

## GTI/AGA ECDA Project - Protocol /Implementation Plan Development

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### Abstract

Along with thirty local distribution companies, GTI and AGA are developing a detailed External Corrosion Direct Assessment implementation protocol. This protocol quantitatively defines the procedures, criteria, and methods to carry out a direct assessment in conjunction with the ASME B31.8S and NACE RP0502 standards. The protocol is being used to conduct fifteen assessments under a wide variety of pipeline and environmental conditions throughout the country. The specific assessment criteria and the reasoning behind them are discussed below for the first two steps of direct assessment - Pre-Assessment and Indirect Inspections.

### Introduction

The Gas Technology Institute (GTI) and the American Gas Association (AGA) have developed a collaborative research program to help Local Distribution Companies who operate high-pressure natural gas transmission lines understand the methods and procedures to perform integrity assessments and meet government-imposed regulations. This program includes the development of a standard External Corrosion Direct Assessment (ECDA) inspection protocol that assists companies in the implementation of NACE Standard Recommended Practice - RP 0502-2002, "Pipeline External Corrosion Direct Assessment Methodology". This operational protocol is really a direct assessment implementation plan. Such a plan is part of the requirement of the Office of Pipeline Safety's (OPS) Notice of Proposed Rulemaking (NPRM) entitled, "Pipeline Integrity Management in High Consequence Areas (Gas Transmission Pipeline)".

The NACE ECDA RP directs *users to develop* procedures, methods, criteria, etc. to carry out many of the action items required for Direct

Assessment. The research program includes a task to perform fifteen direct assessments (each on a different companies pipeline segment). It was determined that the detailed protocol was needed to ensure consistency between these assessments. This would allow the data and conclusions to be pooled together to improve the implementation procedure and provide quantitative data on the performance of different tools used under different environmental and pipeline conditions. This paper will discuss several key procedures and criteria that were drafted during the development of the ECDA protocol. Only the first two (of four) steps of ECDA: Pre-Assessment and Indirect Inspections will be discussed below.

### ECDA Pre-Assessment Step

The objective of the Pre-Assessment step of the protocol/standard is to determine three things:

- Can External Corrosion Direct Assessment (ECDA) be used to determine the performance of the coating and cathodic protection system and judge the integrity of the pipe segment(s) relative to external corrosion.
- What two complementary inspection tools can be used to apply ECDA along the pipeline segment.
- What are the start and finish locations of the inspection regions inside these pipeline segments.

Pre-assessment of a pipeline segment is critical and is used throughout the entire ECDA process. An incomplete or cursory attempt at Pre-assessment will negatively affect the accuracy of the External Corrosion Direct Assessment.

This step is not straight forward due to several factors: surveying techniques for various data

sets are usually different, quality terms are frequently missing, easily correlated references may not be written down, and recorded observations are often not detailed enough and may be worded unclearly. Considerable time is required to resolve all the inconsistencies.

Since data integration and validation is labor intensive, an operator should plan to collect observations that will help establish the following:

- A known position in four dimensional space (x, y, z, & time).
- The change in performance of the cathodic protection system (coating and applied potentials).
- The remaining wall thickness at specific locations.
- The changes in corrosion rates (cumulative time where there was no applied cathodic protection, changes to anode beds, potential observations, current observations by historical record or electrical bills, etc).

Poor Pre-Assessment data will lead to increased uncertainty, and could lead to more work later in the process which is expensive. Examples of uncertainty may include:

- The start and finish of each ECDA region.
- The estimate of the scheduled and monitored defect sizes "left behind" after the ECDA evaluation.
- The corrosion rates of these defects (which drives the re-evaluation period).

Therefore properly collected and analyzed prior history:

- Reduces the number of segments where ECDA would be found ineffective.
- Improves the estimation of the sizes of the indications left unexcavated (estimated

defect geometry) and therefore reduces the number of necessary confirmatory digs, possibly leading to an extension of the number of years between ECDA evaluations.

- Can replace the default (accelerated) corrosion rate estimates in NACE ECDA RP 0502 with actual rates and extend the number of years between ECDA evaluations.

Initial procedures included in the protocol included steps to assign the pipeline into segments, recording of the High Consequence Areas (HCA's) as determined by OPS procedures, and the collection of data element information for an entire segment.

In order to assist with the data collection, integration, and analysis of the pipeline segment Pre-Assessment data, a comprehensive Date Element Table (DET) was developed. The table is formatted in a user friendly manner in electronic spreadsheet form. It includes all of the data elements listed in the NACE ECDA RP and additional fields that were felt to be important by the companies participating in the research program. A sample of the first data element is shown in Fig. 1 below.

Element #		1.1
Data Element from NACE RP 0502 Table-1		Material and grade
Element Units/Form	1 - PIPE RELATED	steel, e.g. B, X42, X60, etc.
1. Value/Data		
2. Noted Changes in Element with Time & Space		
3. External Corrosion Trend Analysis (if applicable)		
4. Applicable Tools (CIS, AC/DCVG, Pearson, EM, Cell-To-Cell)		CIS __ ACVG __ DCVG __ EM __ Pearson __ Cell-To-Cell __
5. Justification of Tool Choice (see ECDA RP 0502 Table-2)		
6. Element Affect on Indirect Inspection Tool Selection		ECDA not appropriate for nonferrous materials.
7. Element Factors That May Affect Region Selection		Special consideration should be given to locations where dissimilar metals are joined.
8. Use & Interpretation of Data Element Information		Can create local corrosion cells when exposed to the environment.
9. General Comments		

Fig. 1. Example of Data Element Table Format for first data element, pipe material and grade.

To improve consistency for the research project, and future users of the protocol, a row for "element units/form" was added. Additionally, there are cells/rows to note changes in the data element with time and space, to record external corrosion trend analysis, justify one's tool choice, and record general comments.

The electronic format makes it simple to update over time, send to personnel in the company for comment, and customize for individual operators or segments. Additionally, the protocol and NACE RP requires that the segment be broken up into regions for assignment of indirect inspection tool, etc. A separate DET is then easily generated for each region.

The completed DET conveniently locates the Pre-Assessment data for each region in one spot, along with the reasoning and justifications for the choices made for region selection, tool selection, and assignment of non-feasible and feasible ECDA regions.

### ECDA Indirect Inspection Step

The objective of this step of the protocol/standard is to use above ground tools to identify and define the severity of coating faults, other anomalies, and areas at which corrosion activity may have occurred or may be occurring.

This comprehensive step is broken down into four activities:

- Conduct indirect inspections.
- Identify and align indications from inspections.
- Classify the severity of each indication.
- Compare results for consistency of: 1) each indication with another; 2) indications with preliminary direct exams if done; and 3) indications with Pre-Assessment data.

This process depends on being able to align the inspection results and identify change. In order to determine if indications are minor, moderate, or severe, there must be a noticeable difference from prior observation, inspections, or measurements, therefore resolution and consistency must also be addressed.

Observational differences are only possible if they exceed the resolution of the process being

measured. The volt/amp-meter should be capable of resolving several orders of magnitude greater than the uncertainties introduced by the current traveling through the inhomogeneous pipe to soil path. The developed protocol suggests an observation resolution basis to set reasonable criteria for the identification and classification of minor, moderate, and severe indications.

Inspections are done by different individuals and also by different services providers over time. They also probably have used standards which have changed over time. It is important to understand the uncertainty associated with each, in order to reliably determine the classifications for minor, moderate, and severe indications.

Interval spacing for indirect inspections should be close enough to permit a detailed assessment. The tool selected should be able to detect and locate suspected corrosion activity on the segment. For the research program the recommended interval spacing and measurement units are listed in Table 1 below:

**Table 1 - Recommended Interval Spacing and Measurement Units**

TOOL	RECOMMENDED	
	INTERVAL SPACING (FT)	MEASUREMENT UNITS
CIS	3 to 10	mV (CSE)
DCVG	3 to 6	% IR cathodic/anodic
PEARSON	15 to 25	% of total signal
PCM <sup>1</sup> (EM, AC Current Attenuation)	Maximum depends on conditions Narrowed Down 60-150 Min 10-15	% drop in signal current vs. distance
C-Scan <sup>1</sup> (EM, AC Current Attenuation)	Maximum depends on conditions Narrowed Down 60-150 Min 10-15	% drop in signal current vs. distance

Cell-To-Cell	10 to 20	mV shift: reverse in polarity <sup>2</sup>
4-Pin Resistivity <sup>3</sup>	Start, Finish, 1/3, 2/3 distance along region length	ohm-cm

Notes:

1. AC current attenuation is performed in a continuous manner over the line, varying the distance from transmitter to receiver (usually start at least 25 ft from transmitter).
2. Soil resistivity effects sensitivity.
3. 4-Pin resistivity is not an indirect inspection tool, but will be required for this program.

Timing of inspections should be conducted as close together in time as practical. For the program it was recommended that the inspections be done within the same week to minimize weather variations. Additionally, no major changes to the segment should be made between the first and second tool used for inspection, e.g. installation or abandonment of pipeline facilities.

Aboveground location measurements should be referenced to precise geographical locations (e.g., Global Positioning Systems - GPS) or permanent geographical features (e.g., edge of a road or test station). These above ground references should be clearly documented so that the above and below ground locations can be aligned and used to identify excavation sites.

The use of a large number of easily located aboveground reference points, as noted directly above, will reduce spatial errors in overlaying the various inspection results. For the program, it was recommended to have an easily identified, aboveground reference point/marker approximately every 300 feet. They should be permanent in nature, e.g. gas valve location, manhole cover, telephone pole, fire hydrant, etc.

Once the data is aligned, it is analyzed to determine if any "indications" exist. An indication is defined as information sufficient to locate coating faults regardless of corrosion activity at the fault.

For the program, an "indication" is defined as a change in signal strength (upset condition) which is at least five times the resolution of the equipment being used to conduct the inspection. One must also take into account the specific background electromagnetic "noise" at each site. Prehistory will help with setting the threshold values chosen for "indications". Each assessment will have unique characteristics associated with it that may require special considerations for data collection and analysis.

Once the indications of coating faults and active corrosion are identified, they are assigned a severity classification.

Classification as used in this program is the process of estimating the likelihood of corrosion activity at each *indication* under typical year round conditions. The program selected the following classifications to be used: Severe, Moderate, and Minor.

- Severe - highest likelihood of corrosion activity.
- Moderate - possible corrosion activity.
- Minor - lowest likelihood of corrosion activity.

The following Severity Classifications (Table 2) take into account the capabilities of the inspection tools and for this program was made as stringent as practical. Table 2 below is an attempt to *quantify* the ideas contained within NACE RP 0502 ECDA. It must be emphasized that the values listed for the level of severity are general in nature and can be location specific. In general, severity should always be based on comparing data from two or more indirect inspection methods, history, and conditions peculiar to the pipeline region under study.

**Table 2 - Severity Classification Table**

Tool	Measurement Amplitude Change Of Indication (In Units of Measurement Resolution see Table 1)		
	MINOR	MODERATE	SEVERE
CIS	Small Dips, on & off potentials both > -0.850 (i.e. more negative)	Medium Dips, on potential > -0.850 (i.e. more negative) off potential < -0.850 (i.e. less negative)	Large Dips, on & off potentials both < -0.850 (i.e. less negative)
DCVG	1-35% cathodic both on & off	35-50% cathodic on, anodic or neutral off	50-100% anodic both on & off
PEARSON	1-30%	30-65%	65-100%
PCM (EM, AC Atten. )	1-30%	30-50%	50-100%
C-Scan (EM, AC Current Atten.)	10-25%	25-60%	60-100%
Cell-To-Cell (with soil resistivity)	<10 mV & (>5000 ohm-cm)	>10 mV & (3000-5000 ohm-cm)	>10 mV & (<3000 ohm-cm)
4-Pin Resistivity	>10,000 ohm-cm	3000-10,000 ohm-cm	<3000 ohm-cm

Interestingly, it was very difficult to find operational criteria for indications with the ACVG inspection technique. Only a couple members of the research program had direct operation experience with this technique.

At the end of the research project, it is envisioned that the lessons learned from the 15 assessments will be fed back into the developed protocol. This includes the criteria used for identification of corrosion indications, tool interval spacing, and severity classification cut off values. Additionally, the improved understanding of how various indirect inspection tools perform under specific pipeline and environmental conditions will be compiled and sent to NACE to aid operators in tool selection.

## Conclusions

- 1) Operators are required to develop implementation plans/protocols for direct assessment if they plan to use it. This requires a formal stating of indication criteria, classification criteria, etc.
- 2) There are a variety of above ground inspection tools described in NACE RP0502 however their usefulness in various terrains needs to have better performance numbers than found in the standard.
- 3) Consistency needs to be improved in data collection and manipulation for the Pre-Assessment step.
- 4) Consistency needs to be improved in conducting and reporting the indications from above ground inspections CIS, DCVG, etc.
- 5) The ECDA process is a work in progress and it's successful implementation requires the input and sharing of information from all stakeholders.

## Acknowledgements

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## References

1. NACE RP 0502-2002, Pipeline External Corrosion Direct Assessment Methodology, NACE International, Houston, TX, 2002.
2. External Corrosion Direct Assessment (ECDA) Implementation Protocol (draft), GTI/AGA Research Collaboration, "Pipeline Integrity Management for Natural Gas Transmission Lines Operated by Local Distribution Companies", 2003.

3. ASME B 31.8S-2001, Managing System Integrity of Gas Pipelines, American Society of Mechanical Engineers, 2002.