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Appalachian Underground Corrosion Short Course

EVALUATION & SELECTION OF DIRECTIONAL DRILL PIPE COATINGS

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HORIZONTAL DIRECTIONAL DRILLING HDD

- Trenchless technology utilized for installing pipelines
- May be an option for pipe installation in high consequence areas (HCA)
- Used at obstacles such as river crossings, under roadways, railroad tracks, etc.
- Minimizes the impact on the environment due to minimal disturbance of the soil in the ROW
- Utilized across a wide range of industries

DIRECTIONAL DRILL BORES

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CABLE LAY BORING

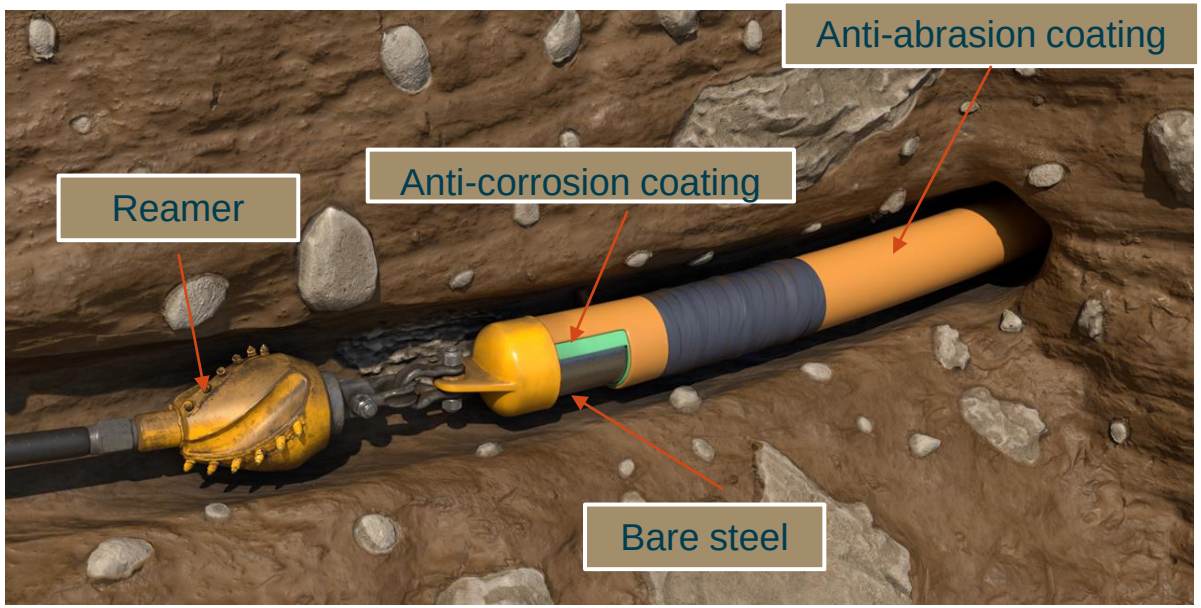
WHY USE HDD

- More economical way to install piping in an inaccessible area as opposed to open cut trench
- Utilized when some of the following are encountered:
  - Structure, geographical obstacles, population impact

Process:

- Geological mapping & evaluation of area to be drilled is conducted
- Fabrication of pipeline to be installed
  - Need sufficient lay down area for pipe prefabrication
  - Field prep and coating of welded joints with acceptable drill coating
  - Field joint coating is critical due to the abuse during the pull
- Borehole drilling
- Casing installation (if cased)
- Pull-through of fabricated pipeline

HDD PROCESS



HDD Damage

- Gouging
- Abrasion
- Extreme Shear
- Impact
- Bending Loads

Long Term Damage

- Moisture Ingress
- Penetration
- Cathodic Disbondment

WHY DO WE HAVE THIS CLASS?

- **49 CFR 192.455 External corrosion control: Buried or submerged pipelines**

a) Except as provided in paragraphs (b), (c), and (f) of this section, **each buried or submerged pipeline installed after July 31, 1971**, must be protected against external corrosion, including the following:

(1) It **must have an external protective coating** meeting the requirements of § 192.461.

(2) It **must have a cathodic protection system** designed to protect the pipeline in accordance with this subpart, installed and placed in operation within 1 year after completion of construction.

§ 192.461 EXTERNAL CORROSION CONTROL: PROTECTIVE COATING.

(4) Have **sufficient strength to resist damage due to handling and soil stress**; and

(5) Have properties **compatible with** any supplemental **cathodic protection**.

(b) Each external protective coating which is an electrically insulating type must also have low moisture absorption and high electrical resistance.

(c) Each external protective coating **must be inspected just prior to lowering** the pipe into the ditch and backfilling, and any damage detrimental to effective corrosion control must be repaired.

(d) Each external protective coating **must be protected from damage** resulting from adverse ditch conditions or damage from supporting blocks.

(e) If coated pipe is installed by boring, driving, or other similar method, precautions must be taken to minimize damage to the coating during installation.

**** This is where ARO coatings need to be considered ****

DO YOU REALLY KNOW WHATS THERE?

- You never really know what is in the ground with HDD applications.
- The soil survey for this project was classified as “good drilling conditions”
- This rock was 200’ from the bore entrance

SPECIALTY HDD COATINGS

- "Temporary" or "Sacrificial" coatings -- must survive during the installation and have the ability to protect the corrosion coating they are protecting

- Most are purely physical property resistance

SO, WHAT TO USE?

- Dependent upon your specific HDD
  - Geological information
  - Pipe size, wall thickness, pull length
  - HCA location
  - Deflection requirement (how much bending will the pipe encounter)
  - Any temperature limitations to consider either low or high?
    - Not only exterior of pipe but interior product as well
- Pipeline contractor (and coating applicator) experience
- Initial corrosion coating selection
  - On site vs. plant application
- Cost

OVERVIEW OF POTENTIAL DAMAGE TYPES AND COATING NEEDS

Damage is generally caused by one of or more of these factors:

- **Gouging** - The material will successfully protect the coating system and prevent coating scarring or failures
- **Abrasion** – Material should perform above the level of typical coatings which is needed to withstand through the pull
- **Shear disbondment** - Materials need to adhere and be flexible enough to survive the bending during a pull even with increased thickness of the coatings
- **Impact - T**he material is tough enough to withstand the impact it is subjected to during pull through

PHYSICAL TESTS FOR COATINGS

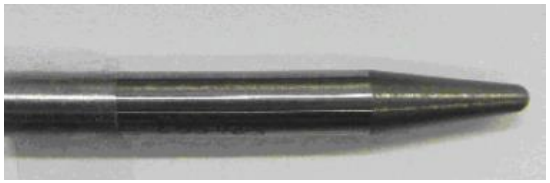
THEY EVALUATE ABILITY OF COATING TO WITHSTAND:

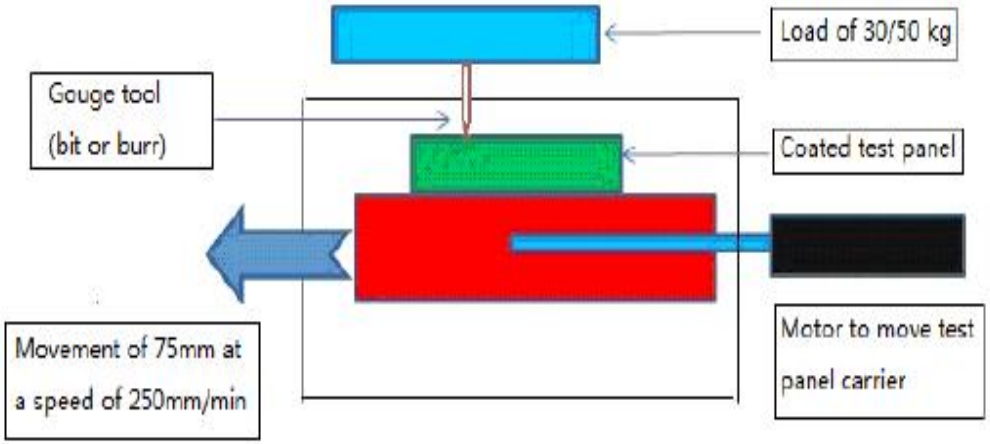
- PULLING AROUND BENDS WITHOUT DISBONDING
- SLIDING THROUGH BENDS
- PULLING OVER BEDROCK OR SOIL
- DRAG FORCES FOR ENTIRE LENGTH OF PULL
- PROTRUSIONS, SHARP OR DULL
- ROCK SHIFTS

TESTS SPECIFIC TO HDD COATINGS

- Gouge Resistance
- Adhesion to corrosion coating
  - Most HDD coatings are a sacrificial layer and are not the corrosion protection coating
- Abrasion Resistance
- Flexibility
- Penetration Resistance
- Impact Resistance

NACE TM0215 GOUGE TEST





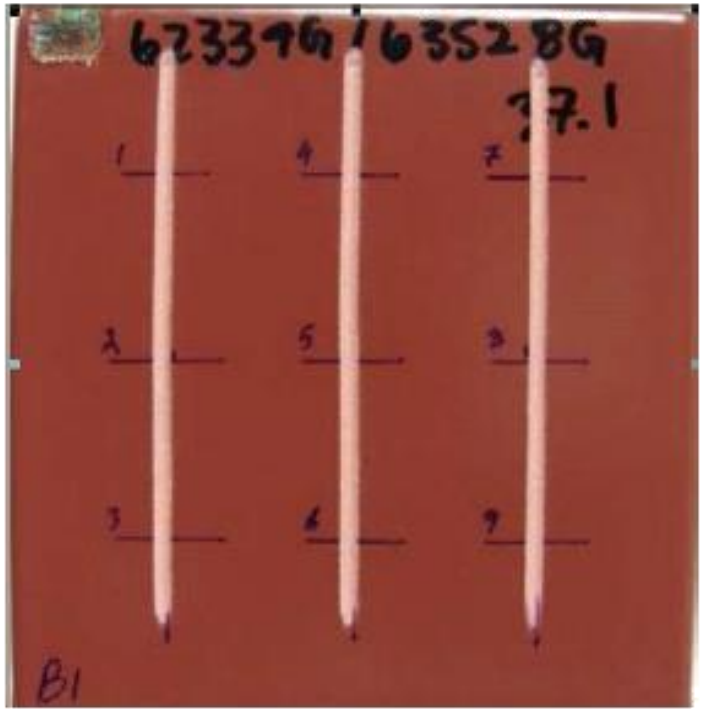
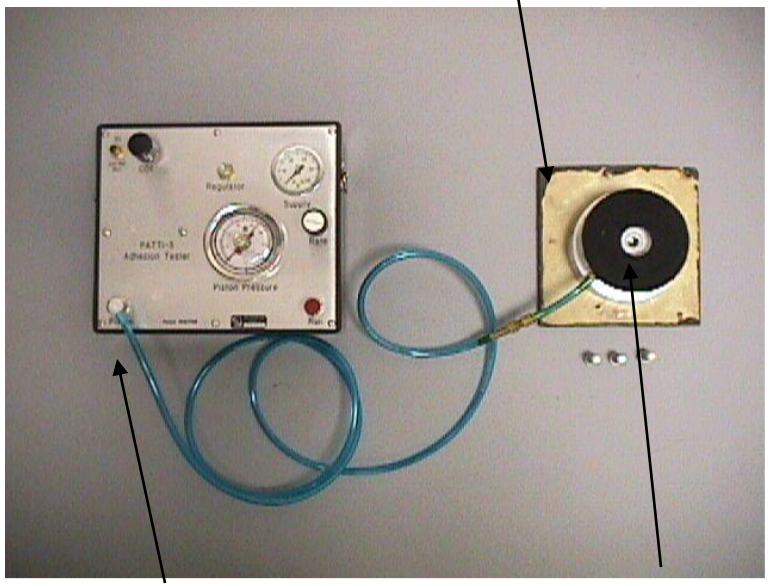


Figure 1: Schematic of a Gouge Test Apparatus

ADHESION TESTS

- ASTM D4541
- Pull-off test, measures force/stress required to pull the coating from the substrate
- Difficult to interpret sometimes because of cohesion failures
- Questionable for sacrificial coatings



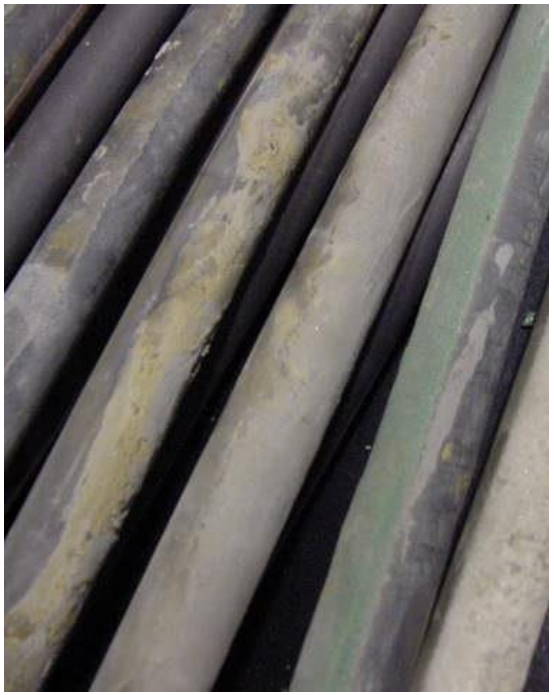
ABRASION WHEEL

- ASTM D4060 Taber Abrasion

- Abrasive wheel grinds at rotating coating, measure weight loss or thickness lost per number of cycles

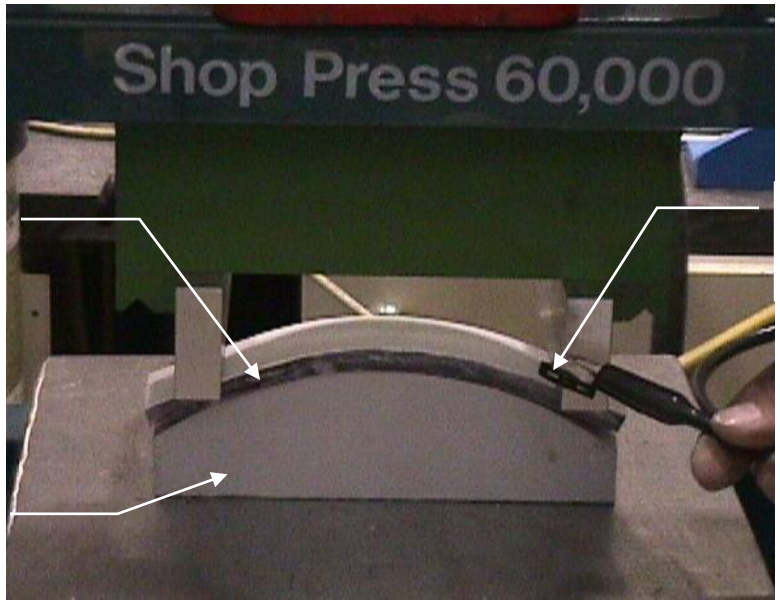
DRUM ABRASION

- ASTM G6 - Drum filled with sharp rocks, tumbles over sample, monitor resistance until holidays are created



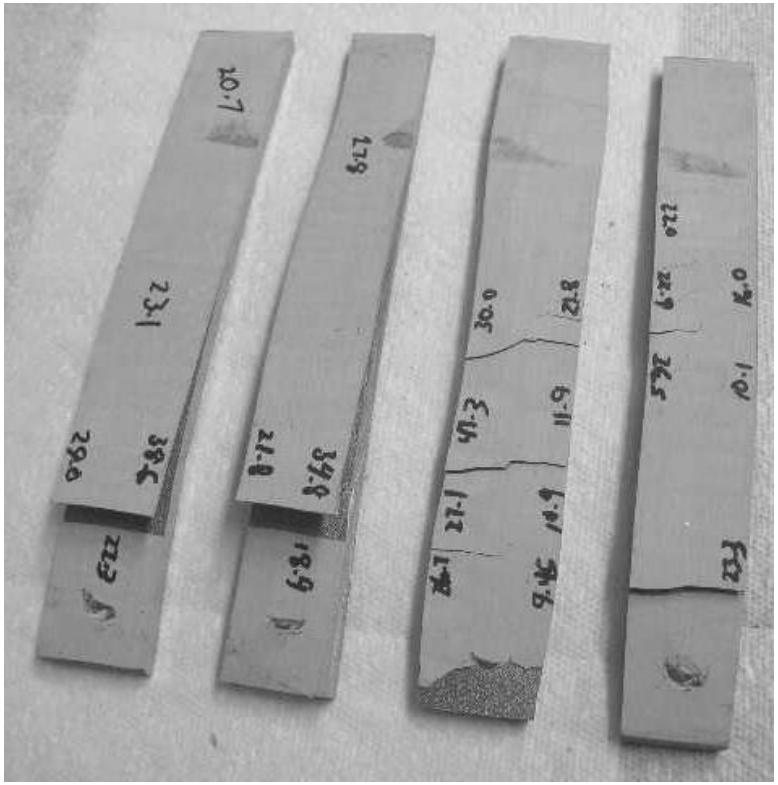
FLEXIBILITY

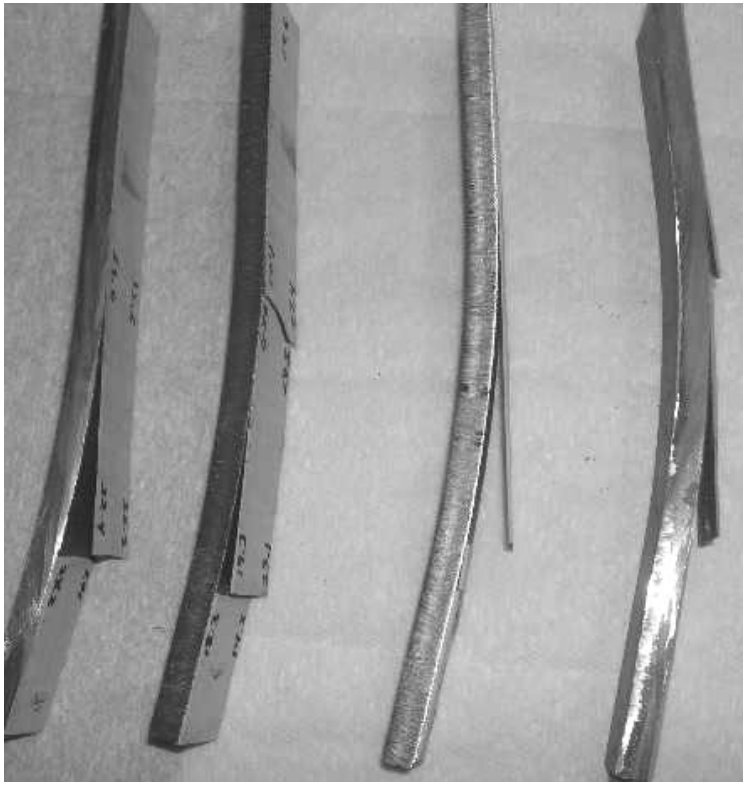
- NACE RP0394, CSA Z245.20-98
- Test temperature variable
- Bend coating over mandrel, look for crack/holiday and shear disbondment; simulates pipe bending during pull



FLEXIBILITY

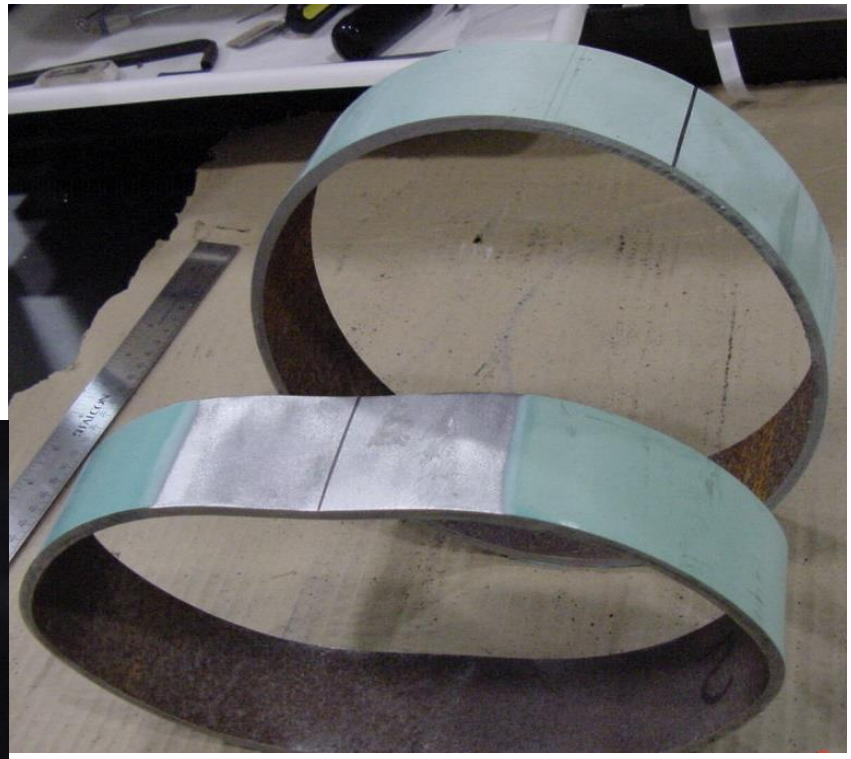
- DON'T WANT THIS! (shear disbonding)

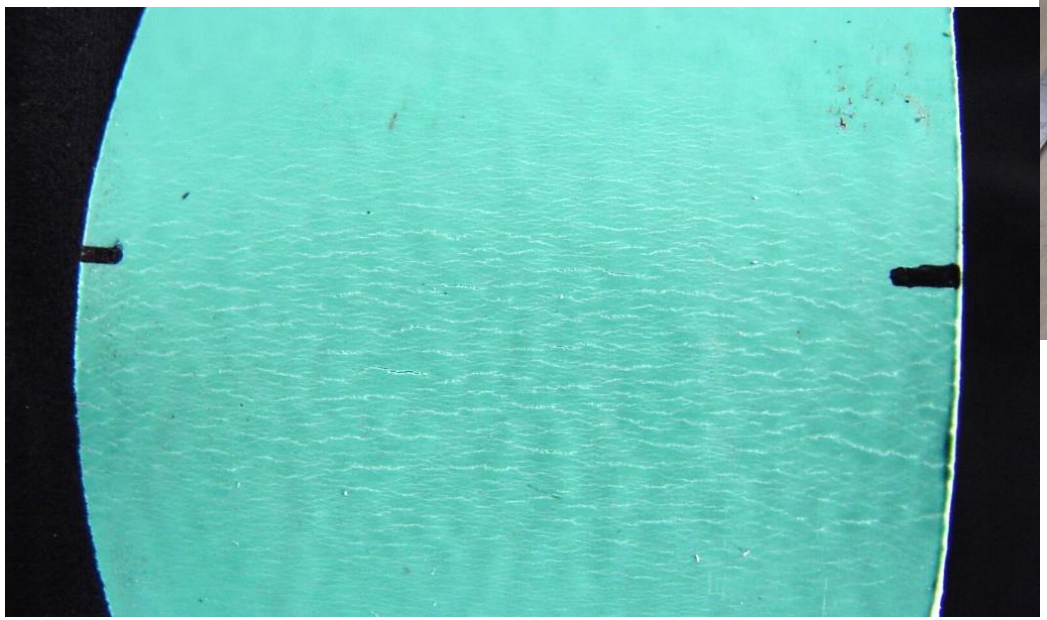




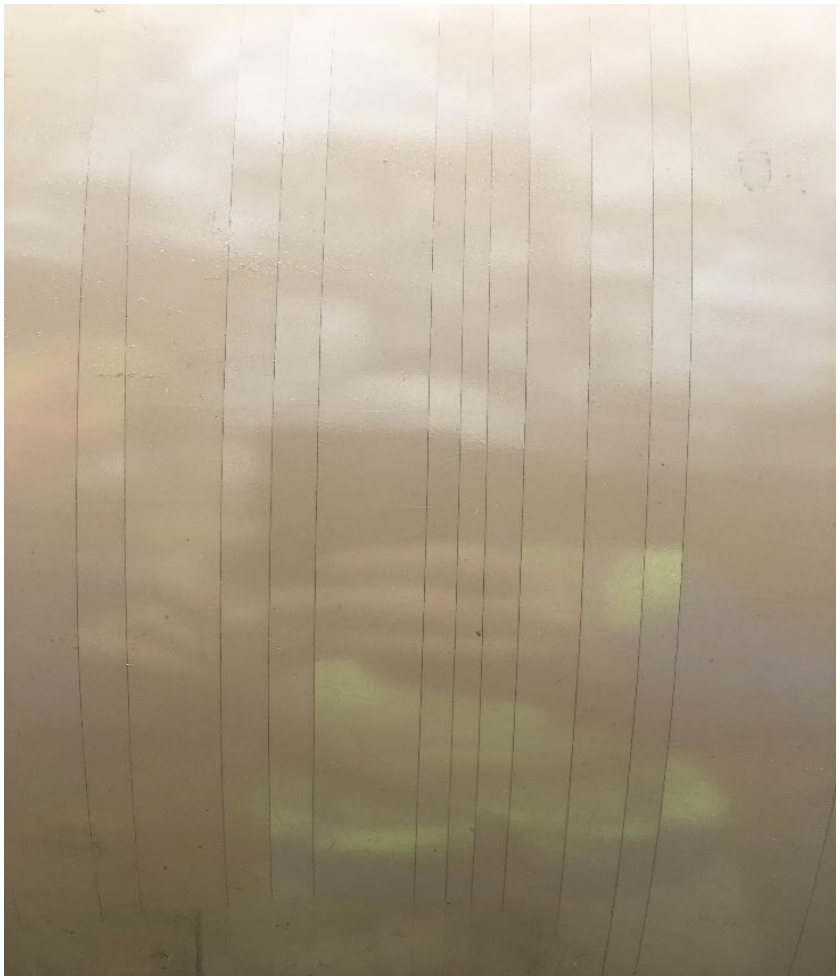
FLEXIBILITY

BEND RING TEST

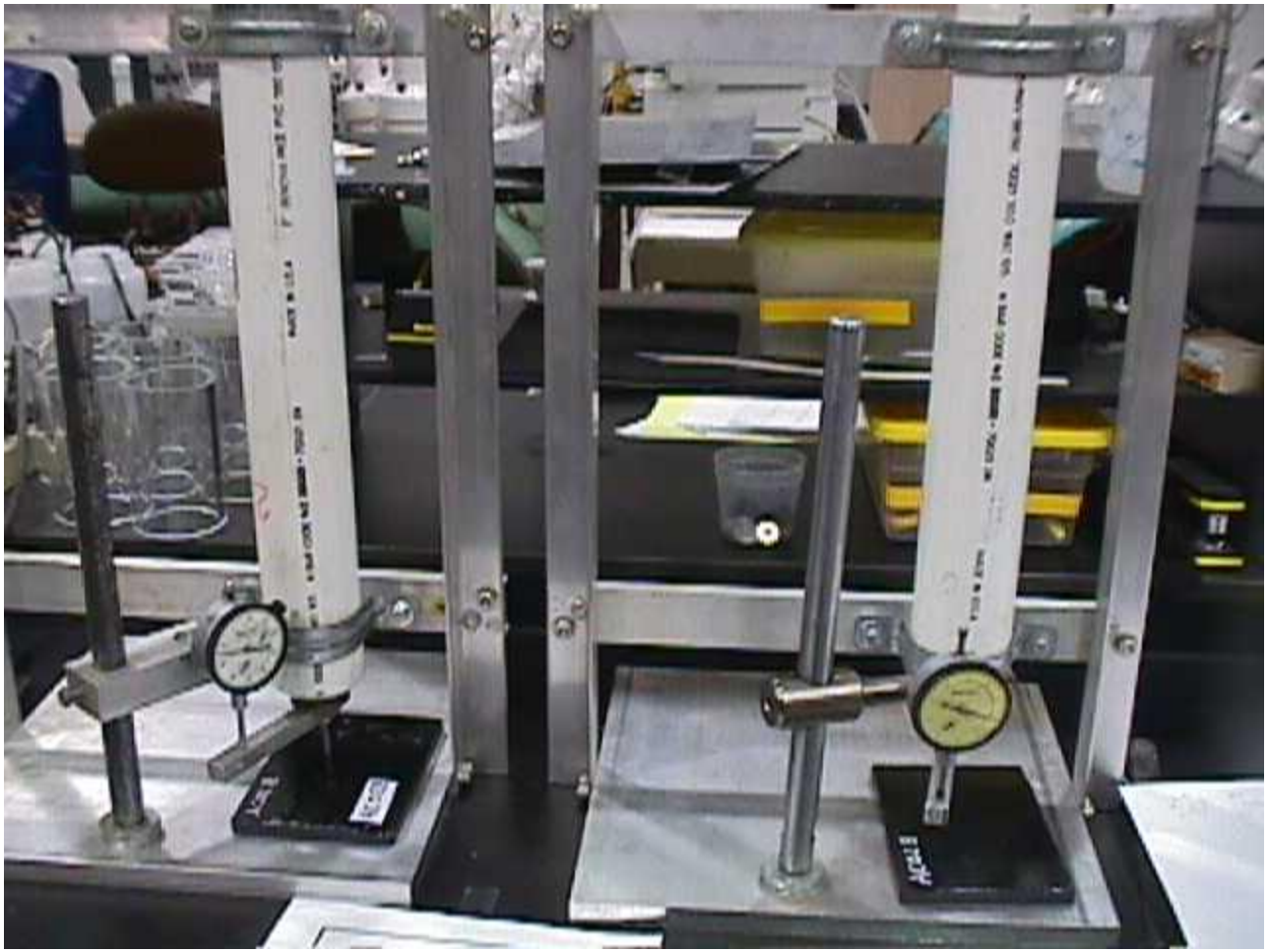




COATING DAMAGE DUE TO TOO MUCH DEFLECTION

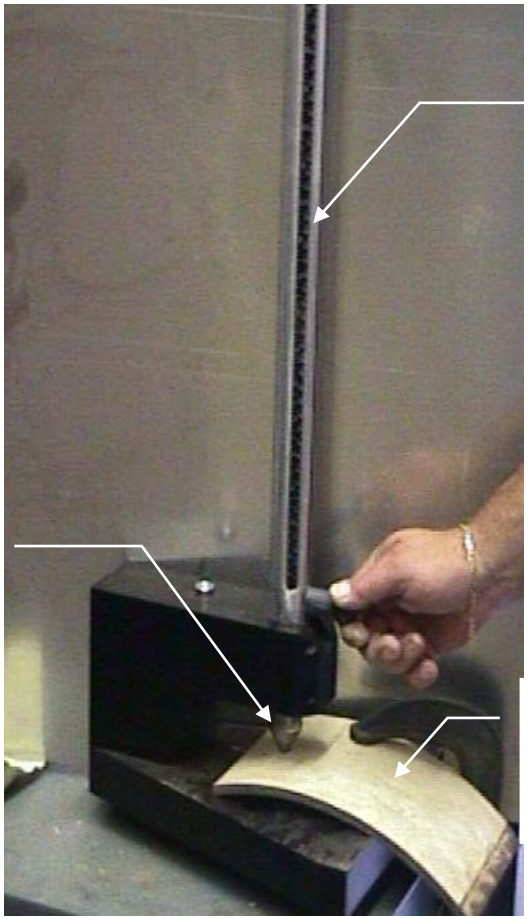


PENETRATION RESISTANCE



IMPACT TEST

- ASTM G14
- Test temperature variable
- Drop weight on coating, examine for holiday creation



COMMON MAINLINE HDD COATINGS
ARO - ABRASION RESISTANT OVERLAY

- EPOXIES, POLYURETHANES & MCO's
  - **FUSION BOND EPOXY (FBE)**
  - **LIQUID EPOXY**
  - **POLYURETHANE**
  - MCO – moisture cured outerwraps (designed for HDD)
- POLYOLEFIN-BASED
  - **3-LAYER POLYETHYLENE (3LPE)**
  - **3-LAYER POLYPROPYLENE (3LPP)**

*Polyolefin's are the most widely uses plastics today and are very versatile with properties including flexibility, strength, lightness, stability, impermeability (to water and other liquids)

COATINGS NOT COMMONLY USED IN HDD DUE TO MINIMAL PROTECTION AGAINST DRILLING DAMAGE

- TAR-BASED
  - **COAL TAR ENAMEL (CTE)**
  - **ASPHALT ENAMEL**
  - **BITUMEN**
  - **HOT-APPLIED & COLD-APPLIED TAPES**

- OTHERS
  - **PETROLATUM**
  - **WAX**
  - **VISCOELASTICS**
  - **Non ARO 2pt liquids**

FBE/ARO MAINLINE COATINGS

- FBE coating applied in higher mil thickness alone
- Extra abrasion protection added to outer layer Abrasion Resistant Overcoat(ARO)

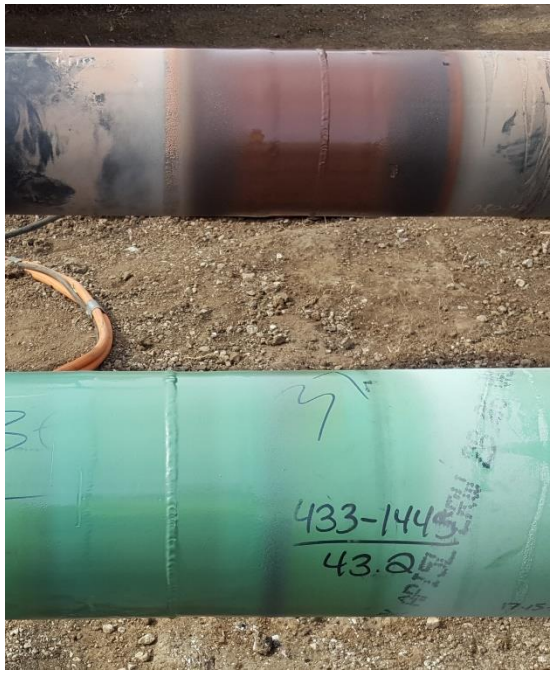
ADVANTAGES/DISADVANTAGES FBE/ARO

FBE and ARO

- Can be applied at the same time as FBE corrosion coating
- Compatibility between coatings assured
- Good adhesion to steel
- ARO – fillers increase abrasion resistance over FBE

- Poor flexibility if applied too thick
- Minimal impact resistant
- ARO is multiple times the price per mil of FBE to apply
- Less lubricity for boreholes which are gravelly

TYPICAL ARO WELD COATINGS

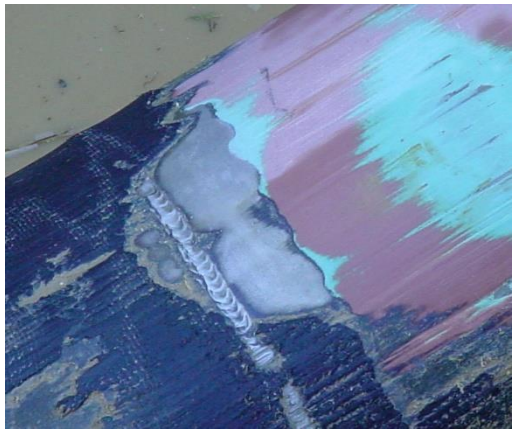


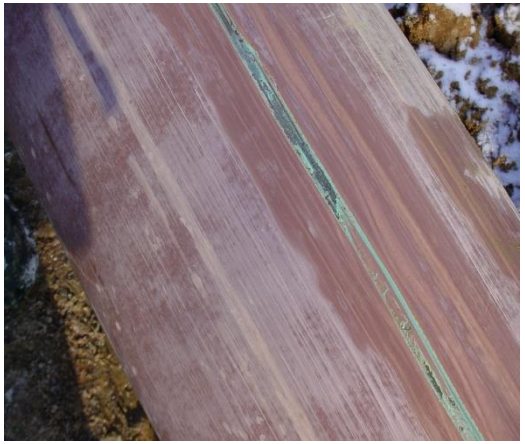
Used on FBE/ARO coated mainline

- Field Applied FBE or FBE/ARO Combination
- Ensure compatibility with mainline coating
- 2-part Liquid Epoxy Systems
- Heat Shrink Sleeves (designed for HDD)
- Fiber Cloth With Resin (mechanical protection only)
  - Moisture Cured Outer wraps MCO

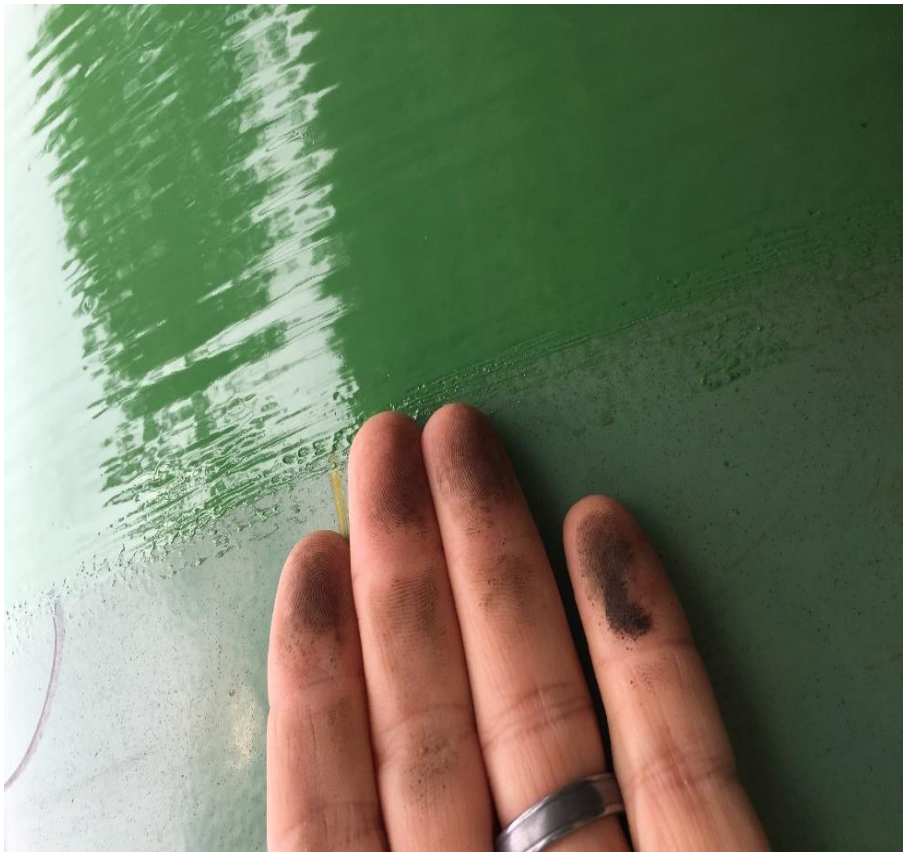
CONSIDERATIONS WHEN SELECTING FIELD JOINT COATING

- **Soil conditions**
  - Will the coating survive pull back?
  - What is the cost of re-pulling?
  - What is the cost to abandon the pipe?
- **Will anomalies be found?**
- **Spot repairs**
  - Will spot repairs be possible?
- **How much will re-pull and repair cost if you have coating issues after installation?**
- **Will the pipe need repositioning during the pull causing potential added abrasion due to back and forth motion?**





BE SURE TO CONFIRM SUBSTRATE IS CLEAN AFTER BLASTING PRIOR TO APPLYING 2PT LIQUID OR SHRINK



- After blasting there is a chance that contaminants may still be present on the substrate and blowing off with air or using a brush alone to clean may not fully remove all contamination
- Use of Acetone or MEK can ensure these contaminants are fully removed may be needed
- If you are going to clean with a solvent you must use something that evaporates 100%

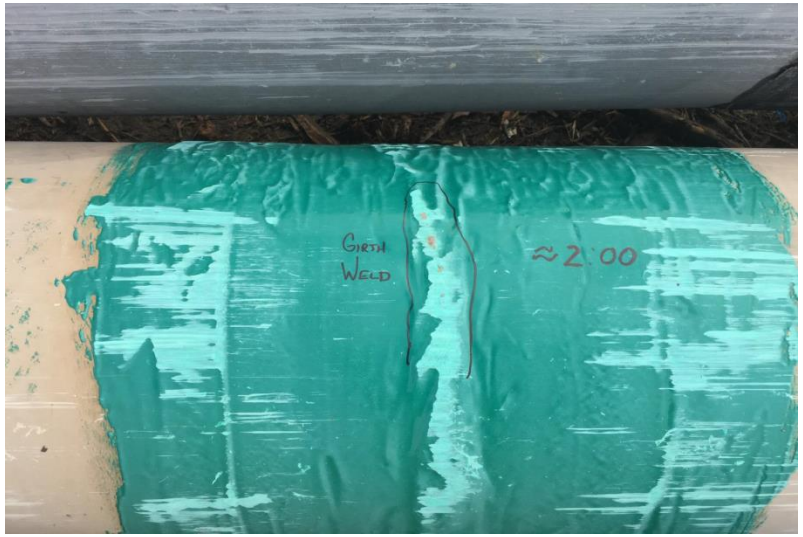
FIELD APPLIED COATINGS

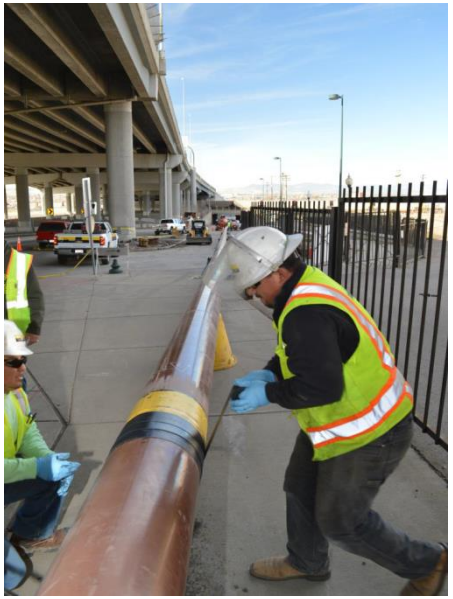
- The majority of coating failures which happen in the field are generally a result of one of the following:
  - Improper coating selection for the project
  - Field applied coating is not applied properly
- Based on the depth of your drill are you confident you will be able to evaluate the effectiveness of your coating in the future for damage, if not, you may want to consider the addition of an MCO for added coating / pipeline protection

MOISTURE CURED OUTERWRAP (MCO) AN EXTRA SACRIFICIAL LAYER OF PROTECTION

- Due to their extreme resistance to gouging and other damage, fiber cloth with resin (MCO) have evolved to further add in protection of the mainline and field applied weld coatings offering an extra sacrificial layer of protection on HDD applications
- Must have corrosion protection coating applied first before adding an additional MCO

MCO ADDS ADDITIONAL SACRIFICIAL LAYER OF PROTECTION TO PROTECT YOUR ASSET





POLYURETHANE PIPE MAINLINE COATING

- Spray on systems
- High Build Molded Systems

ADVANTAGES / DISADVANTAGES POLYURETHANES

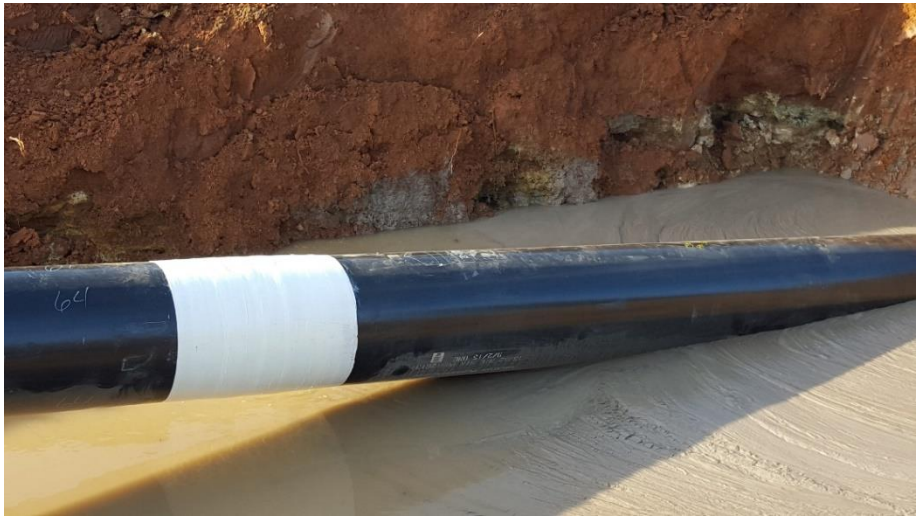
- Can apply on-site
- Capable of very thick film builds
- Fast curing
- High Lubricity – Low Friction
- Good Flexibility
- Excellent resistance to Salt and Fresh water (low water absorption)

- Not very tough, must apply thicker to get protection
- Low Adhesion in comparison to other systems

TYPICAL ARO WELD COATINGS FOR POLYURETHANE COATING

Used on Polyurethane coated mainline

- Spray or brush applied Polyurethane
- Heat Shrink Sleeves
- Fiber Reinforced Urethanes
- IMPU – Injection molded PU



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MULTI-LAYER MAINLINE COATINGS POLYPROPYLENE AND POLYETHYLENE

- Polypropylene(PP) and Polyethylene(PE) outer layer acts as mechanical protection to the FBE layer
- PP and PE systems have capability to withstand elevated temperatures

ADVANTAGES/DISADVANTAGES MULTI LAYER PP/PE

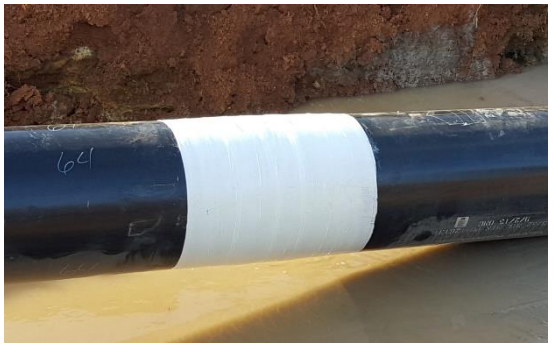
- Already a standard pipeline
- Polypropylene(PP) and Polyethylene(PE) outer layer acts as mechanical protection to the FBE layer
- PP and PE systems have capability to withstand elevated temperatures

- Poor gouge resistance
- Potential issues with CP shielding

TYPICAL ARO WELD COATINGS

Used on Polyurethane coated mainline

- Heat Shrink Sleeves
- Fiber Reinforced Urethanes
- IMPU – Injection molded PP/PE
- Flame Sprayed PP/PE



DAMAGE TO HDD COATINGS

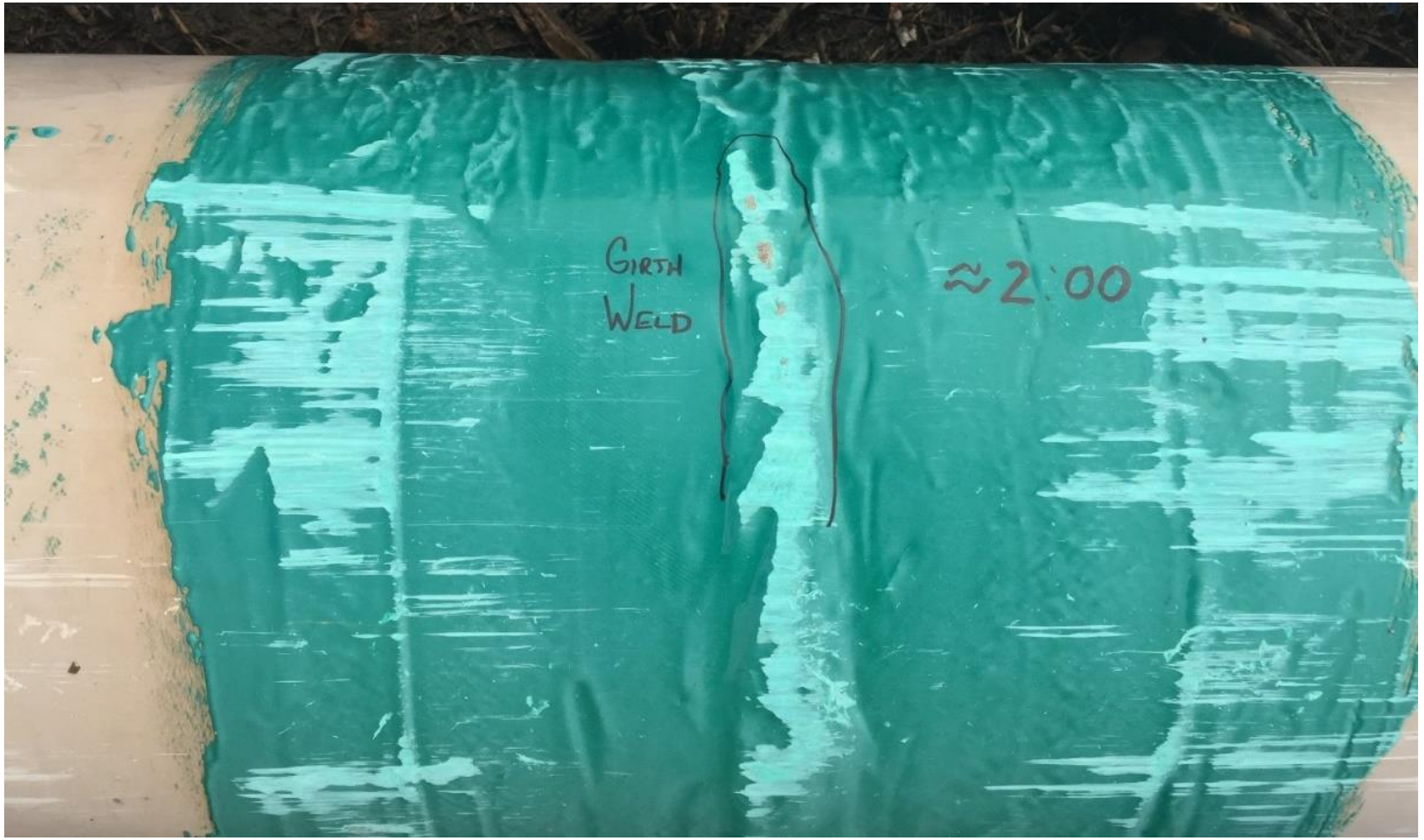
Generally one of 2 forms

- Gouging – from dragging through sharp rocks
- Shear disbondment or cracking – due to bending of excessively thick coatings

Note: gouge-resistant coatings usually are not very flexible!!

GOUGING FROM HDD

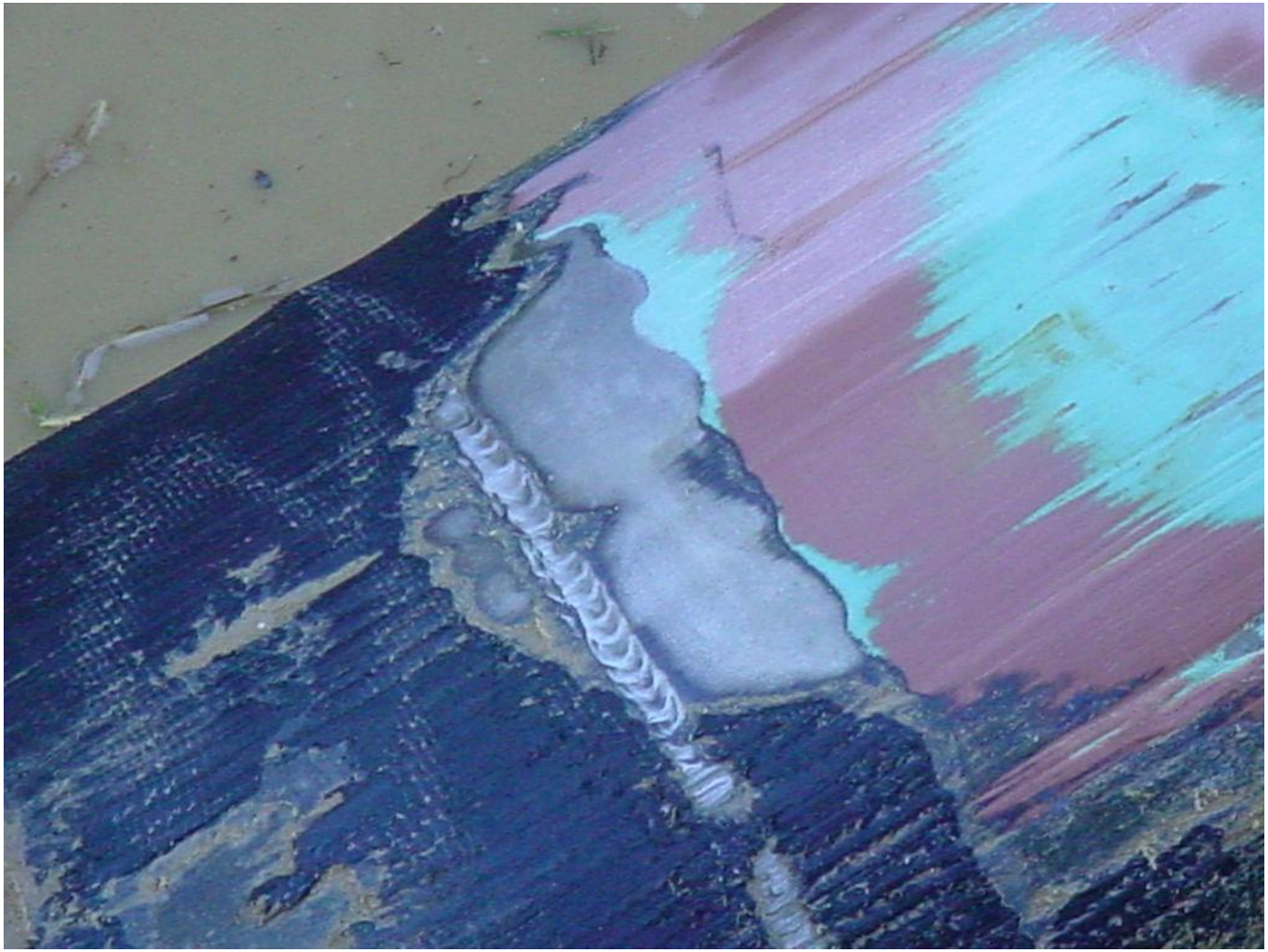
ABRASION WEAR FROM HDD



SHEAR DISBONDMENT

BENDING/SHEAR DISBONDMENT

ABRASION FROM HDD



CATHODIC DISBONDMENT

- Occurs at holidays, disbonded area protected locally generally around the edges of the holiday.
- Creation of holidays during HDD installation
- Excessive coating thickness can lead to CP shielding
- Potential for excessive disbondment in some areas if cathodic protection is not uniformly distributed

ASSESSMENT OF AN HDD COATING PERFORMANCE

- Often evaluated by pulling a sacrificial joint through prior to pullback
- Monitor CP current requirements and coating conductance to determine %bare area after installation
- Highly dependent upon geological factors

SUMMARY

- HDD installations are numerous and vary greatly in type, size, and condition
- Ordinary pipeline coatings do not hold up well to HDD installations, must use special system to protect your coating (per CFR 192)
- Selection of coating is dependent upon the specific HDD project

SUMMARY

- Because coating holidays are expected, cathodic protection system has to be adequate to protect pipe and may change from job to job
- It is critical to properly prepare and apply the field applied weld joint coating as these are a critical link in protecting your asset
- Accurate assessment of coating condition after installation can be difficult
- HDD installations are now commonplace and should be part of every major pipeline construction contractor's skill set

QUESTIONS?
COMMENTS?
CONCERNS?
THANK YOU