Technology Today:

Introduction to the Four-Step ECDA Process

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Appalachian Underground Corrosion Short Course

Outline

- Overview of ECDA

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- Phase 1 – Pre-Assessment

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- Phase 1 – Pre-Assessment
- Phase 2 – Indirect Survey

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- Overview of ECDA
- Phase 1 – Pre-Assessment
- Phase 2 – Indirect Survey
- Phase 3 – Direct Examination

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- Overview of ECDA
- Phase 1 – Pre-Assessment
- Phase 2 – Indirect Survey
- Phase 3 – Direct Examination
- Phase 4 – Post-Assessment

Intro to ECDA

- Pipeline Safety Improvement Act of 2002:
  - Identify HCA's
  - Risk assessment to prioritize HCA's
  - Baseline survey
  - Integrity management and reinspection

PHMSA
Pipeline and Hazardous Materials Safety Administration

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Intro to ECDA

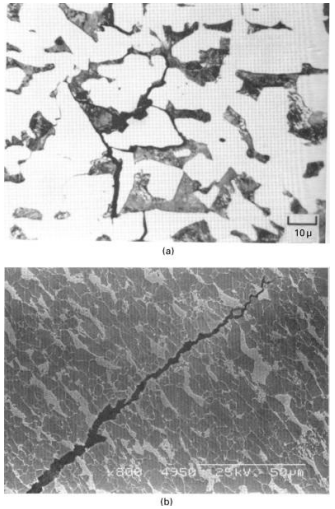
- Baseline survey tools

In-line Inspection

Hydrostatic Testing

ECDA

ICDA



SCCDA

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Intro to ECDA

- Use ECDA (SCCDA or ICDA, as well) only when applicable to the risk.

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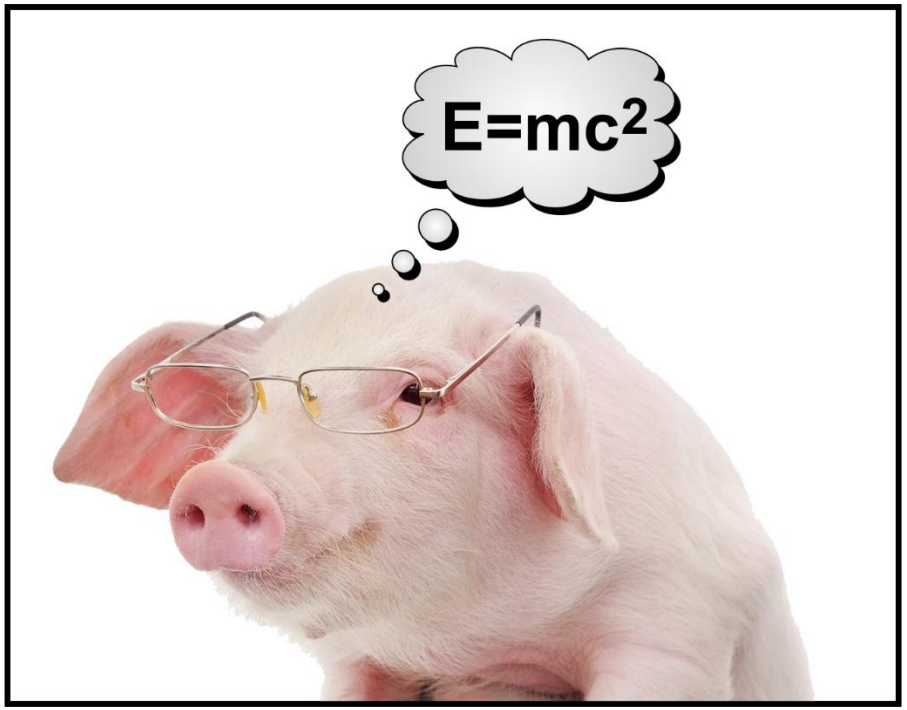
Intro to ECDA

- EXTERNAL CORROSION DIRECT ASSESSMENT: Integrity Management Tool to evaluate the threat of external corrosion on the integrity of a pipeline.

Intro to ECDA

- Inline inspection tool (ILI or “smart pig”) cannot be used.



- Telescopic Connections
- Small Diameter Pipelines
- Short Pipelines
- Sharp Radius Bends
- Less than Full Opening Valves
- No Alternate Supply if Pig is “Hung Up”
- Low Pressure & Low Flow Conditions
- Scheduling and Coordination is an Anti-trust Issue

Intro to ECDA

- Hydrostatic pressure testing cannot be used

- Service Interruptions
- Sole Source Supplies
- Concerns of Causing Pipeline Damage
- Dewatering Concerns/Difficult to Dry
- Growth of Sub-critical Defects
- Water Availability & Disposal
- No Characterization of Future Risk

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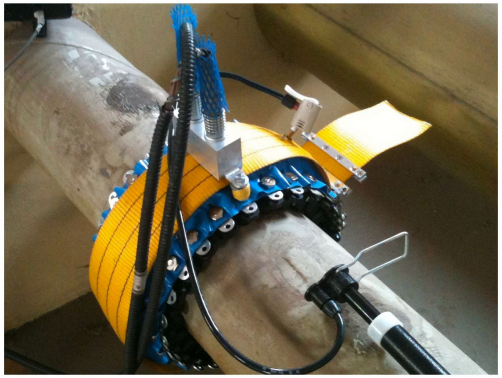
Intro to ECDA

- Spike hydrostatic testing (cracks and crack-like defects)

- Guided wave (road, rail, and concrete crossings)



- Full excavation

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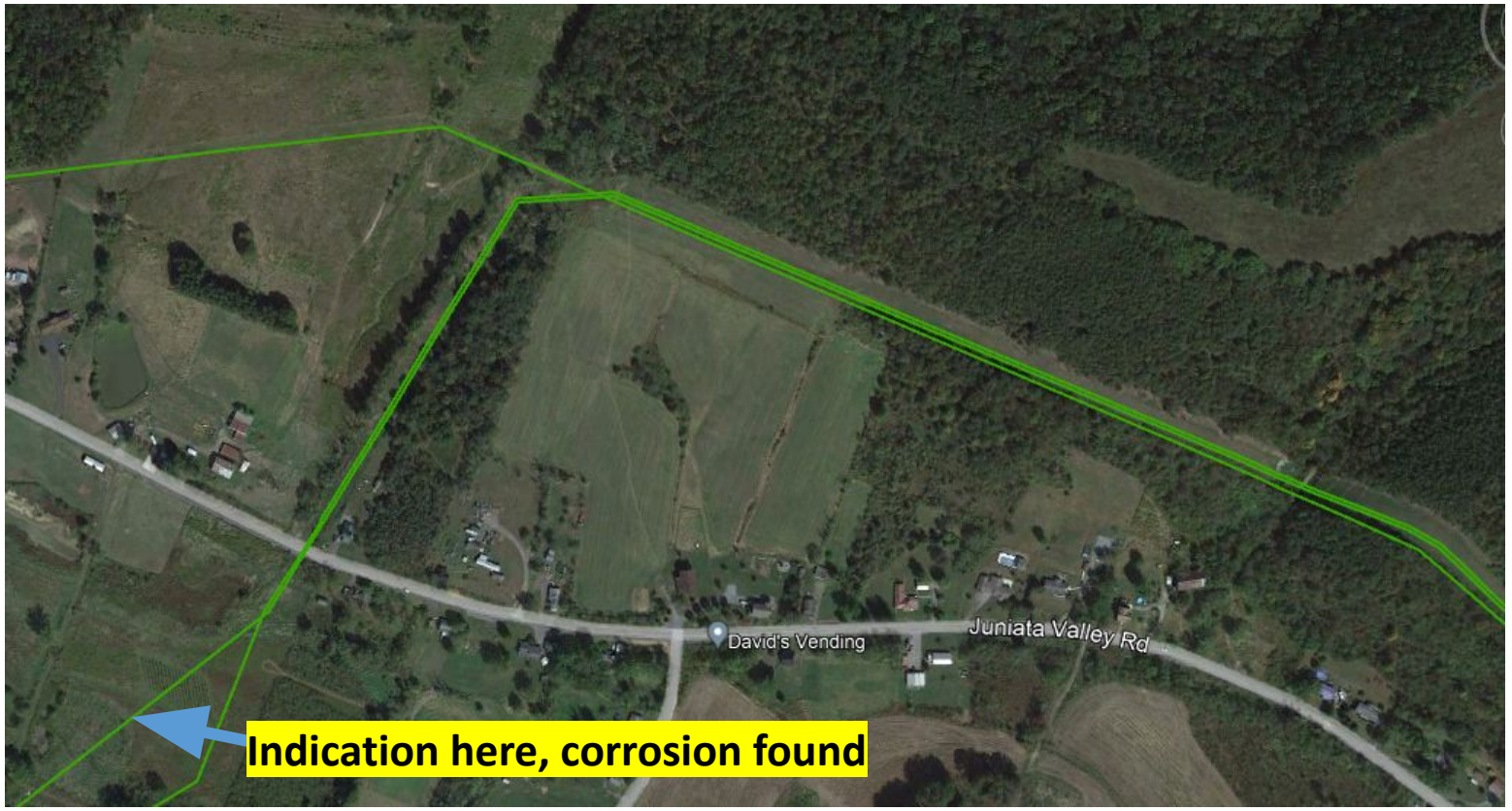
Intro to ECDA



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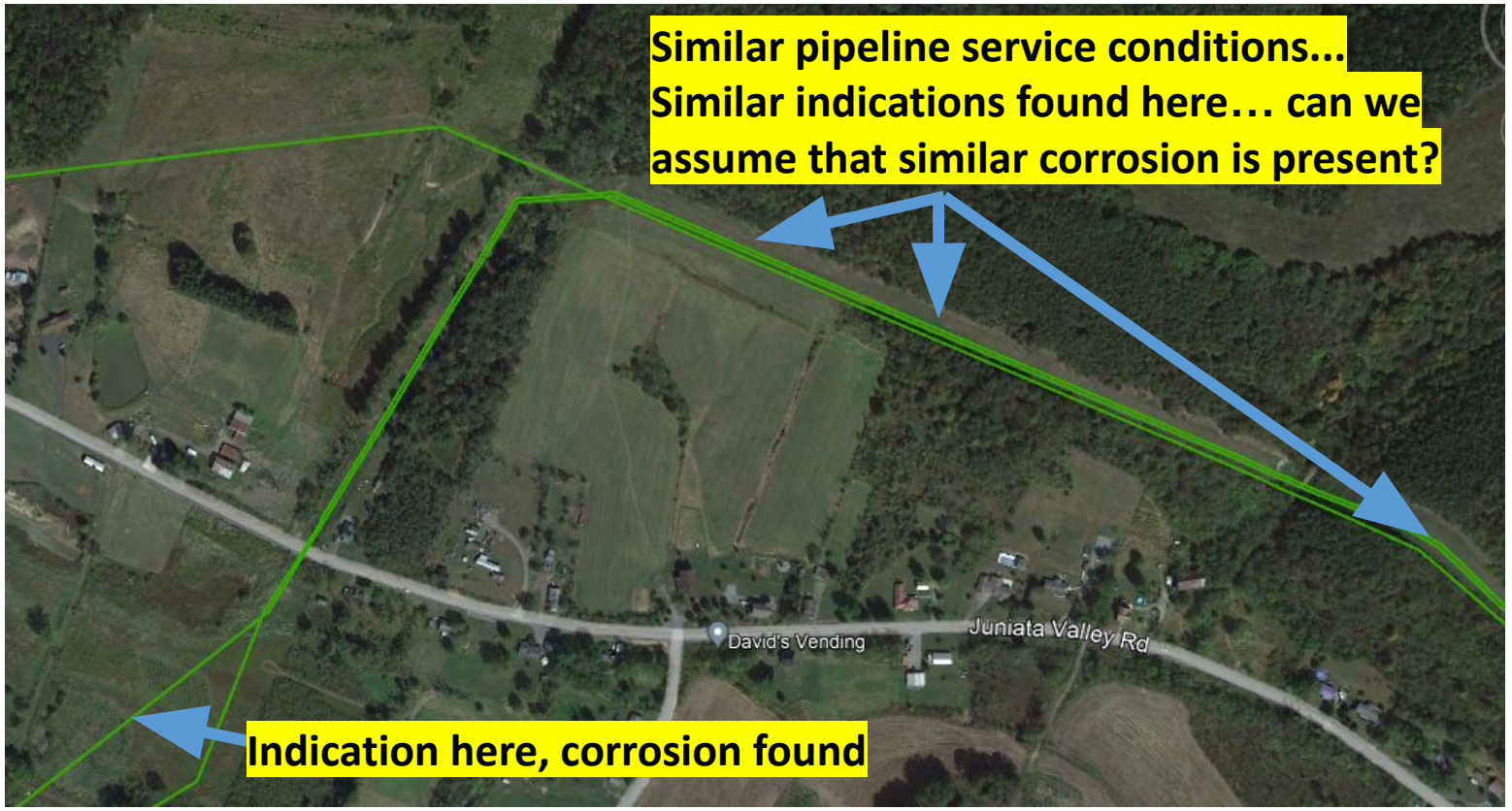

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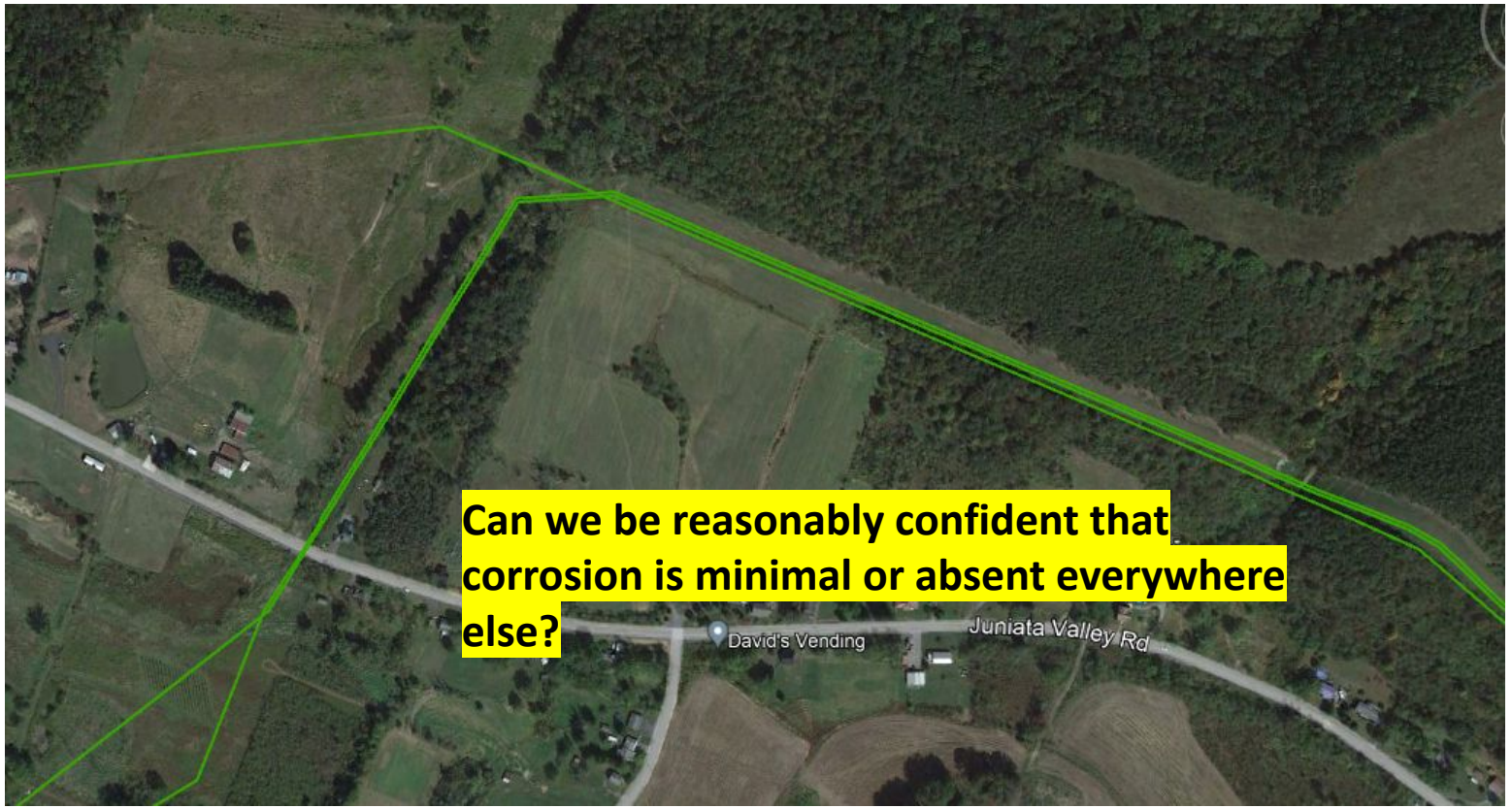
Intro to ECDA



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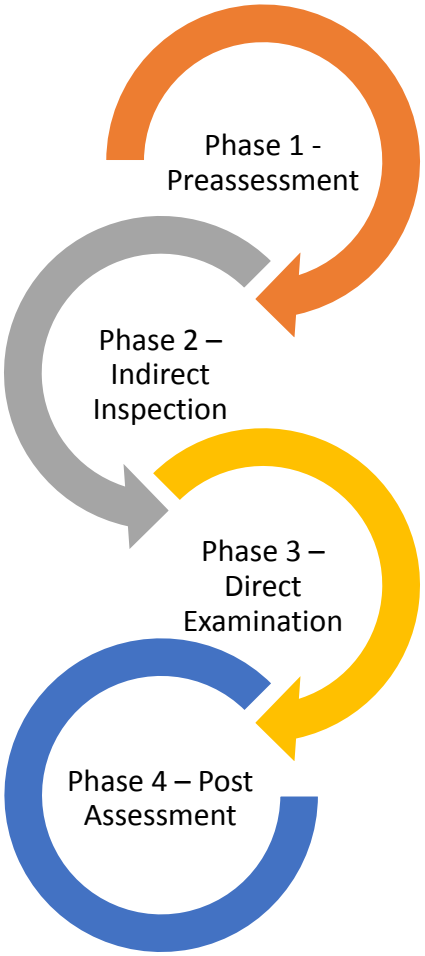
Overview of Four Steps



Data gathering

Overline Survey (CIS, DCVG, ACVG, Soil Res, etc.)

Verification digs and mitigation

Overall assessment and reinspection intervals

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Phase 1 – Pre-Assessment

Data gathering

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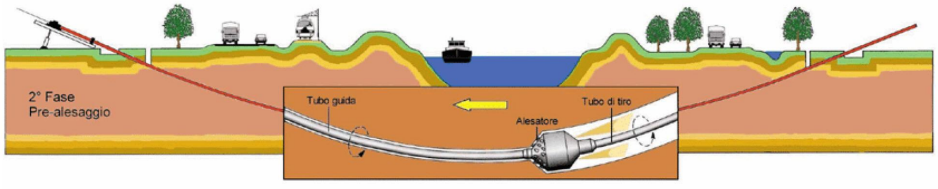
Phase 1 – Pre-Assessment

Service Environment

Pipeline Properties



Construction Information

Corrosion Control

Operations Information

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Phase 1 – Pre-assessment

- Gather information about the pipeline in question:
  - Pipeline materials of construction and weld methods
  - Coating types
  - Operating pressures
  - Wall thickness
  - Diameter
  - Cathodic protection history and history of interference
  - Installation method and depth

Phase 1 – Pre-assessment

- Gather information about the pipeline in question:
  - Has an ECDA been performed or attempted before?
  - Are there HCAs or MCAs?
  - What are the service conditions (soils, water, other backfill)?
  - What maintenance activities have been performed in the past (leak history, replacements, mechanical repairs, recoating, etc.)
  - Are all segments of the pipeline the same age?

Phase 1 – Pre-assessment

- From Phase 1, you will determine:
- Is ECDA still applicable to this pipeline? (did not have CIS, had a history of interference problems, poor maintenance records, poor construction records)
- How many ECDA regions you must segment your pipeline into?
- What types and how many indirect survey tools you will need?

Phase 1 – Pre-assessment

- Remember – ECDA regions do not have to be contiguous
- Not all of the pipeline needs to be evaluated by ECDA for ECDA to be applicable. Other areas will require different assessment methods.

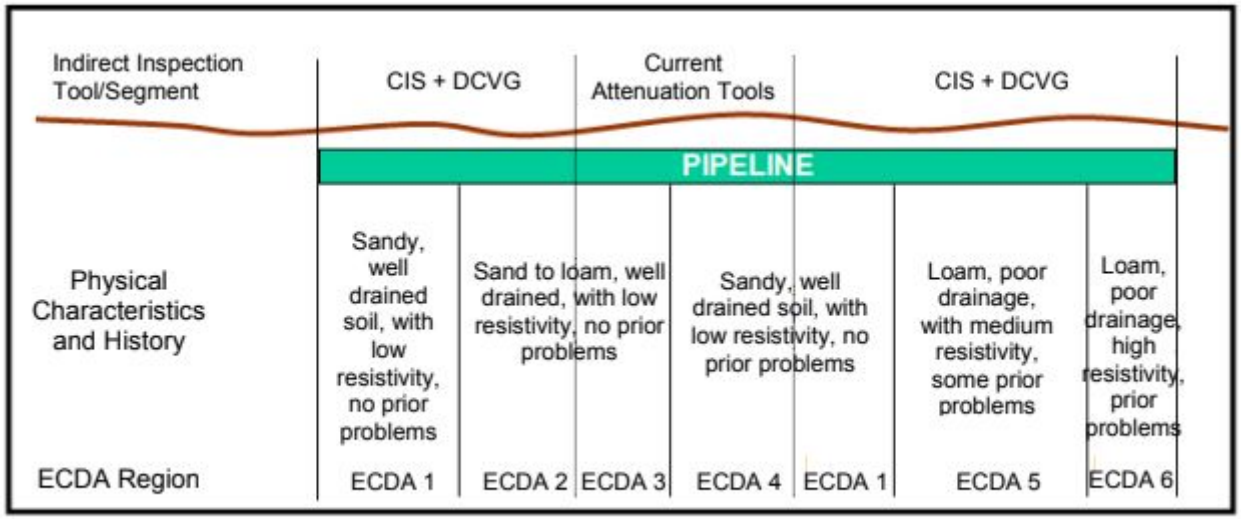

Figure 4: Example Definitions of ECDA Regions

Phase 2 – Indirect Survey

- Examples of Indirect Survey Tools:
  - CIS
  - DCVG
  - ACVG
  - ACCA
  - Pearson Survey
  - Depth of Cover
  - Soil Resistivity

Phase 2 – Indirect Survey

- Examples of Indirect Survey Tools:
  - CIS
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MINIMUM OF 2 COMPLIMENTARY INDIRECT TOOLS PER REGION

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Phase 2 – Indirect Survey

Table 2
ECDA Tool Selection Matrix [A]

CONDITIONS	Close-Interval Survey (CIS)	Voltage Gradient Surveys (ACVG and DCVG)	Pearson[8]	Current Attenuation Surveys
Coating holidays	2	1, 2	2	1, 2
Anodic zones on bare pipe	2	3	3	3
Near river or water crossing	2	2	2	2
Under frozen ground	3	3	3	1, 2
Stray currents	2	1, 2	2	1, 2
Shielded corrosion activity	3	3	3	3
Adjacent metallic structures	2	1, 2	3	1, 2
Near parallel pipelines	2	1, 2	3	1, 2
Under high-voltage alternating current (HVAC) overhead electric transmission lines	2	1, 2	2	2
Under paved roads	3	3	3	1, 2
Crossing other pipeline(s)	2	1, 2	2	1, 2
Cased piping	3	3	3	3
At very deep burial locations	3	3	3	3
Wetlands	2	1, 2	2	1, 2
Rocky terrain/rock ledges/rock backfill	3	3	3	2

KEY

1 = Applicable: Small coating holidays (isolated and typically < 600 mm^2 [1 in^2]) and conditions that do not cause fluctuations in CP potentials under normal operating conditions.
2 = Applicable: Large coating holidays (isolated or continuous) or conditions that cause fluctuations in CP potentials under normal operating conditions.
3 = Applicable where the operator can demonstrate, through sound engineering practice and thorough analysis of the inspection location, that the chosen methodology produces accurate comprehensive results and results in a valid integrity assessment of the pipe being evaluated.

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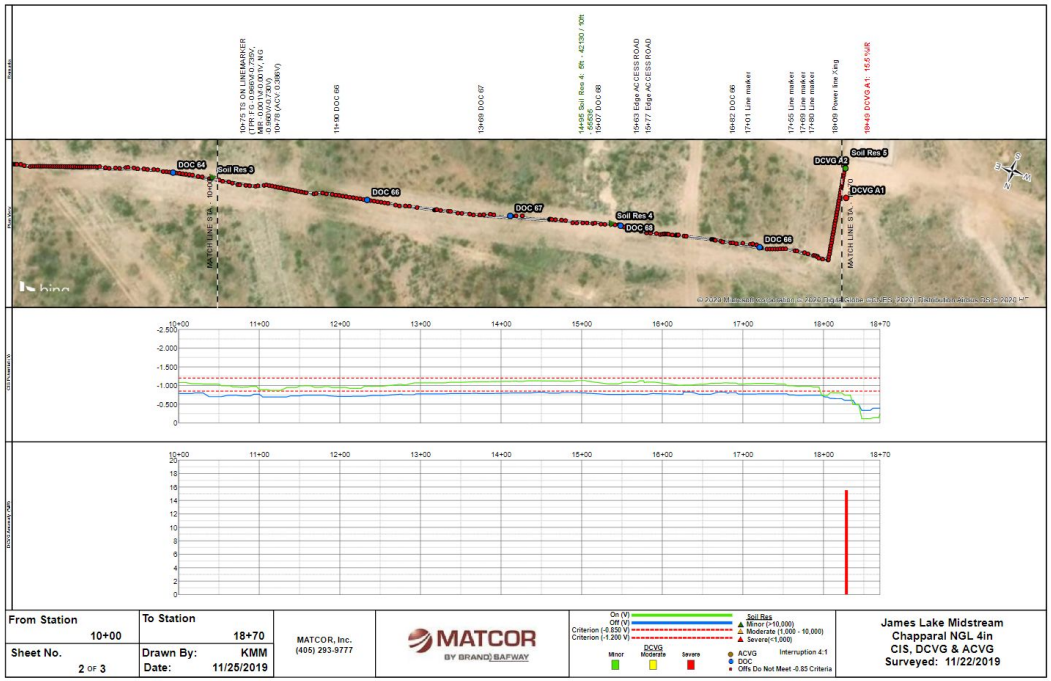
Phase 2 – Indirect Survey

- Data alignment can be challenging:
  - Physical alignment is difficult because of limitations of the tools used
  - When two indications are near each other, how close must they be in order to be related?



Phase 2 – Indirect Survey

- Next challenge is identifying and categorizing defects… particularly for CIS.
- DCVG severity ratings may also be misleading.

Tool	Severity of Measurement Amplitude Change of Indication (In Units of Measurement Resolution see Table 4.4.2)		
	MINOR	MODERATE	SEVERE
CIS[1] (impressed current system)	Small Dips, on & off potentials both are more negative than -0.850 V	Medium Dips, on potential more negative than -0.850 V off potential not more negative than -0.850 V	Large Dips, on & off potentials, both not more negative than -0.850 V
CIS[1] (constant current / sac. anodes) on-reads	Small Dips, more negative than -0.850 V	Medium Dips, not more negative than -0.850 V	Large Dips, not more negative than -0.850 V
DCVG	1-35% cathodic both on & off	35-50% cathodic on, anodic or neutral off	50-100% anodic both on & off
PEARSON (ACVG)	1-30%	30-65%	65-100%
PCM [1] (EM, AC Atten.)	1-30%	30-50%	50-100%
PCM A-Frame (ACVG)	30-50 dBμV	50-70 dBμV	> 70 dBμV (2 ft intervals around defect)
C-Scan (EM, AC 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	1000-10,000 ohm-cm	<1000 ohm-cm

Note 1 - Level of dips depends on conditions peculiar to the pipeline region under study.

Phase 2 – Indirect Survey

- At the end of Phase 2, you will have:
- Again, you need to assess whether the indirect examinations were successful
- A list of indications that have been categorized and paired with other indications

Phase 3 – Direct Examination

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Phase 3 – Direct Examination

- The Direct Examination Step includes the following activities:
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  - Root cause analyses

Phase 3 – Direct Examination

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  - Excavations and data collection at areas where corrosion activity is most likely;
  - Measurements of coating damage and corrosion defects;
  - Evaluations of remaining strength
  - Root cause analyses
  - A process evaluation / reclassification and reprioritization

Phase 3 – Direct Examination

- Prioritization, is the process of estimating the need for direct examination of each indication based on the likelihood of current corrosion activity plus the extent and severity of prior corrosion.

- The three levels of priority are:
  - Immediate
  - Scheduled
  - Monitored

Phase 3 – Direct Examination

Immediate Action Required

- Indications that are likely to have ongoing corrosion activity and that, when coupled with prior corrosion, pose an immediate threat to the pipeline under normal operating conditions.
- Multiple severe indications in close proximity
- Isolated indications that are classified as severe by more than one indirect inspection technique.
- For initial ECDA applications, any location at which unresolved discrepancies have been noted between indirect inspection results.
- Significant prior corrosion is suspected at or near the indication.

Phase 3 – Direct Examination

Scheduled Action Required

- Indications that may have ongoing corrosion activity but that, when coupled with prior corrosion, do not pose an immediate threat to the pipeline under normal operating conditions.
- Severe indications that are not in close proximity to other severe indications and which were not placed in the "immediate“ category.
- Significant or moderate prior corrosion is likely at or near the indications.

Phase 3 – Direct Examination

Suitable for Monitoring

- This priority category should include indications that are considered inactive or as having the lowest likelihood of ongoing or prior corrosion activity.
- All remaining indications not classified as “immediate” or “scheduled” shall be prioritized as “suitable for monitoring”

Phase 3 – Direct Examination

- A minimum of one dig is required regardless of the results of the indirect inspections and pre-assessment steps.
- During the Direct Examination Step, defects other than external corrosion may be found, while defects such as mechanical damage and stress corrosion cracking may be found, alternative methods must be considered for assessing the impact of such defect types.

Phase 3 – Direct Examination

<table>
<tr><th colspan="4">Anytime ECDA is Being Applied (including when ECDA applied for the first time)</th></tr>
<tr><th colspan="3">And There ARE Identified Indications in the Segment</th><th>And There are NO Indications Identified (In the Segment)</th></tr>
<tr><th>Immediate Action</th><th colspan="2">Scheduled Action</th><th>Suitable For Monitoring</th></tr>
<tr><td>All indications that are prioritized as immediate require direct examination.</td><td>If an ECDA Region contains scheduled indications and no immediate indications, then perform an excavation on the most severe scheduled indication in the region.</td><td>If an ECDA Region contains scheduled indications and it contained one or more immediate indications, then perform an excavation on the most severe scheduled indication in the region.</td><td rowspan="2">If an ECDA region contains only monitored indications (i.e., no immediate or scheduled), one excavation is required at the indication most likely to have corrosion.</td><td rowspan="2">Perform at least one excavation in the region identified as most likely for corrosion from the Pre-Assessment Step (pick the location in this region identified as the most likely to have corrosion).</td></tr>
<tr><td>Note: For a segment where ECDA is being applied for the first time, we recommend that at least two direct exams are required per region as described directly above (not including the process validation digs shaded in gray below). If the above only results in one total excavation for the entire region, then at least one more examination is recommended at a random location identified as likely for corrosion.</td><td rowspan="2">Note: For a segment where ECDA is being applied for the first time, at least two direct exams are required per region as described directly above (not including the process validation digs shaded in gray below). If the above only results in one total excavation for the entire region, then at least one more examination is required at a random location identified as likely for corrosion.</td><td>OR - If an excavation at a scheduled indication fails ASME B31G criteria for Immediate Action and that is deeper or more severe than at an immediate indication, then do at least one more direct examination (i.e. the indication with next highest priority).</td></tr>
<tr><td>Indications that were reprioritized from immediate to scheduled follow the scheduled guidelines in the Scheduled columns.</td><td>Note: For a segment where ECDA is being applied for the first time, two additional direct exams are required per region as described directly above (not including the process validation digs shaded in gray below).</td><td colspan="2">Note: For a segment where ECDA is being applied for the first time, at least two direct exams are required per region as described directly above (not including the process validation digs shaded in gray below). If the above only results in one total excavation for the entire region, then at least one more examination is required at a random location identified as likely for corrosion.</td></tr>
<tr><td colspan="4">Process Validation Dig: Perform at least one additional process validation examination at a random location where no indications were detected. This confirms assumptions (for process validation in Post-Assessment).</td></tr>
</table>

<table>
<tr><th colspan="2">ADDITIONAL Requirement When ECDA is Being Applied for the FIRST Time Only</th></tr>
<tr><th>And There are Identified Indications in the Segment</th><th>And There are no Indications Identified (In the Segment)</th></tr>
<tr><td>Process Validation Dig: Perform at least one additional (to any other one listed in this table) excavation, randomly selected and categorized as scheduled (or monitored if no scheduled indications exist)in the location identified as most likely for corrosion from the Pre-Assessment Step. This confirms assumptions (for process validation in Post-Assessment).</td><td>Process Validation Dig: Perform at least one additional (to any other one listed in this table) excavation in the region identified as most likely to have corrosion from the Pre-Assessment Step (pick the location in this region identified as the most likely to have corrosion). This confirms assumptions (for process validation in Post-Assessment).</td></tr>
</table>

Phase 3 – Direct Examination

Example	First Application of ECDA	Number of Indications in SEGMENT			No. of Non-Validation Digs Required from Indications (from each priority)	Additional non-validation digs needed when using ECDA the first time	No. Validation Digs (for Post-Assessment Step)	Total Digs
		Immediate Action	Scheduled Action	Suitable For Monitoring				
A	Yes	4	3	2	4+1+0	2	2	9
B	No	4	3	2	4+1+0	NA	1	6
C	Yes	0	4	1	0+1+0	1	2	4
D	Yes	1	0	0	1+0+0	1 (recommended)	2	4
E	Yes	0	0	0	0+0+0 +1 (at most likely location for corrosion)[1]	1	2	4
F	No	0	0	0	0+0+0 +1 (at most likely location for corrosion)[1]	NA	1	2
G	Yes	0	0	3	0+0+1	1	2	4
H	No	0	0	3	0+0+1	NA	1	2

Excavation – number of digs

FAQ: How large does an excavation need to be?

Excavation – number of digs

FAQ: How large does an excavation need to be?

- Large enough to capture entire “indication” area
- Some operators require a full 40-foot section of pipe
- Excavation may require widening depending on findings – corrosion and coating damage may require widening

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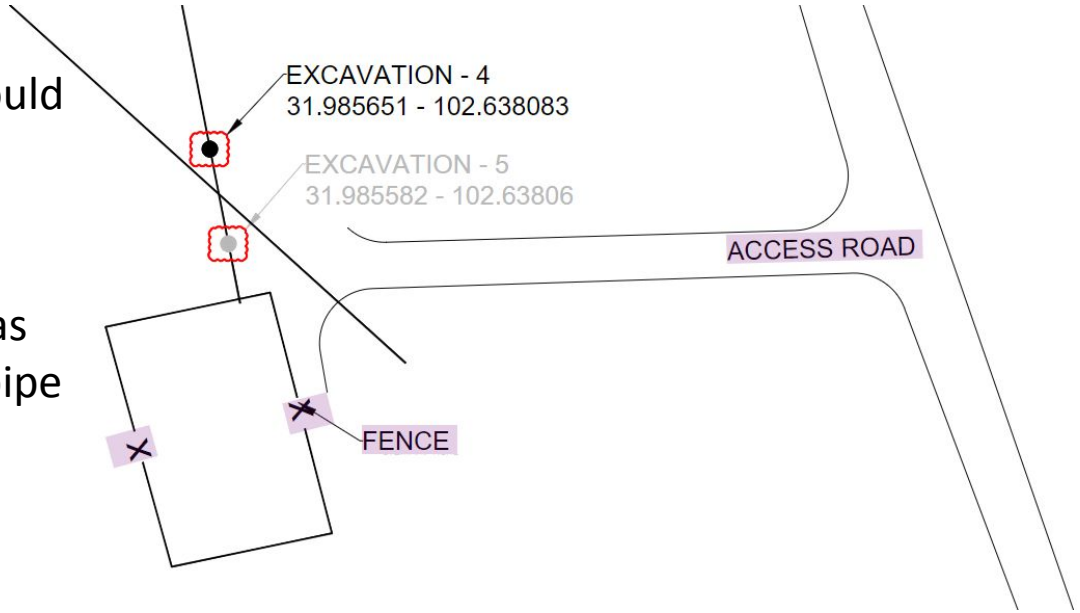
Excavation – number of digs

FAQ: How far apart must two excavations be spaced to be considered separate?

Excavation – number of digs

FAQ: How far apart must two excavations be spaced to be considered separate?

- Indirect survey indications should be distinctly separate
- Excavation sites should be separated enough to provide as wide a representation of the pipe condition as possible



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Data Collection

- Environmental Information
  - Pipe-to-soil potentials

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Data Collection

- Environmental Information
  - Pipe-to-soil potentials
  - Soil resistivity

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Data Collection

- Environmental Information
  - Pipe-to-soil potentials
  - Soil resistivity
  - Soil samples
  - Groundwater samples

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Data Collection

- Environmental Information
  - Pipe-to-soil potentials
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  - Soil samples
  - Groundwater samples
  - Under-coating pH

Data Collection

- Coating and Corrosion Damage information
  - Coating type

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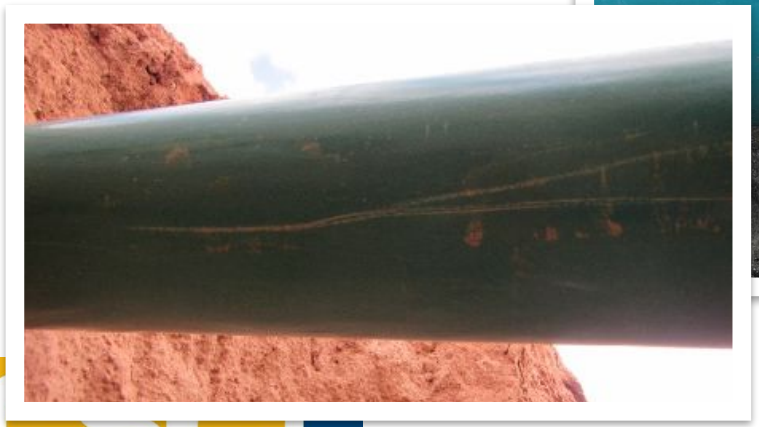
Data Collection

- Coating and Corrosion Damage information
  - Coating condition

- ❑ Cracking
- ❑ Blistering
- ❑ Chipping
- ❑ Disbondment
- ❑ Scrapes



Data Collection

- Coating and Corrosion Damage information
  - Coating thickness

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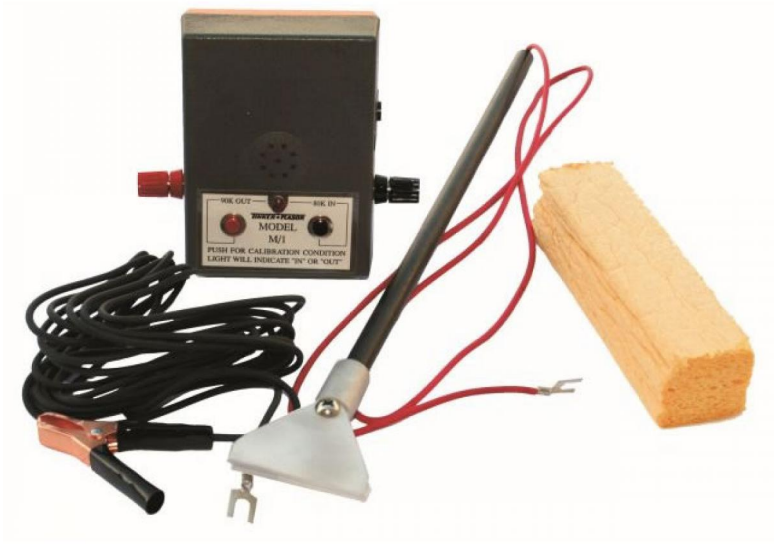
Data Collection

- Coating and Corrosion Damage information
  - Mapping of coating degradation



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Data Collection

- Coating and Corrosion Damage information
  - Corrosion product collection

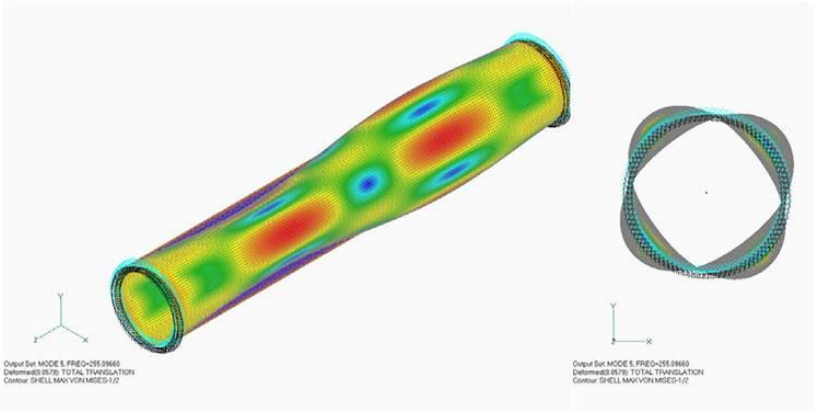
Data Collection

- Coating and Corrosion Damage information
  - Characterize corrosion defects

Data Collection

- Coating and Corrosion Damage information
  - Mapping and measurement of corrosion damage

- Individual pit shapes and sizes
- Overall profile of corrosion (pit map)
- Sample of corrosion product (if possible)
- Photographs of corrosion
- Pipe wall thickness



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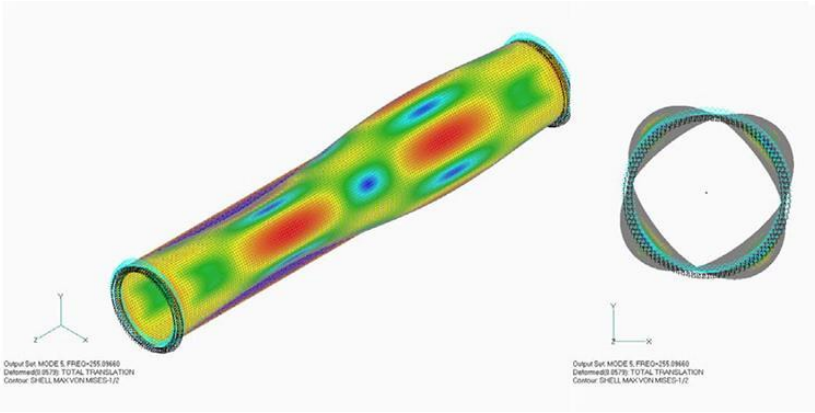
NEW MEGA RULE REQUIREMENTS AROUND CHARACTERIZING DENTS



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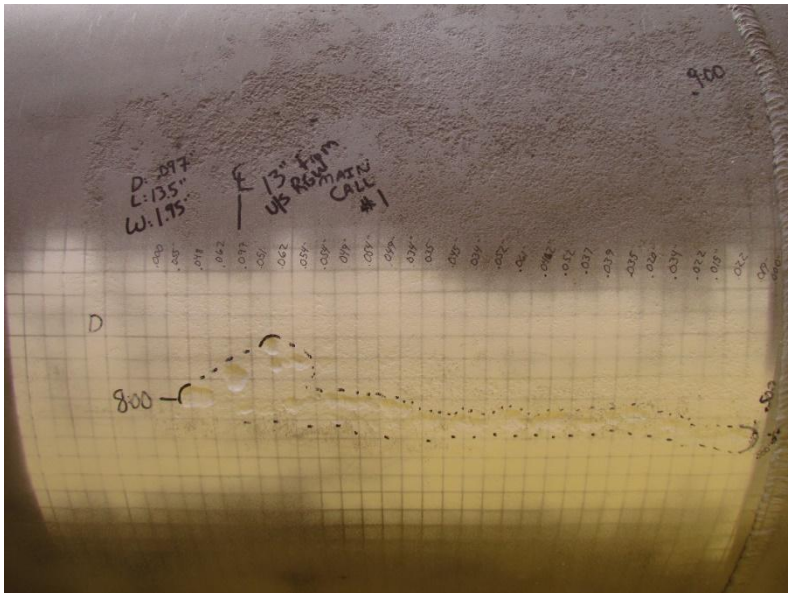

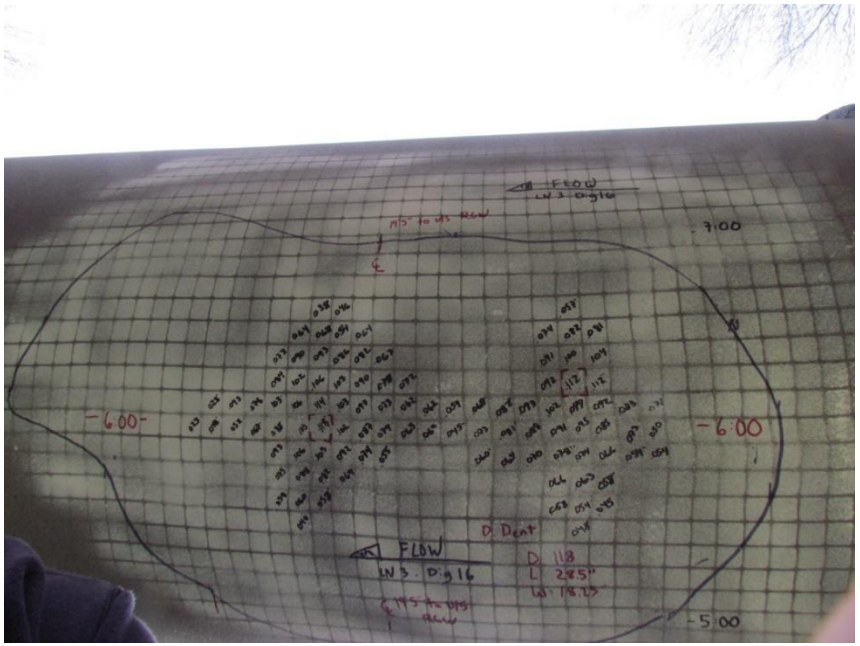

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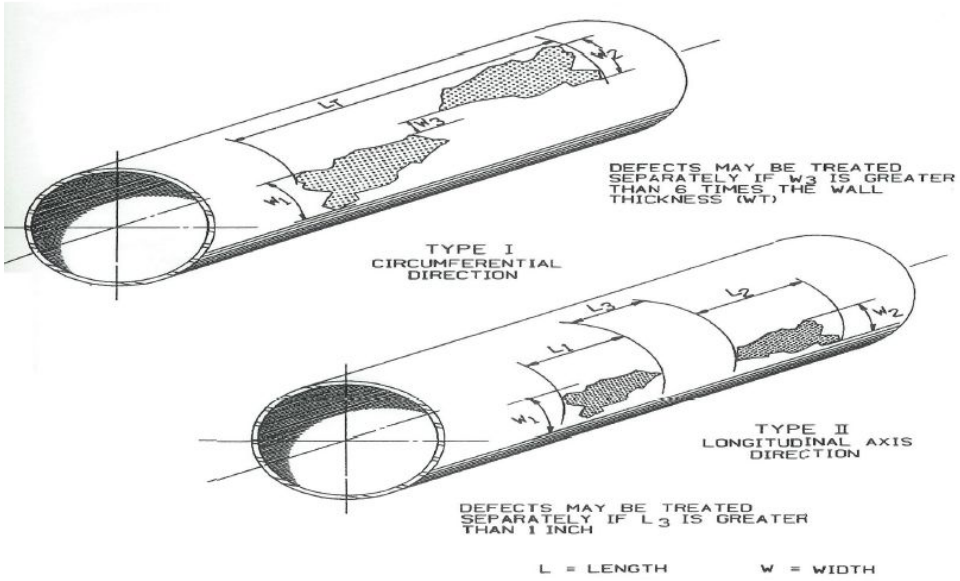
- Coating and Corrosion Damage information
  - Mapping and measurement of corrosion damage



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Data Collection

- Coating and Corrosion Damage information
  - Photographic documentation

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Data Collection Sheet

Piping Inspection and Remedial Action Report

Part A - Facility Description and Location

1. System or Facility Name: James Lake Midstream – Chaparral NGL 4-inch Pipeline, Goldsmith, TX
2. Cost Center:
3. Survey Data: Direct inspection location 4 of 5
4. Station No.: From: To:
5. GPS Coordinates: N: 31.985651 W: 102.638083 ☐ Survey ☒ Handheld Unit Used: Trimble
   Datum: ☐ NAD 27 ☐ NAD 83 ☐ WGS 72 ☒ WGS 84 ☐ Other:
6. City, County (Parish), State: Goldsmith, Ector County, TX
7. Type of Facility: ☐ Mainline ☐ Pig Trap ☐ Platform Riser ☐ Meter Station ☐ Block Valve Site ☒ Other (Describe) Lateral Pipeline ☐ Pump or Compressor Station ☐ Storage
8. AFE/WBS Element No.: Trunk Line Chart and/or Alignment Sheet #:

Part B - Purpose

1. ☒ Inspection ☐ Repair
2. Activity Causing Inspection or Repair: ☐ Construction Crossing ☐ Third Party Report ☐ Annual Riser Inspection ☒ Other: ECDA ☐ Routine Operation ☐ Maintenance /Repair ☐ Hydrostatic Test ☐ 5 Year Navigable Waterway Inspection ☐ Instrumented Pig Survey ☐ Aerial Patrol ☐ Scheduled Aboveground Inspection

Part C - Inspection Results

1. Components Inspected: ☒ Coating or paint only ☐ Repair Sleeve/Patch ☐ Other ☒ Pipe ☐ Fitting ☐ Bend ☐ Valve ☐ Pipe Coupling ☐ Pump/Compressor
2. Burial: ☐ Aboveground ☒ Below ground/Burial Depth: 78 inches to top of pipe
   Soil Type: ☐ Clay/Gumbo ☒ Rocky ☒ Sandy ☒ Loam ☐ Silt ☐ Other:
3. Was Commodity Leaking? ☐ Yes ☒ No
4. Coating: Type FBE Disbonded? ☐ Yes ☒ No % Disbonded
   Condition: ☐ Excellent ☒ Good ☐ Fair ☐ Poor ☐ Bare
5. Pipe-to-Soil Potential: @ Grade Level +0.100 vdc @ Pipe Depth +1.570 vdc.
6. Soil Condition ☒ Dry = 14,400 Ohm-cm² ☒ Wet = 3,300 Ohm-cm²
7. Corrosion: ☐ None ☒ External ☐ Internal ☐ Active ☐ Inactive ☐ Undetermined
8. Mechanical or Construction Damage: ☐ None ☐ Gouge ☐ Plain Dent ☐ Gouge in Dent ☐ Arc Burn ☒ Other (Description) Coating damage
9. Location of Condition ☒ Body ☐ Longitudinal Seam Weld ☐ Fabrication/Construction Weld ☐ Mechanical Seal/Gasket/Packing ☐ Other (Describe)
10. Description of Component(s) with Reportable Condition Nominal Diameter 4 Inch
    Nominal Wall: 0.237 In. Measured Wall: 0.231 In. Grade X52 Seam Type ERW
11. Dimensions of Condition Depth 0.055 in. ☒ Minimum Remaining Wall 0.182 in., Length 2 in.
12. Inspector Name: Ethan Delno, Kevin Groll Date January 21, 2020

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20. Additional Notes or Observations:

Pipeline coating damaged from backfill. Total of 82 through-coating anomalies found through visual inspection and low-voltage holiday detection. All coating damage was between 9 o'clock and 3 o'clock positions with most defects between 11 o'clock and 1 o'clock positions.

Four anomalies exhibited measurable corrosion pitting. Corrosion pit depth and location measurements are detailed in the sketch and RSTRENG calculations included with this form. Measurements confirmed that the pipeline can continue to operate safely at the current MAOP without any structural repairs.

The deepest corrosion pits were centered around old exothermic weld which had not been properly coated. Corrosion likely occurred due to galvanic reaction between the copper weld metal and the pipe steel in the presence of moisture and contaminants trapped below the disbanded repair coating.

Additionally, the electropositive structure-to-soil potentials measured at pipe depth indicate possible DC interference from the bare foreign line (operated by DCP Midstream) that crosses to the Chaparral 4" NGL line at the south end of the excavation.

Soil pH = 6.0 (as measured with antimony electrode)
pH on pipe surface at coating defect = 7.0 (as measured with litmus paper)
Measured coating thickness = 18.0 mils
Structure-to-soil potential at pipe depth (south end near foreign line) = +1.570 VDC vs. CSE
Structure-to-soil potential at pipe depth (north end) = +0.800 VDC vs. CSE

Recommendations: Removed damaged coating and apply repair coating. Further investigation is needed to determine the cause of electropositive potentials measured at pipe depth. DC influence or interference from the nearby foreign pipeline is likely. New test leads, bond wires, and sacrificial magnesium anodes were installed on the Chaparral 4" NGL line by others at the time of the direct assessment. Testing should be confirmed to quantify the DC interference issue and the effectiveness of the interference mitigation provisions.

21.

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Data Evaluation

Remaining Life:

- ASME B31.G and Modified B31.G
- RSTRENG
- DNV RP F101

Data Evaluation

Action Reassessment:

- Was the corrosion damage as expected?
  - If yes – proceed with other excavations as planned
  - If no – reassess excavation priority
- Priority can be moved up
- Priority can be moved down only 1 level
- First time ECDA cannot be moved down
- If ECDA results do not match expected findings, was ECDA effective and appropriate?

Data Evaluation

Root Cause Determination:

- Does root cause of corrosion align with ECDA findings?
- Can ECDA be used in the future to evaluate this pipeline given the root causes of corrosion?

Phase 4 – Post-assessment

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Phase 4 – Post-assessment

Bring all data together:

- Define re-assessment intervals
- Assess overall effectiveness of ECDA program
- Remaining life calculations
- Feedback & Continuous Improvement

Phase 4 – Post-assessment

Reassessment intervals based on

- All immediate indications have been addressed during direct examination
- All monitored indications are expected to experience insignificant growth
- Remaining life calculations
- Must not exceed DOT 192.939

Phase 4 – Post-assessment

DOT 192.939

- Pipelines operating at or above 50% SMYS
  - Direct Assessment every 10 years
  - Confirmatory Direct Assessment every 7 years
- Pipelines operating at or above 30% SMYS, up to 50% SMYS
  - Direct Assessment every 15 years
  - Confirmatory Direct Assessment every 7 years
- Pipelines operating below 30% SMYS
  - Direct Assessment every 25 years
  - Confirmatory Direct Assessment every 7 years

Phase 4 – Post-assessment

- When corrosion defects are found during the direct examinations, the maximum reassessment interval for each ECDA region shall be taken as one-half the calculated remaining life
- Different ECDA regions may have different reassessment intervals based on variations in expected growth rates between ECDA regions

Phase 4 – Post-assessment

Remaining life calculations

- If no corrosion defects are found, no remaining life calculations are needed, the remaining life can be taken as the same for a new pipeline
- The maximum remaining flaw size shall be taken as the same size as the most severe indication
  - Root cause shows most severe indication is unique, use next most severe indication
  - Substitute based on more sophisticated method

Phase 4 – Post-assessment

Assessment of ECDA effectiveness

- Are the ECDA results from Phases 1 through 4 congruent?
- Did you find what you expected to find?
- Can ECDA be used as a reliable integrity management tool based on your findings?
- What steps can be taken to improve the integrity management process for your pipeline segment?

Phase 4 – Post-assessment

Does ECDA really work?

YES, BUT…..

- It will not work for all pipeline segments
- The results of the indirect inspections may lead you to utilize ILI or pressure testing
- All four steps in the ECDA process must be completed thoroughly and documented

Phase 4 – Post-assessment

- Documentation, Documentation, Documentation
- Detail procedures
- Share information
- Expect to revise your procedures
- ECDA is only one part of your company's Pipeline Integrity Management Program

Thank You!

Questions?

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