WHEN TRUST MATTERS

SCC Field Inspection Protocol

Appalachian Underground Corrosion Short Course

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Scope of Presentation

- Data Requirements for SCC DA
- Preparation for Field Inspection
- Safety Considerations
- Protocol For Data Collection and Inspection
- Measurement and Sentencing of SCC
- Measurement and Sentencing of Other Defects

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SCC DA Process (SP 0204-2015)

- **Four Steps**
  - Pre-Assessment
    - Gather existing data
  - Indirect Inspections
    - Above-ground measurements
  - Direct Inspections
    - In the ditch
  - Post-Assessment
    - Evaluate what you found
    - Evaluate effectiveness of SCCDA approach

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NACE SP 0204 Requirements

- **Data Necessary to Confirm Integrity of Pipeline (Required)**
  - Pipe diameter and wall thickness
  - Seam weld type
  - MPI inspection results
  - Location and size of SCC clusters
  - Photographs of crack clusters following MPI
  - Results of crack length and depth measurements
  - Identification and measurement of corrosion defect dimensions
  - Presence and sentencing of any other defects found on the pipe
- **Additional Data Collected (Optional)**
  - Scope based on goals of the SCC DA program

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Record Keeping

- **Record Keeping**
  - One of the Most Important Parts of the SCC Dig Program
- **Documentation**
  - Common references for measurements
    - Exact chainage of dig limits and upstream girth weld
    - Flow direction and orientation
  - Field notes
  - Photographs

Information to Include in Photographs

- **Overview Photographs**
  - Landmarks & topography
  - Measuring tape (if possible)
  - Dig chainage
- **Close-Up Photographs, Use Label With:**
  - Colony or indication number
  - Exact chainage
  - Flow direction
  - Distance from upstream girth weld
  - Orientation with respect to top of pipe, looking downstream
  - Ruler or measuring tape

Prior to Field Inspection

- **Complete Pre-Assessment and Indirect Inspections**
  - Select dig sites
- **Assemble SCC Inspection Team**
- **Inform Landowners**
- **Decide On Method Of Pipe Cleaning**
  - Walnut shells/soft blast media
  - High Pressure water blasting
  - Grit blasting

Pipe Cleaning Pros and Cons

Cleaning Method	Advantages	Disadvantages
Water Blast	Rapid Cleaning Minimal Pipe Surface Damage	Messy Equipment Intensive
Walnut Shells/ Soft Media	Minimal Pipe Surface Damage Not Messy	Very Slow Allergies
Grit Blasting	Rapid Cleaning Minimal Mess	Damage Can Mask SCC

Prior To Field Inspection

- **Decide on Amount of Pipe to Inspect at Each Site**
  - Length of pipe
  - Number of girth welds
  - Longitudinal seam weld
  - Poor or damaged coating areas vs. total surface area
- **Typical Protocol**
  - Examine one joint of pipe including two girth welds
  - Examine all areas where coating is damaged
  - Examine all of the long seam

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Prior to Field Inspection (continued)

- **Get Contracts In Place**
  - Construction - backhoe & labor
  - Pipe cleaning crew
  - NDE crew
  - SCC expert (Internal or External)
- **Prepare Equipment and Materials (Consumables) List**
  - Some general items
  - Some company specific items

Perform Dig Program Safely

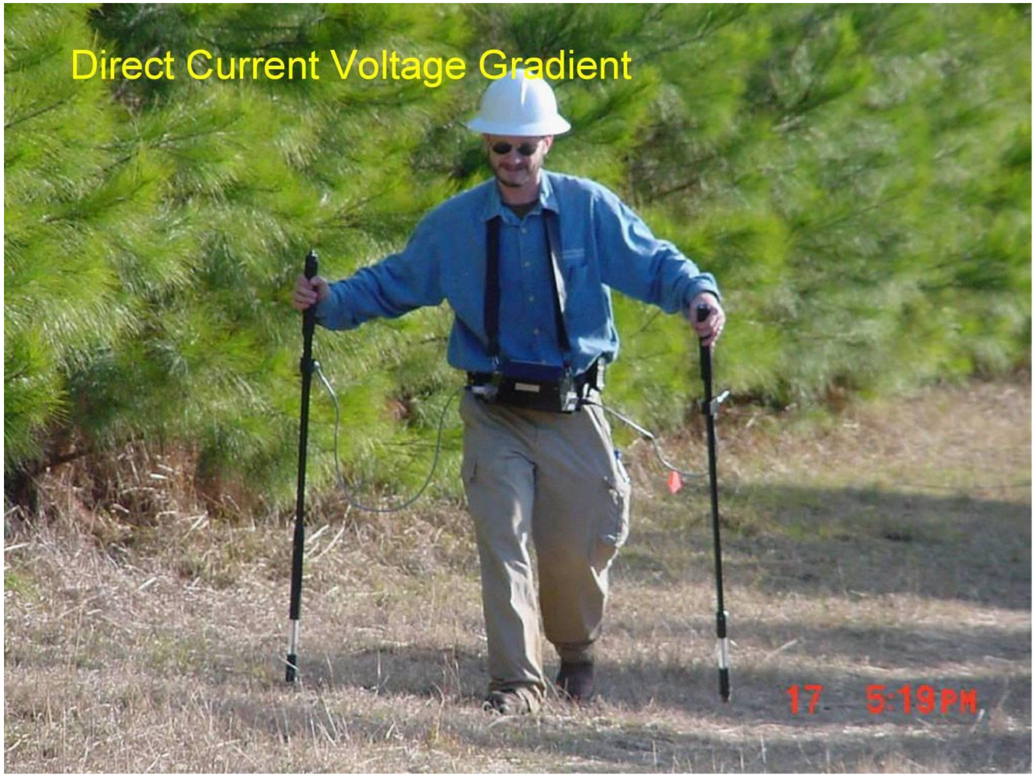
- **Perform Safety Review and Provide Safety Training to Crews**
  - Most Digs Require Pressure Reduction on Pipeline
    - Typically 20%
    - Exception (inspecting low pressure pipeline)
  - Follow Other Applicable OSHA (29CFR 1926 Subpart P) and Company Policies
    - Dig slope angle
    - Proximity of vehicles and other ignition sources to dig site
    - Personal safety gear (fire retardant clothing, hard hats, eye protection, hearing protection, hard toed footwear)

Prior to Field Inspection

- **Verify Data Used for Site Selection**
  - ILI Indication
  - Above Ground Inspections
- **Close Interval Survey (CIS)**
- **Coating Fault Surveys**
  - DCVG
- **Soil Verifications**
  - Topography
  - Drainage
  - Soil Type (core sample)

Close Interval Survey at Dig Site

DCVG Measurement at Dig Site

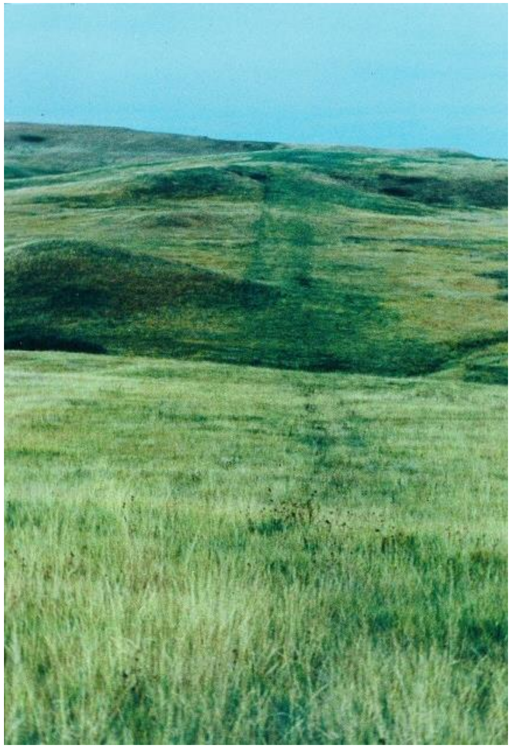


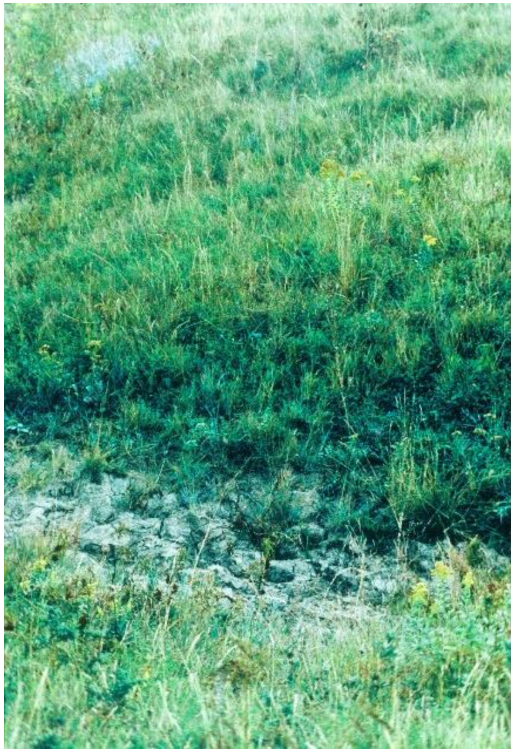
Taking a Soil Core Sample

Soil Core Sample

Topography

Topography (continued)





Exposing Pipe

- Clear Topsoil And Stockpile For Site Reclamation
- Begin Dig
- Take “on” and “off” Pipe-to-Soil Potential Measurements At Both Ends of Each Dig Site
  - At ground level
  - Near surface of the pipe

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Soil And Groundwater Sampling

- **Soil**
  - Obtain at least four samples from each dig site
    - One at each end of the dig
    - One at 3:00 or 9:00 o'clock location near pipe
  - Photograph soil samples and describe texture and color
    - Record any odor
    - Gray-black color and rotten egg smell usually indicate anoxic conditions
    - Tan color usually indicates oxic conditions
- **Obtain Uncontaminated Groundwater Sample from Dig**

Examination of Pipe and Coating

- **Photograph Ditch and General Appearance of Pipe**
- **Record Long Seam Weld Orientation for Each Joint**
  - If possible
- **Locate Girth Weld(s)**
- **Measure Length of Joints**
- **Clean Loose Debris From Coating With Rags**

Dig and General Appearance of Pipe

Dig and General Appearance of Pipe (continued)

Examination of Pipe and Coating

Examine Coating Very Carefully

- Overall coating condition
- Local coating damage
- Sagging
- Bulging and wrinkles
- Electrolyte under coating
- Adhesion failure
- Mechanical damage

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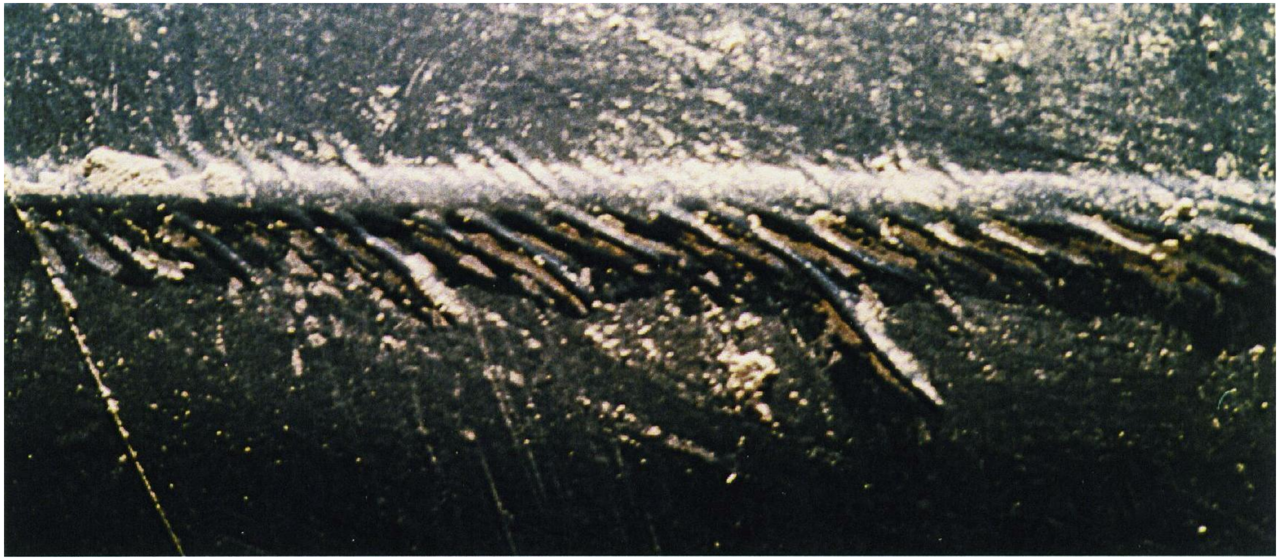
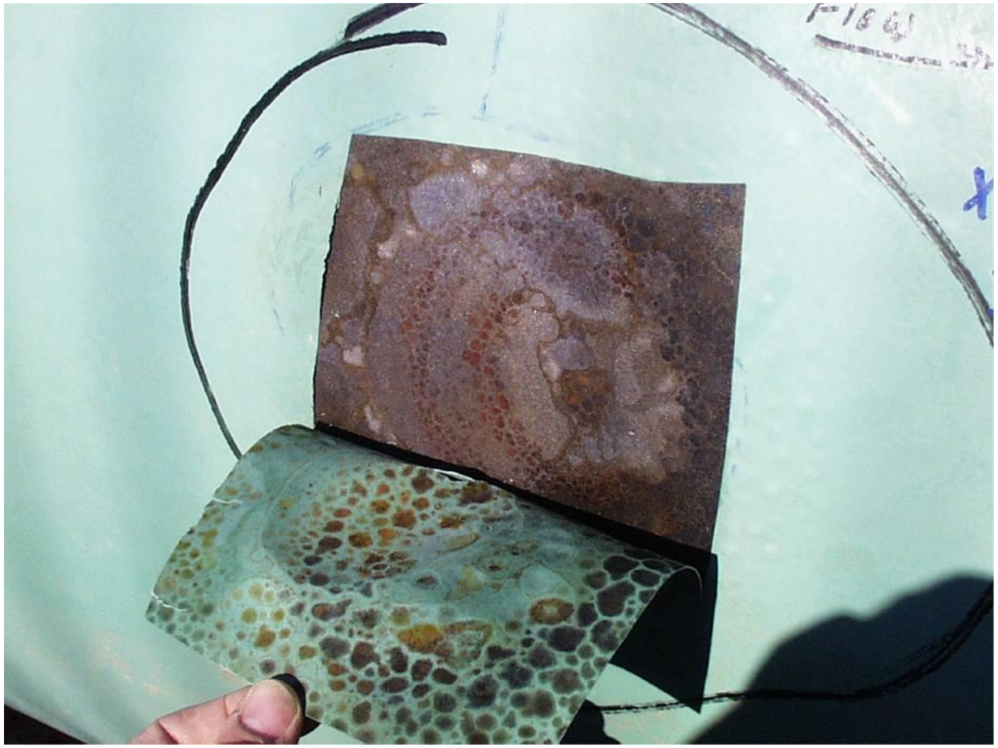
Disbonded (Unbonded?) Tape Coating

Tenting of Tape Coating at Long Seam



Missing/Disbonded Asphalt Coating

Blistered FBE Coating



Missing/Disbonded Coal Tar Coating

Examination of Coating

- **Look for Trapped Electrolyte and Deposits (Run Hands Over Coating Protrusions)**
- **Obtain Electrolyte Samples from Under Disbonded Coating With Syringes (Obtain as Many Electrolyte Samples as Possible)**
  - Measure electrolyte pH with pH paper
  - Store in argon filled test tubes
- **Measure, Record, and Photograph All Locations of Damage and Where Electrolyte Samples Were Taken**
  - Record locations with respect to upstream girth weld and orientation on pipe looking downstream

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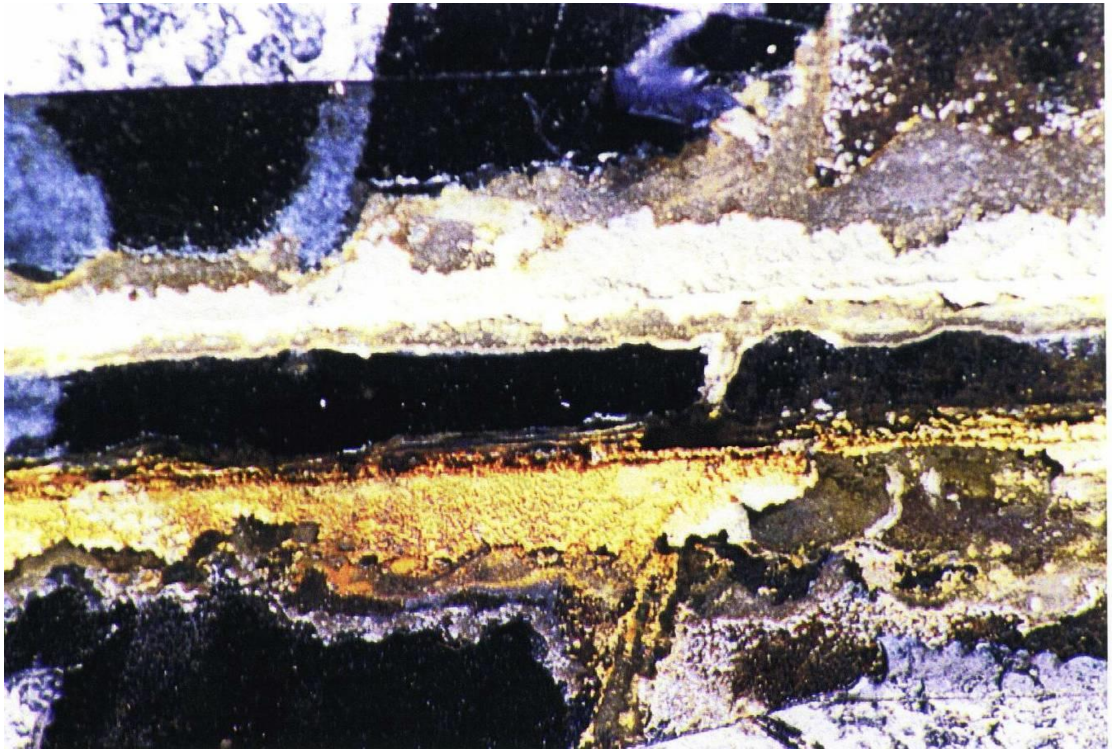
Removal of Coating

- **Mark Areas for Coating Removal, Typically:**
  - 8 to 10 inches above and below longitudinal welds
  - 12 to 14 inches on either side of girth welds
  - 8 to 10 inches around any coating damage
- **Use a Utility Knife to Cut Boundaries of Coating**
- **Remove Coating by Hand**
- **Record Actual Coating Type and Number of Layers**

Deposits Under Coating

- **Circle, Label, and Photograph the Corrosion Areas and Deposits of Interest (Worst Areas)**
- **Describe Deposits or Pastes Under Coating**
  - Record texture (runny, pasty, solid)
  - Record initial color & any changes in color after exposure to air
  - Check the pH of any moist deposits or pastes with pH paper on-site
    - ASAP after exposure
- **Obtain Samples of Deposits and Pastes**
  - Scrape into a sample vial and label
- **Perform Required On-Site Analyses of Deposits**
  - Inoculations for microbiologically influenced corrosion (MIC)
  - Spot tests for sulfides or carbonates

Deposits Under Tented Tape Coating



Deposits Along Welds Under Tape Coating

Pipe Cleaning

- **Mark Maximum Limits of Area to be Cleaned on Pipe**
  - Spray paint
  - Marking crayon
- **The Following Areas are Commonly Inspected:**
  - 4 to 6 inches on either side of longitudinal welds
  - 6 to 8 inches on either side of girth welds
  - 4 to 6 inches around any anomalies
- **Clean Pipe Surfaces Using Chosen Technique**
  - Water blasting
  - Grit blasting
  - Walnut shells or other soft media
- **Blast Cleaning Should Remove**
  - All coating
  - Butyl tape backing
  - Deposits and corrosion products
  - Avoid excessive grit blasting

Water Blasting

Inspection of Cleaned Pipe

- **Verify Pipe Characteristics**
  - Diameter
    - Measure circumference at cleaned area near girth welds
  - Wall Thickness (UT thickness gage)
- **Look for Evidence of SCC**
- **Look for Evidence of Other Integrity Threats**
  - Mill defects
  - Corrosion/pitting
  - Mechanical damage
  - Dents
  - Blisters

Inspection of Cleaned Pipe (continued)

- **If Other Threats Present, Sentence Defects**
  - Follow company protocols and policies for defect assessment and mitigation
    - R-Streng/effective area analysis of corrosion defects
- **Perform Magnetic Particle Inspection (MPI) on Cleaned Areas**
  - Black on White MPI (BWMPI)
  - Wet Fluorescent MPI (WFMPI)
  - Dry Powder (DP)

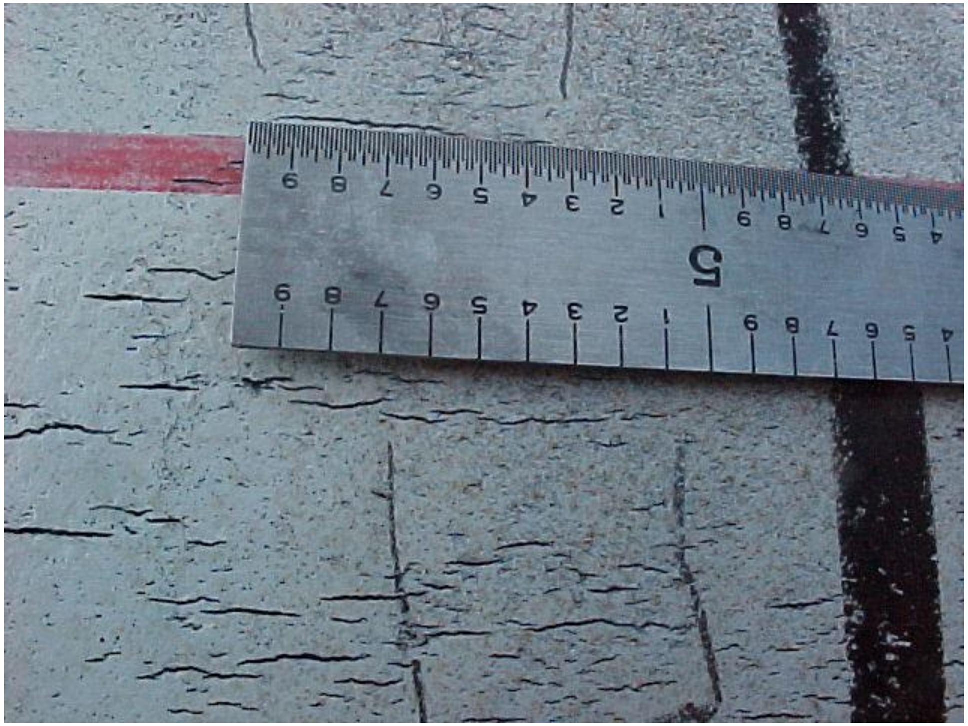
MPI Pros and Cons

MPI Method	Advantages	Disadvantages
WFMPI	Most Sensitive (>1 mm) Rapid Inspection	Equipment Intensive Difficult to Document
BWMPI	Sensitive (> 1-2 mm) Easy to Photograph Less Equipment than WFMPI	Time Consuming Lot of Consumables
Dry Powder	Easiest	Least Sensitive (> 2-5 mm) Affected by Moisture & Wind

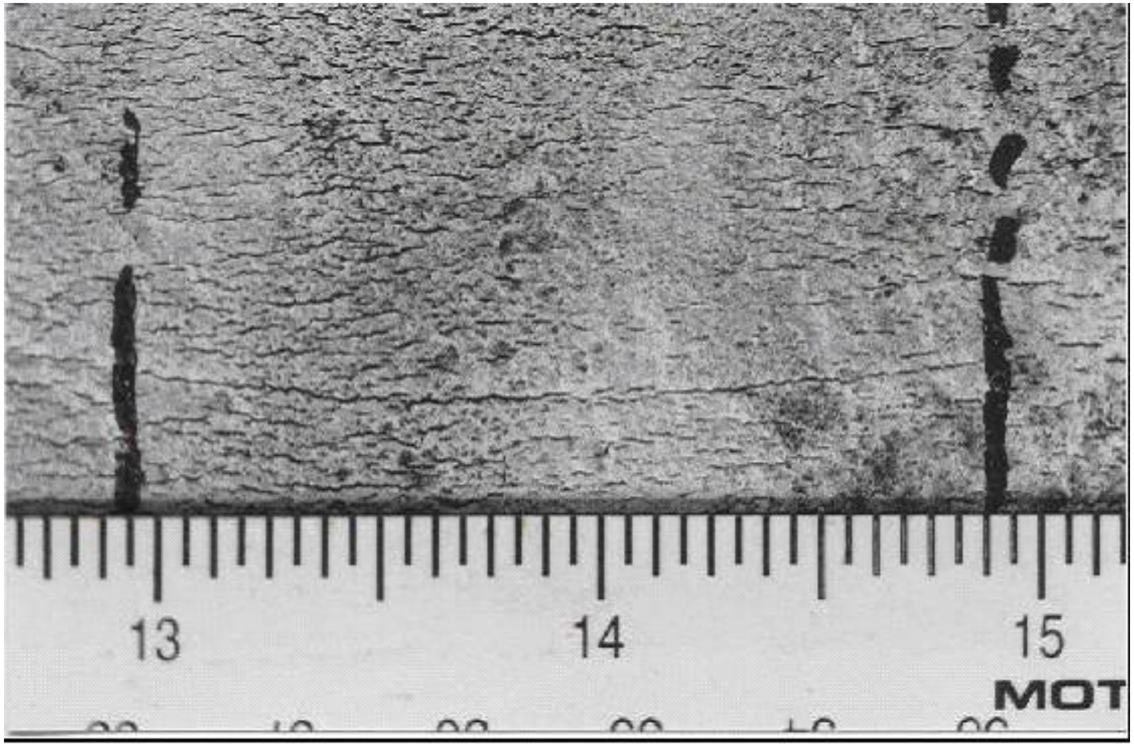
Inspection of Pipe

- **Identify SCC Indications - Is It SCC?**
- **Yes - The indication is definitely SCC**
  - SCC has very well defined characteristics
    - Occur in colonies of cracks
    - Usually axially oriented in response to hoop stress
    - Cracks interlinking
- **No - The indication is definitely not SCC**
  - Very straight or curved indications
  - Individual cracks
- **Maybe - It is not clear from MPI whether the indication is SCC or not**
  - Can usually be determined by light grinding then, MPI again

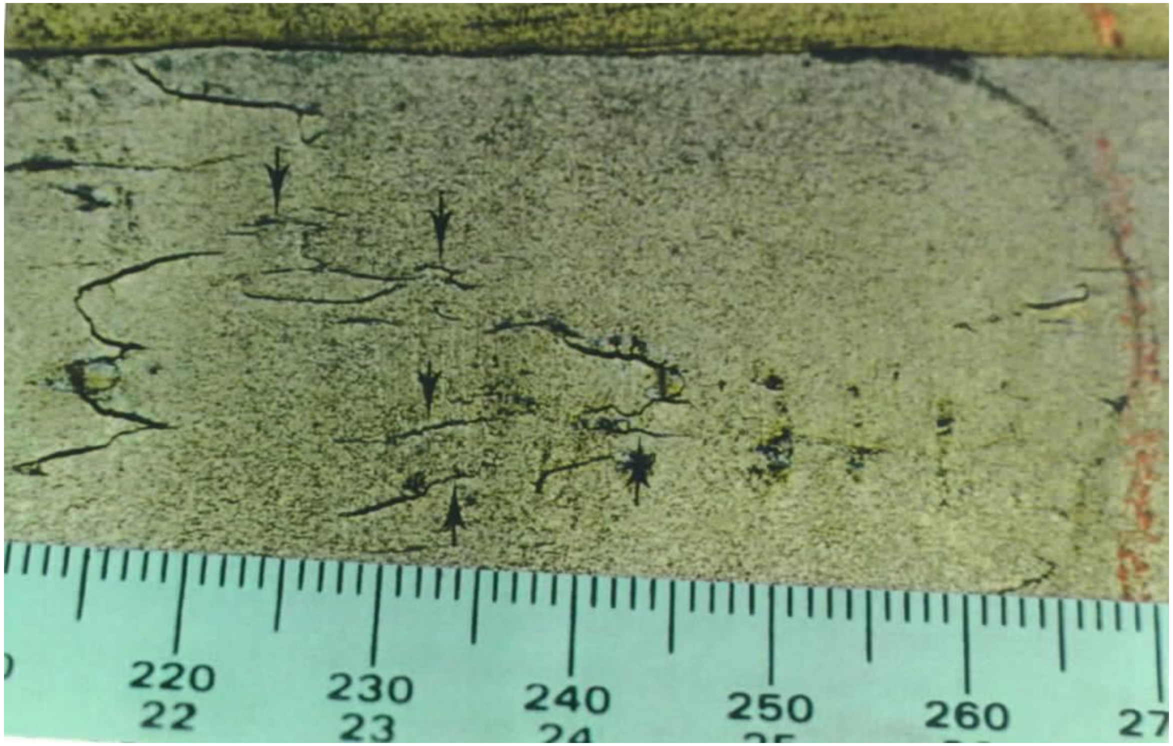
Examples of SCC



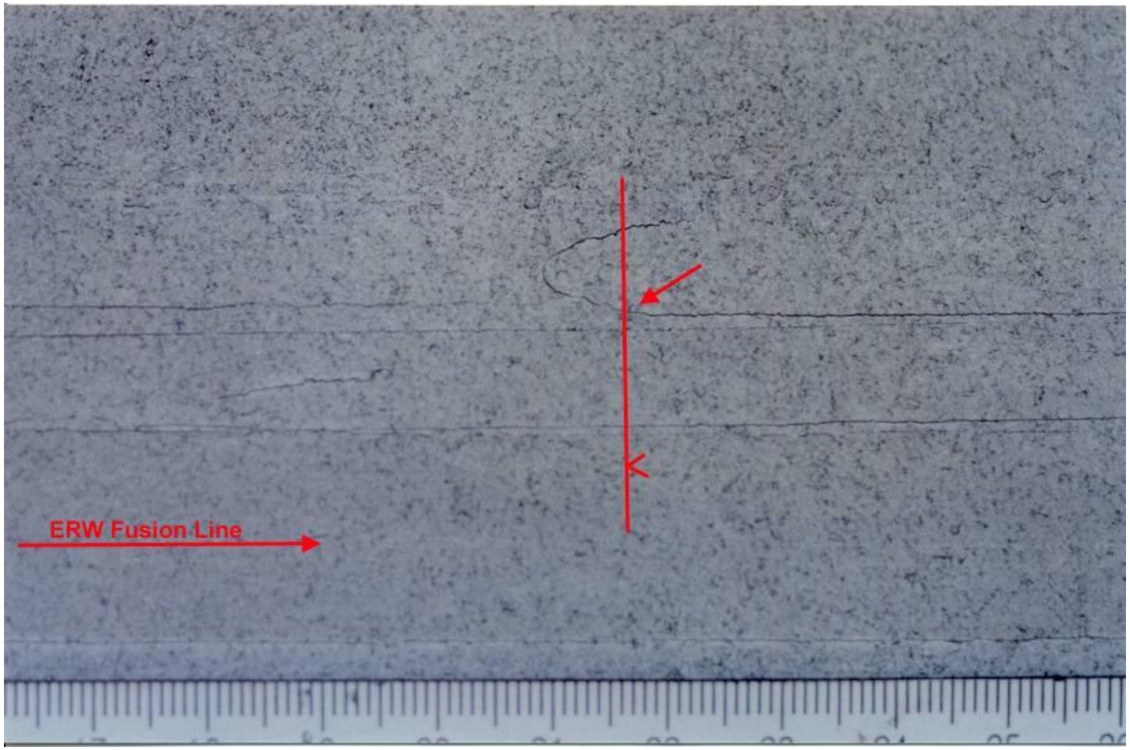
Examples of SCC (continued)



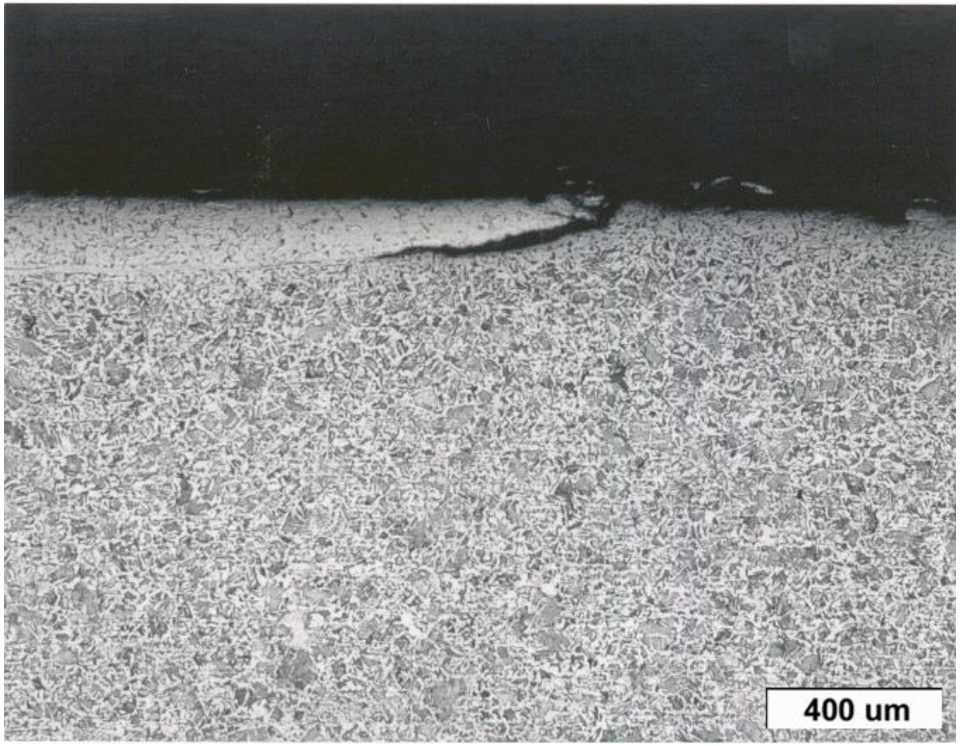
Scabs With Possible SCC



Scab and Weld Defects in ERW Pipe



Scab in Cross Section

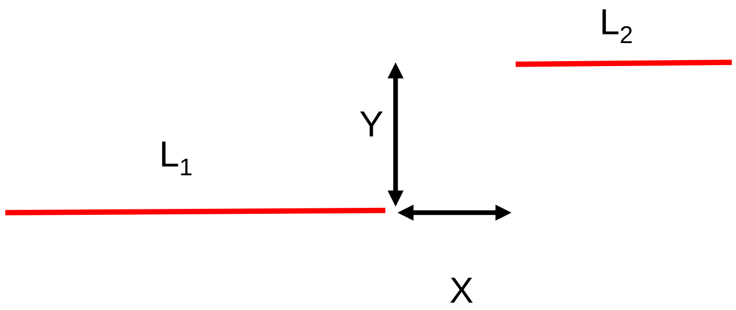


Measurement of SCC

- **Colony Location**
  - O'clock orientation and distance D/S of U/S Girth Weld
- **Colony Size (Length By Width)**
- **Evidence of Crack Inter-Linking**
- **Isolated Colony or Near Weld Toe**
  - Toe cracks are more severe integrity threat
- **Dense or Sparse Spacing**
  - Dense – circumferential spacing < 0.20 wall thickness
  - Sparse – circumferential spacing > 0.20 wall thickness
  - Sparsely Spaced Cracks More Severe Integrity Threat

Measurement of SCC (continued)

- **Maximum Interacting Crack Length (CEPA Rules)**
  - $Y < 0.14 (L_1 + L_2)/2$
  - $X < 0.25 (L_1 + L_2)/2$



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Measurement of SCC (continued)

- **Estimate Maximum Crack Depth**
  - Grind (buff) longest crack in crack colony
  - Ultrasonic testing (UT)
    - Less accurate than grinding
    - Normally requires calibration using grinding
    - Calibrate UT by performing UT and grinding longest crack
    - Use UT for shorter cracks

Purposes of Grinding

- **Confirm that Colony is SCC**
  - SCC typically perpendicular to pipe surfaces
- **Establish Depth of Deepest Crack in Colony**
- **Establish Aspect Ratio of Crack**
  - Depths of other (un-ground) cracks can be estimated
- **Remove SCC or Other Indications**
  - Treat ground area as wall loss indication
- **Calibrate UT or Other Indirect Measurement Techniques**

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Grinding (continued)

- **Establish a Company Policy and Protocol on Grinding**
  - UT generally required prior to grinding
    - Confirm wall thickness
    - Look for evidence of defects
  - Maximum wall thickness removal (to a critical depth as a percentage of wall thickness)
    - Removal of up to 10% of the wall thickness is acceptable by ASME B31G (with no further actions required)
    - Maximum grinding depth typically < 40%
    - Function of length, maximum operating pressure, and pipe dimensions
    - Flaw depth >40% (Typically repair or cut out)

Grinding (continued)

- **Establish a Company Policy and Protocol for Grinding on Welds.**
  - Weld Type
    - LF ERW vs HF ERW
    - Flash welds
    - Lap welds
    - DSAW
  - Pipe age
  - Pipeline history
- **Use the Proper Equipment and Technique**
  - Minimize overheating of pipe
  - Perform MPI at various stages during crack removal

Grinding at a DSAW Long Seam Weld

Sentence SCC Defects

- **Ground Defects**
  - Measure profile of ground area and treat as wall loss defect
    - Effective area method (R-Streng)
- **Remaining SCC Defects**
  - Estimate failure pressure using model for crack-like defects
    - Log Secant
    - CorLAS^{TM}
- **Failure Pressure > 110% of SMYS**
  - Typically recoat
- **Failure Pressure < 110% of SMYS**
  - Actions depend on Company Policy

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Recoating, Backfilling, & Site Reclamation

- **Recoat All Exposed Areas**
- **Various Coating Procedures Are Used**
  - Tape generally acceptable only on tape coated pipelines
- **Photograph Pipe Prior to Backfilling**

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Post Assessment

- ❑ **Determine Whether SCC Mitigation is Required**
  - If so, prioritize remedial actions
- ❑ **Define Reassessment Intervals**
- ❑ **Evaluate Effectiveness of SCCDA Approach**

NACE SP0204-2015

- **Adopted ASME (B 31.8S, Section A3) Severity Categories and Mitigation Activities**
  - Applicable to high-pH SCC on gas pipelines
- **CEPA RP can be used for guidance for near neutral pH SCC**
- **Additional Caution for Liquid Pipelines**
  - Must consider fatigue/corrosion fatigue

ASME B31.8S-2012 Appendix A3

Category	Description	Action
0	< 10% WT or < 2-in and < 30% WT	Schedule SCCDA
1	FP > 110% SMYS	Next SCCDA Assessment < 3 Yrs
2	125% MAOP < FP ≤ 110% SMYS	Consider temporary pressure reduction and conduct hydrotest, ILI or MPI within 2 Yrs
3	110% MAOP < FP ≤ 125% MAOP	Immediate pressure reduction and assessment using hydrotest, ILI, or 100% MPI (or equivalent).
4	FP ≤ 110% MAOP	Immediate pressure reduction and assessment using hydrotest, ILI, or 100% MPI (or equivalent).

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CEPA RP-2nd Edition

Category	Description	Action
	< 10% of WT	Grit Blast and Recoat
I	**FP ≥ 110% X MOP X SF**	Condition Monitor
II	**MOP X SF < FP < 110% X MOP X SF**	Mitigation Activities Within Four Years
III	**MOP < FP < MOP X SF**	Mitigation Activities Within Two Years and Pressure Reduction
IV	**FP < MOP**	Mitigation Activities Within 90 Days and Pressure Reduction

FP = Failure Pressure, MOP = Maximum Operating Pressure,
SF = Safety Factor (1.25 to 1.39)

Mitigation

- **Discrete Mitigation- Isolated SCC Requiring Mitigation**
  - Repair pipe
  - Replace affected pipe segment
  - Hydrostatically test pipe segment
  - Perform Engineering Critical Assessment
- **General Mitigation – Widespread SCC Requiring Mitigation**
  - Hydrostatically test pipeline segment
  - Perform ILI using appropriate tools
  - Extensive pipe replacements
  - Recoating

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Post Assessment

- **Evaluate Effectiveness of SCCDA Approach**
  - Compare results of multiple SCCDA integrity assessments
    - Are they providing consistent results?
  - Compare SCCDA results with historical performance of pipeline
  - Compare SCCDA results with other integrity assessments
    - ILI
    - Hydrostatic testing

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Summary

- **Well Established Procedures for SCC Field Inspection**
- **Record Keeping – One of the Most Important Parts of Field Inspection Program**
- **NACE SP 0204 Requirements**
  - Data necessary to confirm integrity of pipeline
- **Additional Data Collected Depends on Goals of the SCC DA Program**
- **NACE SP 0204 Does Not Define Severity Categories or Mitigation Activities**
  - References ASME B31.8S Appendix A3 and CEPA RP

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