps of seconds:

- Delay to avoid the switch off peak effect
- The sampling time
- The sampling frequency
- Switching cycle times.

Result and scoring

The result of the CIPS method is the E_{ON} and E_{OFF} values. The scoring of E_{ON} is the same as the pre-assessment and E_{OFF} scoring values have to be defined.

According the potential results, pipelines are easily affected by stray current. The mainly stray current sources who distort the result are: DC operated railways, trams and fast train (AC) and high voltage lines.

CURRENT VOLTAGE GRADIENT SURVEYS

DCVG method

The DCVG method (similarly to the CIPS survey method) uses the phenomenon of a cathodic protection system of the pipelines. The protective current flows into the coating defect causing voltage gradient on the surface of the soil that can be measured by a sensitive mV meter between the two probes placed on the soil. Due to the on/off switching of the cathode stations this phenomenon is accompanied by a very sensible deflection from the centre position of the mV meter that accurately points out the location of the defect. *Figure 2* shows several typical electrical potential fields of coating defects with the aid of some well-selected equipotential lines.

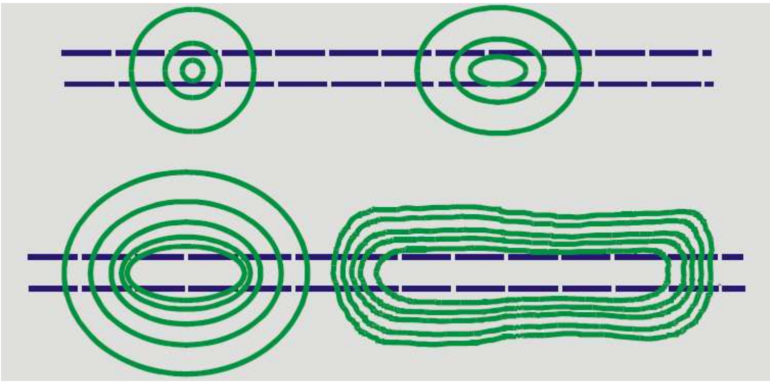


Figure 2 – Electrical potential fields of coating defects

Results and scoring

DCVG will give a severity value for each coating defect. Scoring will be apply in the same way as step one.

For example, DCVG assessment could be:

$$\%IR = \frac{OL/RE}{(ON_{POT} - OFF_{POT}) + OL/RE}.100\%$$

With:

% IR	Severity of coating defect
OL/RE	Over the line-to-remote earth potential
ON_{POT}	ON potential of defect epicenter
OFF_{POT}	Polarized (Instant OFF) potential of defect epicenter

Coating Damage Severity Classification		
Percent IR (%IR)	Coating Damage Severity Class	Score
1-15	*SMALL*	*0.1*
16-35	*MEDIUM*	*0.4*
36-70	*LARGE*	*0.7*
71 ou plus	*VERY LARGE*	*1*

It is to be noted that according to Fluxys experience, very low level of confidence concerning the severity evaluation have been observed. But anyway a coating defect is almost a sine qua non condition to get corrosion evolution excepted for corrosion under disbounded coating (one of the major actual challenge).

THIRD STEP: DIRECT EXAMINATION

OBJECTIVES

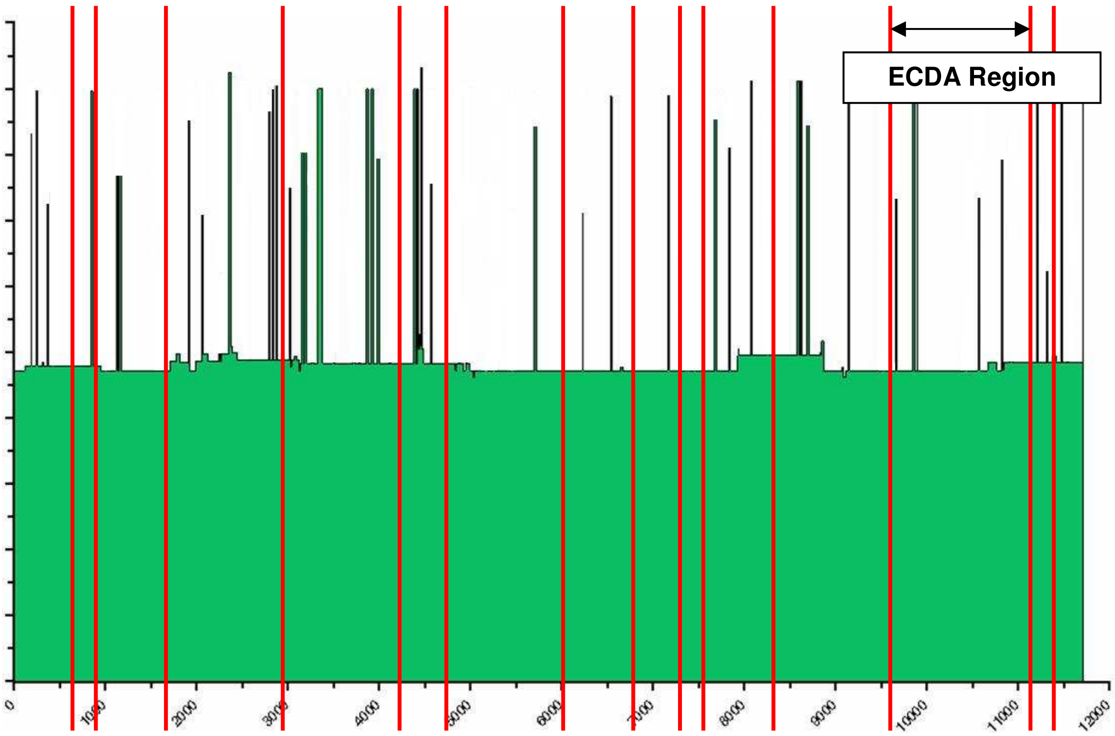
The objectives of the direct examination step are to determine which indications after step 2 are the most severe and collect data by direct examination in order to assess corrosion activity.

All the score of the indirect inspection will be add to the pre-assessment results for analyze.

At least one excavation on each region despite there is or not a significant probability of corrosion has to be done. Not observing corrosion in an excavation where no corrosion is expected by the model is also a valuable information in order to validate the model.

DETERMINING MOST SEVERE INDICATIONS

The following example (*Graphic 2*) shows the result of the indirect inspections superposed with the ECDA regions found during the Pre-assessment.



Graphic 2 – Scoring result

A minimum of one excavation have to be done on each ECDA region. The operator shall establish criteria for prioritizing the need for digging. There is no time requirement for scheduling the excavation, neither order imposed by the standard. However it seems reasonable to take some action directly after the end of the Indirect Inspection step.

Observations during direct examination will be reported according to internal procedure.

Two cases are possible when one excavation is done:

- There is corrosion where there was a probability of corrosion (or there is no corrosion where there was no corrosion expected): the ECDA model is correct.
- There is corrosion where no corrosion was expected (or no corrosion where corrosion expected): the ECDA model is not applicable and has to be reviewed. Iterative process.

CONCLUSION

The direct examination step will validate the ECDA model.

FOURTH STEP: POST-ASSESSMENT

OBJECTIVES

The objectives of the Post-Assessment step are to define reassessment intervals and assess the overall effectiveness of the ECDA process.

This assessment includes the following activities:

- Remaining life calculations. In the absence of an alternative analysis method, the NACE standard recommends an equation to calculate the remaining life of the pipe.
- Definition of reassessment intervals. This step depends of the result of the Direct Examinations. Different ECDA regions may have other reassessment intervals.
- Assessment of ECDA effectiveness.

GENERAL CONCLUSIONS

ECDA uses a very structured and iterative methodology composed of 4 steps, where each of them has their importance in the process.

Fluxys want to validate the ECDA methodology by applying it on a test case. Up to now, only the first two steps have been processed. The first outfindings are:

- The difficulty to collect a significant historical and integrity pipeline data.
- The difficulty to develop of a pertinent scoring model.
- The need to handle a huge amount of data.
- The minimum of one excavation per regions.

References

1. GERG 2.47 : Refining & extending the applicability of ECDA process
2. GERG 2.52 : Validation of ECDA
3. NACE 2002 Standard Recommended Practice RP0502-2002