

# AUCSC

Appalachian Underground Corrosion Short Course

## EVALUATION & SELECTION OF DIRECTIONAL DRILL PIPE COATINGS

Speaker : Lou Taylor

NACE CIP 1; NACE PCS 2; NACE CP 1

Regional Sales Manager

Liberty Sales & Distribution

[ltaylor@libertysales.net](mailto:ltaylor@libertysales.net)

Office: (877) 373-0118

Cell: (267) 664-8177



# DIRECTIONAL DRILLING

- 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



# OIL & GAS LINE BORING



# CABLE LAY BORING



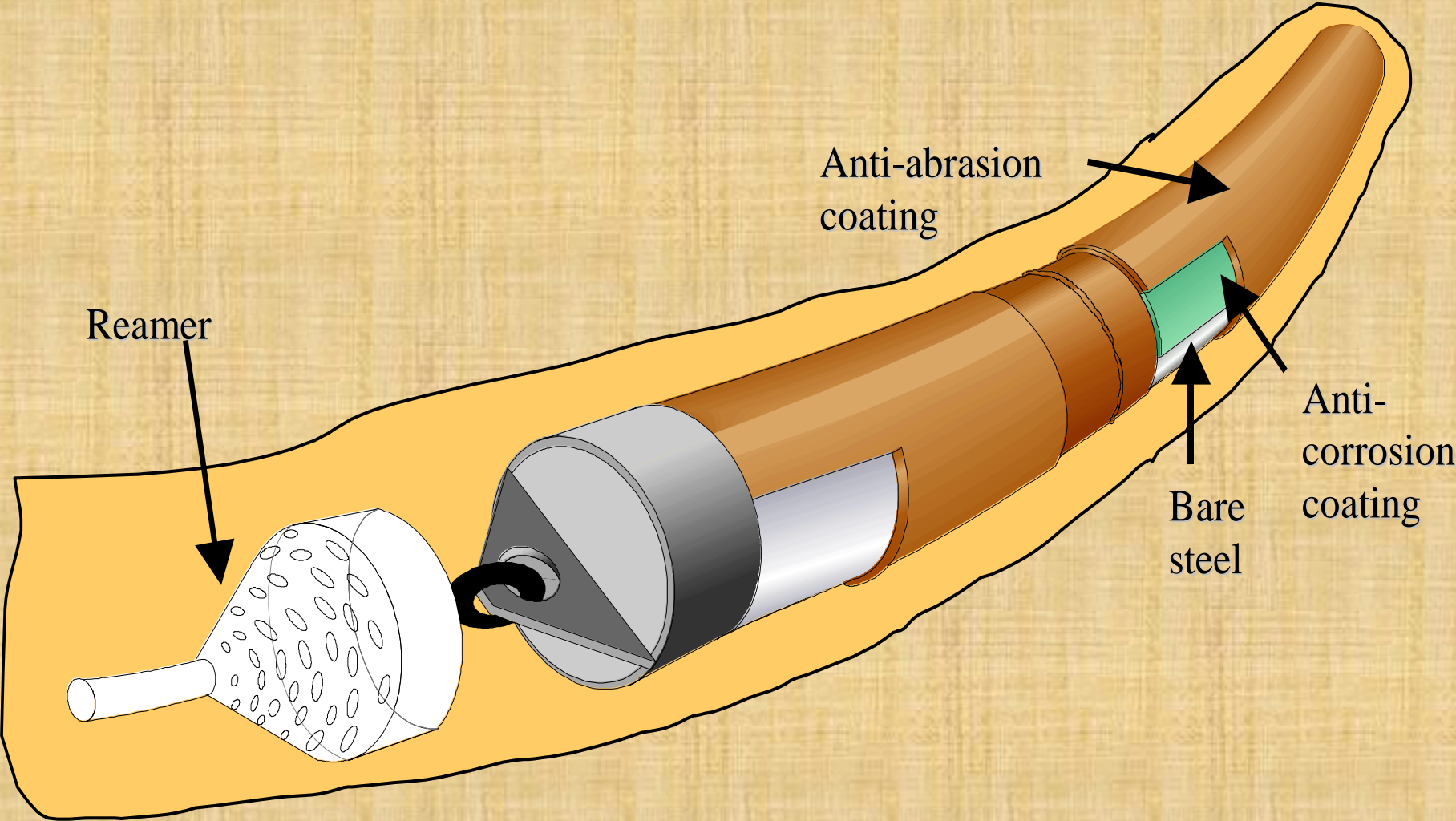
# WHY USE HDD

- 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 INSTALLATIONS



# 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 \*\***

# SPECIALTY HDD COATINGS

- “Temporary” or “Sacrificial” coatings -- must survive during the installation and have the ability to protect the CP coating they are protecting
- Purely physical property resistance
- Choice of abrasion resistance and toughness vs. lubricity
  - Lubricity is how much wear is caused to a surface by a given wear inducing object in a given amount of time.

# 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** - The 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 TM0215-2015  
Item No. 21270

**Standard Test Method**

**Test Method for Measurement of Gouge  
Resistance of Coating Systems**



# NACE TM0215 GOUGE TEST

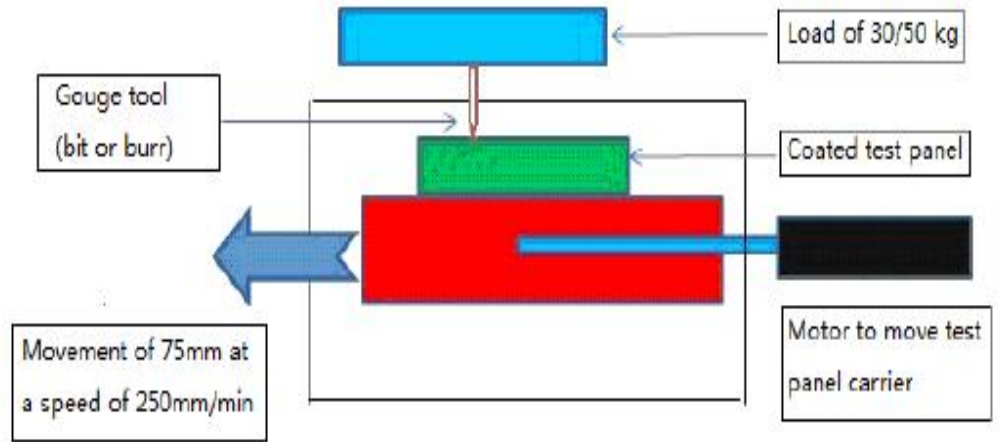
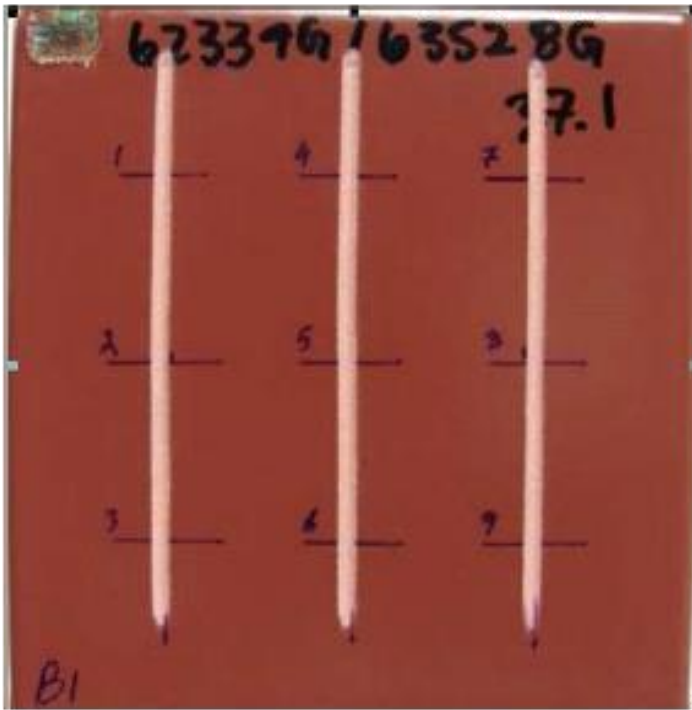


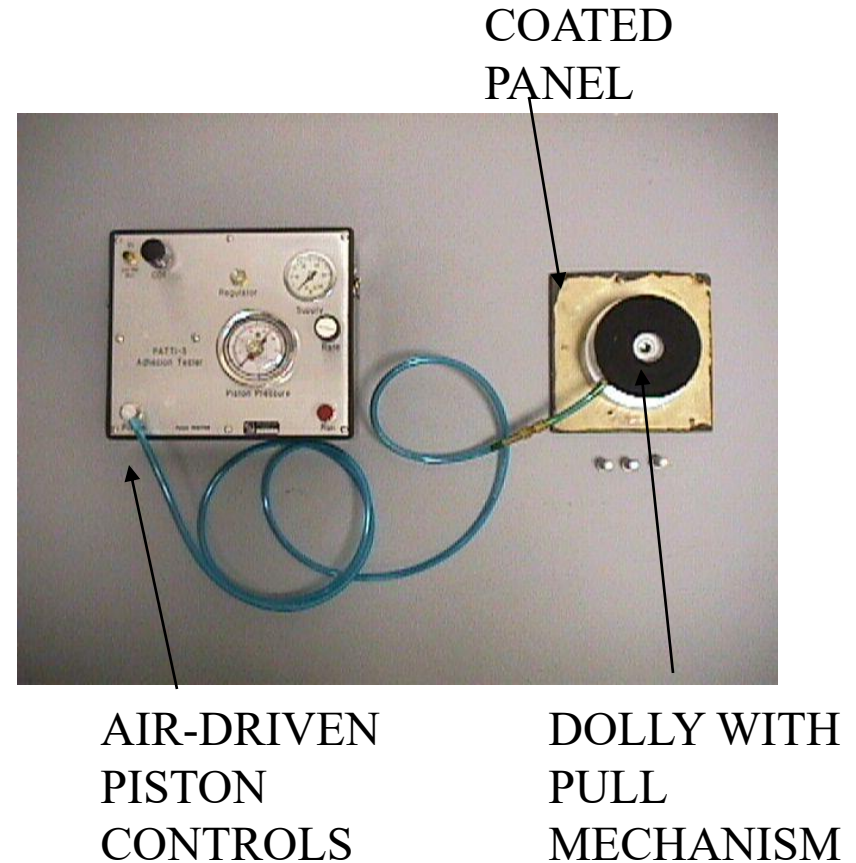
Figure 1: Schematic of a Gouge Test Apparatus





# 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



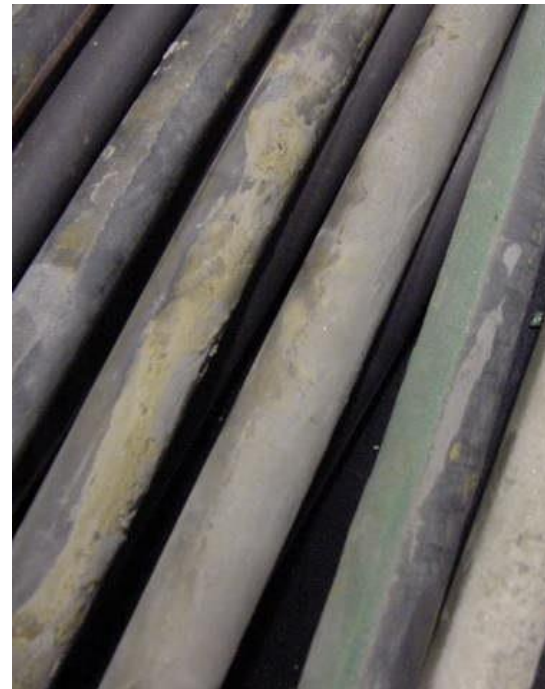
# ABRASION WHEEL

- 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



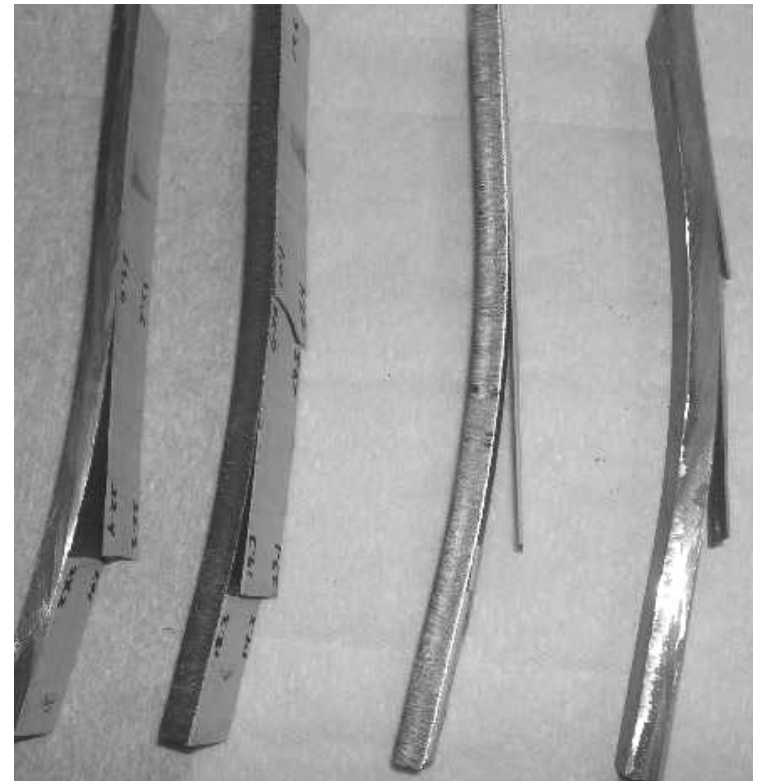
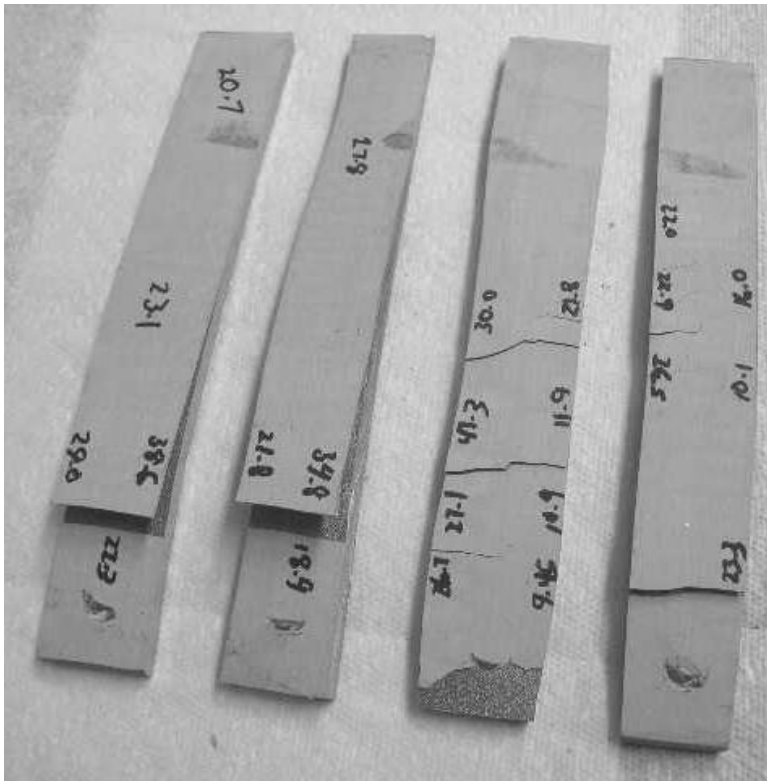
# FLEXIBILITY

- 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

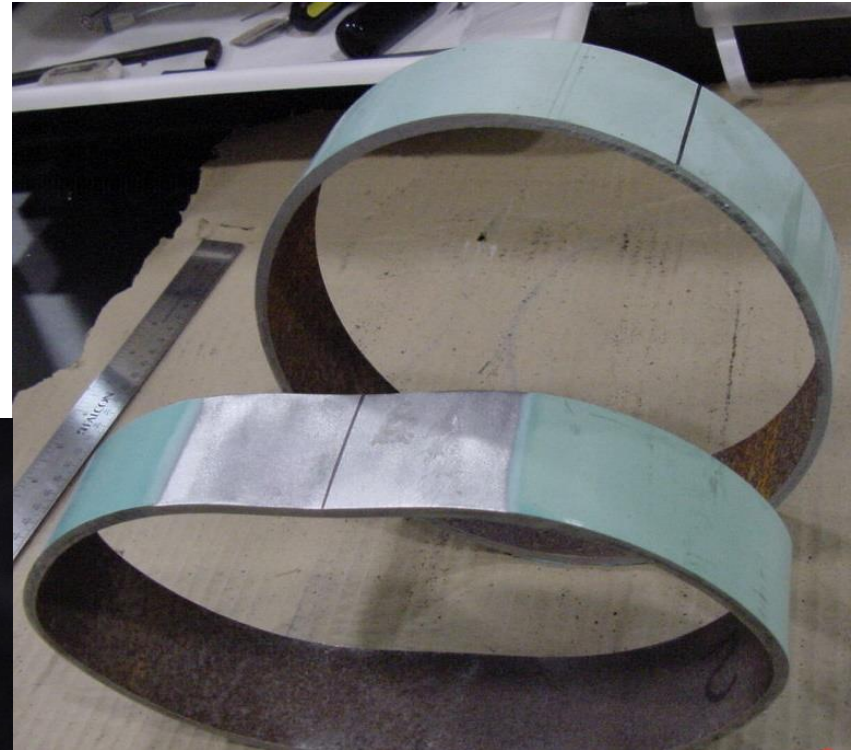
- DON'T WANT THIS! (shear disbonding)



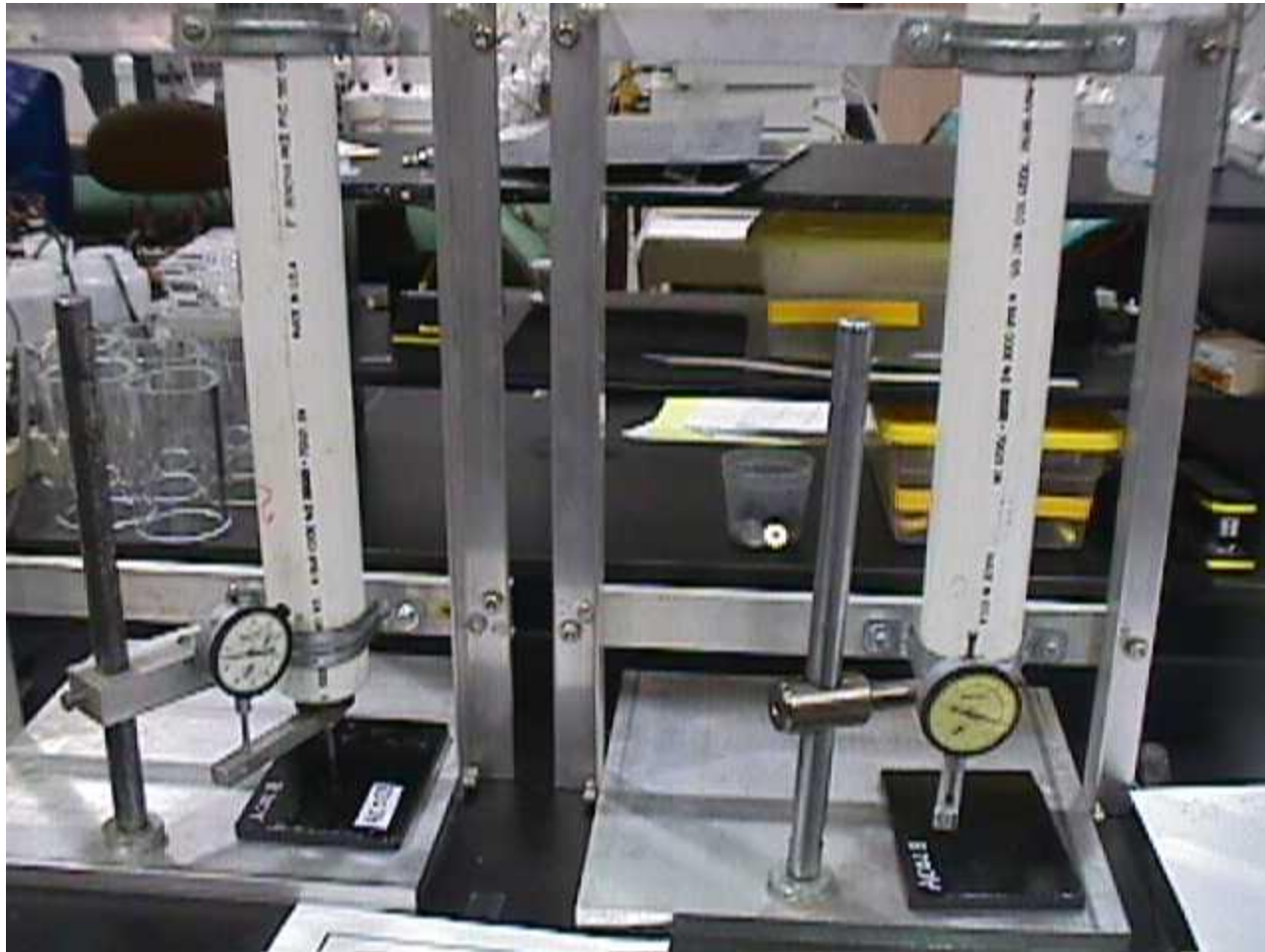
# FLEXIBILITY

## BENT RING TEST

Typically used more for steel  
or weld strength

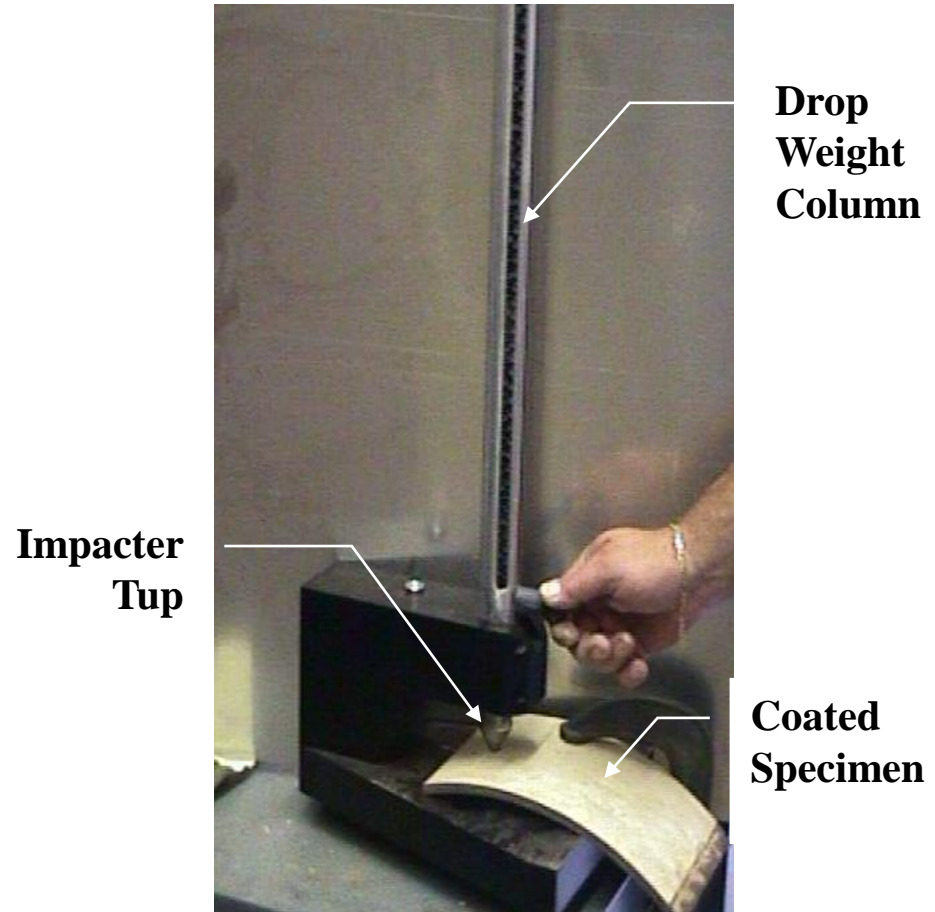


# PENETRATION RESISTANCE



# IMPACT TEST

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





# COMMON **MAINLINE** HDD COATINGS

## ARO - **ABRASION RESISTANT OVERLAY**

- EPOXIES AND POLYURETHANES
  - **FUSION BOND EPOXY (FBE)**
  - **LIQUID EPOXY**
  - **POLYURETHANE**
  
- 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 THERMOPLASTICS
  - 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

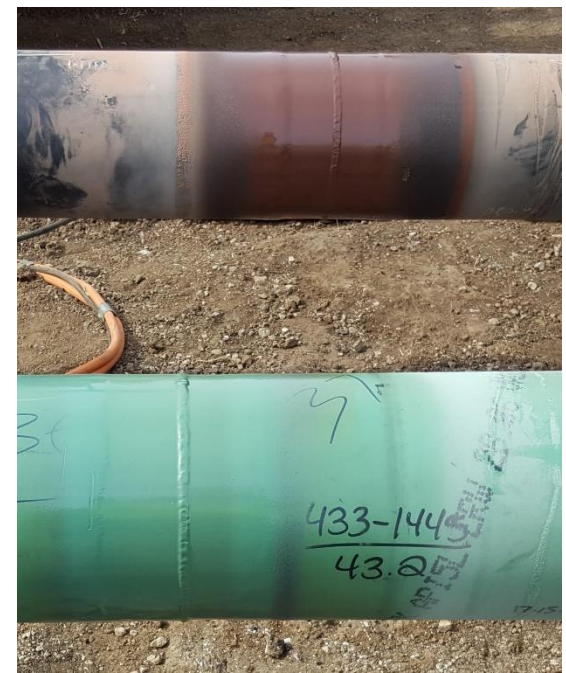
## FBE and ARO

- 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
- Not 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
- 2-part Liquid Epoxy Systems
- Heat Shrink Sleeves (**designed for DD**)
- Fiber Cloth With Resin (mechanical protection only)
  - Moisture Cured Outer wraps MCO

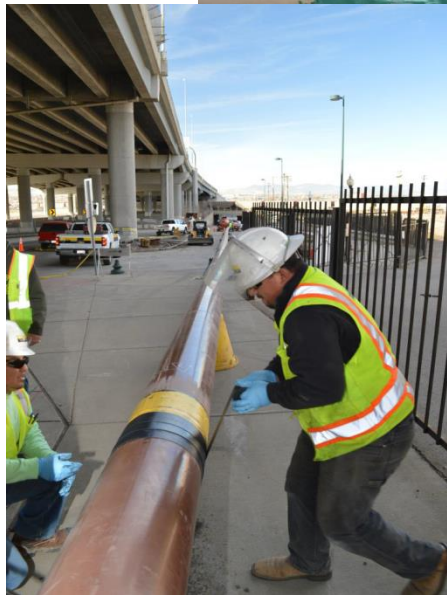
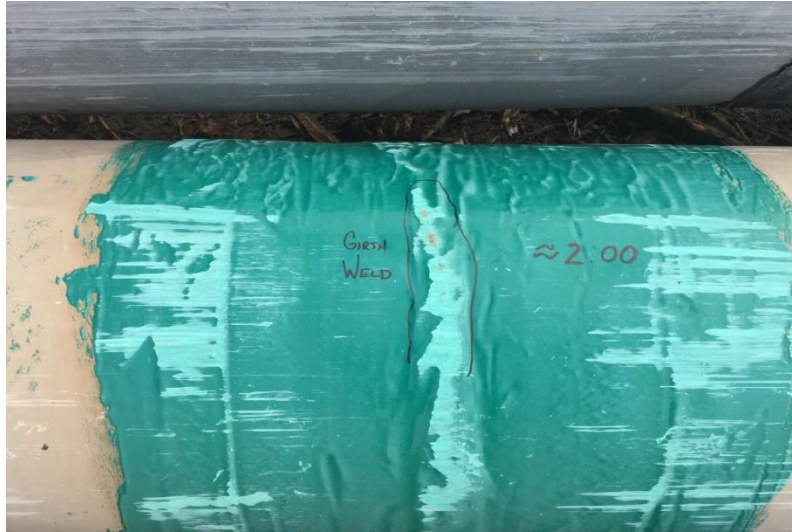


# FIELD APPLIED WELD COATINGS

- The majority of coating failures which happen in the field are generally a result of one of the following:
  - Improper coating selection
  - Field applied coating is not applied properly
- Due to their extreme resistance to gouging and other damage, fiber cloths with resin have evolved to further add in protection of the field applied weld coatings as well as an extra added layer of sacrificial protection on the mainline coating for extreme HDD applications



# MCO ADDS ADDITIONAL SACRIFICIAL LAYER OF PROTECTION



# 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



# 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**



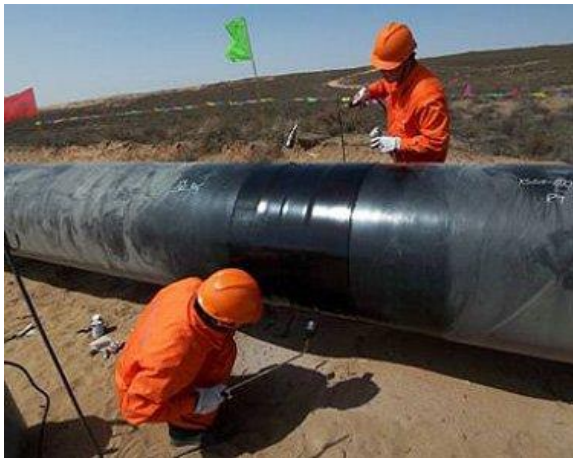
# ADVANTAGES / DISADVANTAGES MULTI LAYER PP/PE

- 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

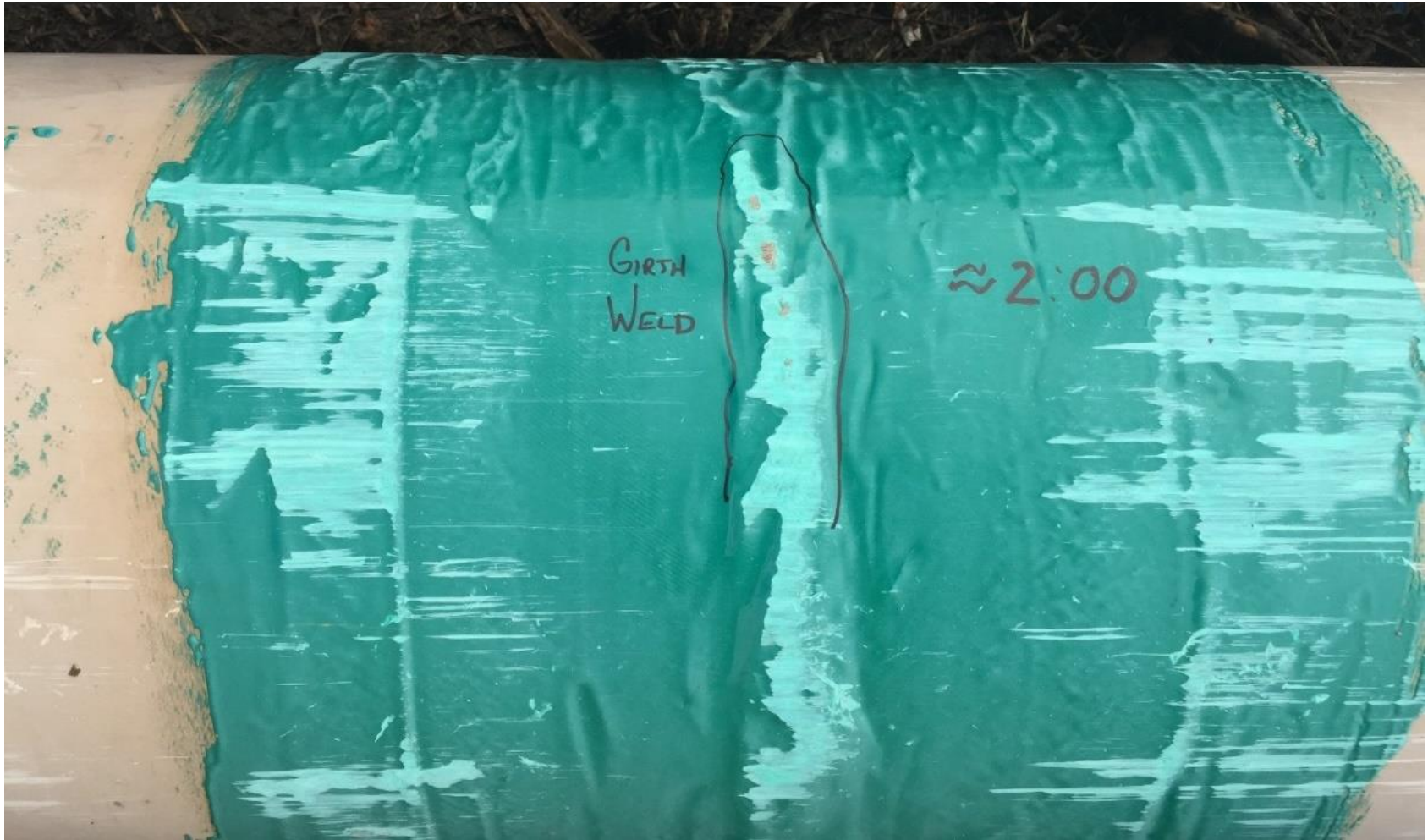
- Gouging – from dragging through sharp rocks
- Shear disbondment – due to bending of excessively thick coatings

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

# GOUGING FROM HDD



# ABRASION WEAR FROM HDD





# SHEAR DISBONDMENT



# BENDING/SHEAR DISBONDMENT



# ABRASION FROM HDD

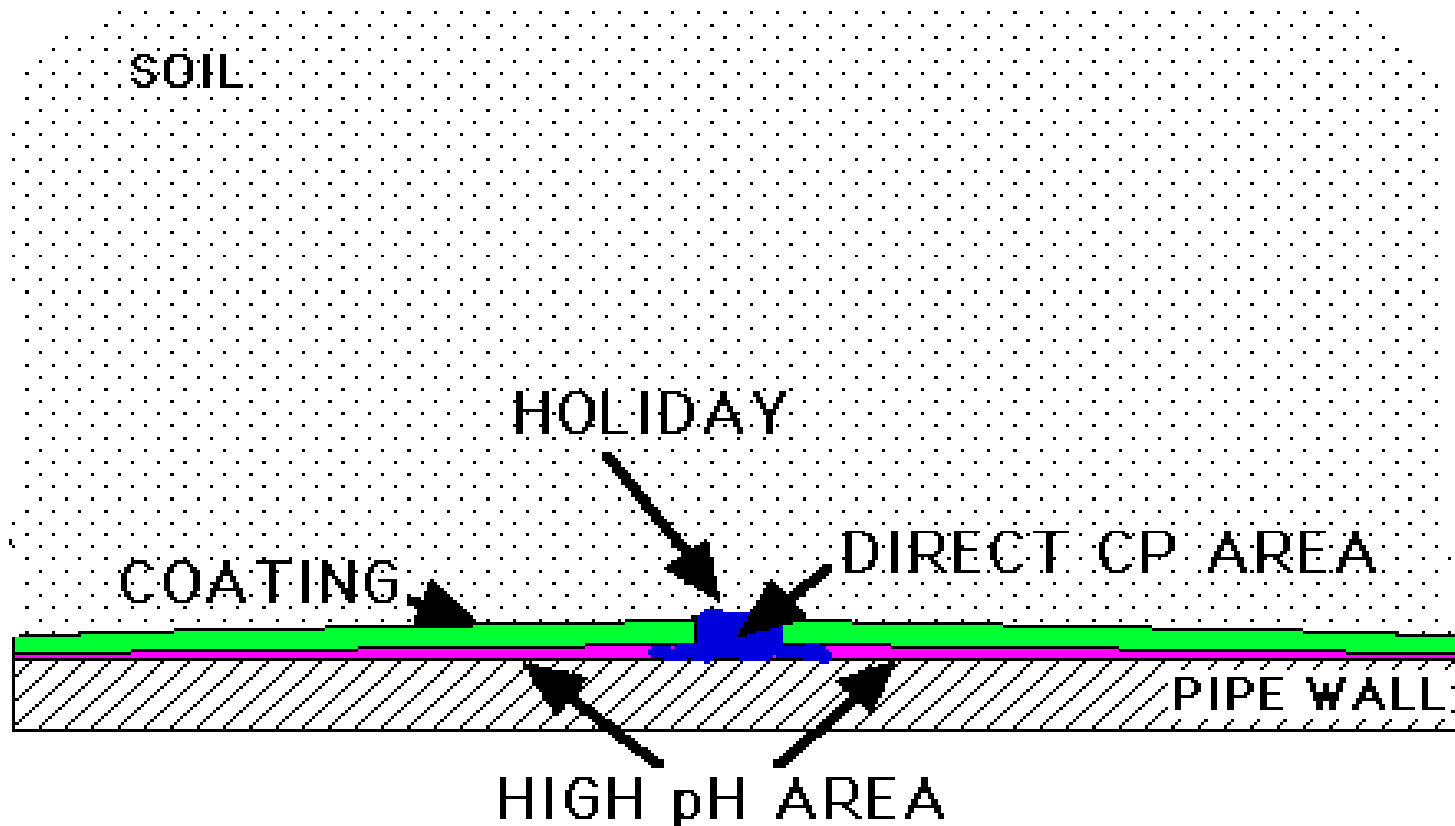


# CONSIDERATIONS FOR IN-SERVICE PROPERTIES

- Coating must *still* perform as an anti-corrosion coating
- Cathodic protection interaction
  - If impressed current system applied on either side of HDD, over potentials could be encountered
  - Excessive thickness can lead to shielding of CP

# CP IN DISBONDED AREA

Occurs at holidays, disbonded area protected locally



# CATHODIC DISBONDMENT

- Occurs at holidays, disbonded area protected locally
- Creation of holidays during HDD installation
- Extra 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??

**Speaker : Lou Taylor**

**NACE CIP 1; NACE PCS 2; NACE CP 1**

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