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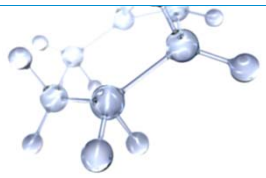
EVALUATION OF COATINGS FOR HORIZONTAL DIRECTIONAL DRILLBORES



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DIRECTIONAL DRILLBORES

- Trenchless technology for laying pipelines
- Used at river crossings, under roadways, railroad tracks, etc.
- Similar technology also used for drilling wells -- "reach" distance a key for economic factors in field applications

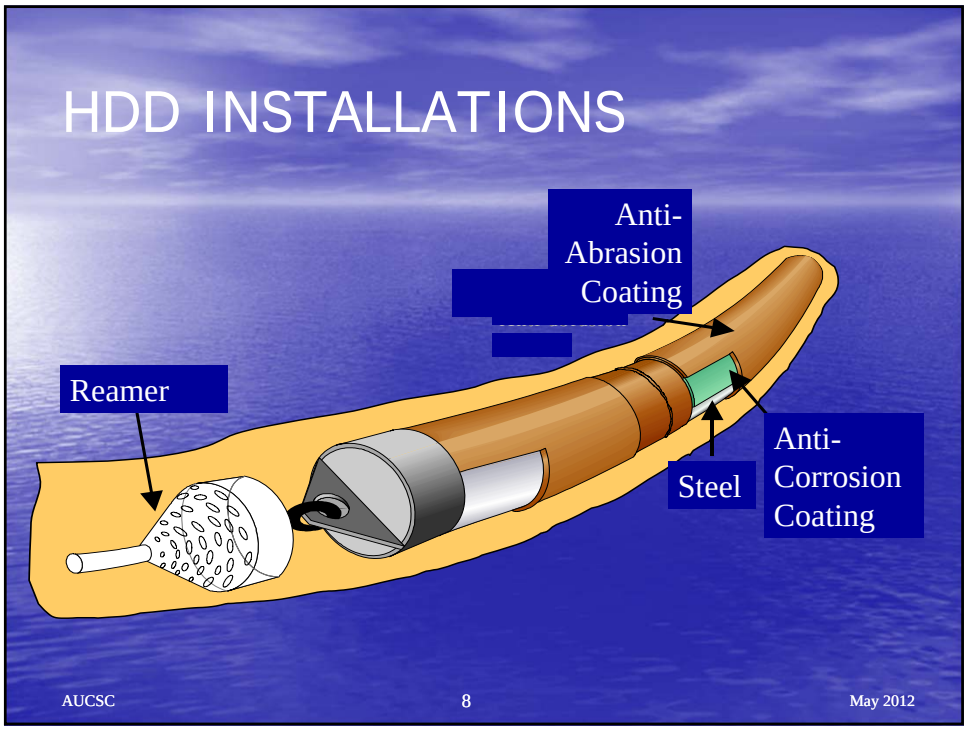
DIRECTIONAL DRILLBORES

OIL & GAS LINES

CABLE LAYS

PROCEDURE

- Geological mapping of area to be drilled
- Fabrication of pipeline to be installed
- Borehole drilling
- Casing installation (if cased)
- Pull-through of fabricated pipeline


HDD INSTALLATIONS
Anti-
Abrasion
Coating
Reamer
Steel
Anti-
Corrosion
Coating
AUCSC
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May 2012

CONSIDERATIONS FOR EXTERNAL COATINGS

- Standard performance tests for carrier pipe coating
- Coating must also be rated for resistance to damage during HDD installation
- Compatibility with CP system important

TYPES OF PIPELINE COATINGS

- EPOXIES AND POLYURETHANES
  - **FUSION BOND EPOXY (FBE)**
  - **LIQUID EPOXY**
  - **POLYURETHANE**
- POLYOLEFIN-BASED
  - **EXTRUDED POLYETHYLENE (2-LAYER)**
  - **POLYETHYLENE TAPE**
  - **3-LAYER POLYETHYLENE or POLYPROPYLENE**

TYPES OF PIPELINE COATINGS

- TAR-BASED THERMOPLASTICS
  - **COAL TAR ENAMEL (rarely used today)**
  - **ASPHALT ENAMEL (rarely used today)**
  - **HOT-APPLIED TAR TAPES**
- OTHERS
  - **PETROLATUM**
  - **WAX**

Specialty HDD Coatings

- "Temporary" coatings -- must survive only during the installation (but will remain after installation)
- Purely physical property resistance
- Choice of abrasion resistance and toughness vs. lubricity

HDD Coatings

- Extra thickness (2x) FBE

Advantages/Disadvantages

Extra thickness (2x) FBE

- Can be applied at the same time as FBE corrosion coating
- Compatibility between coatings assured
- Good adhesion to steel

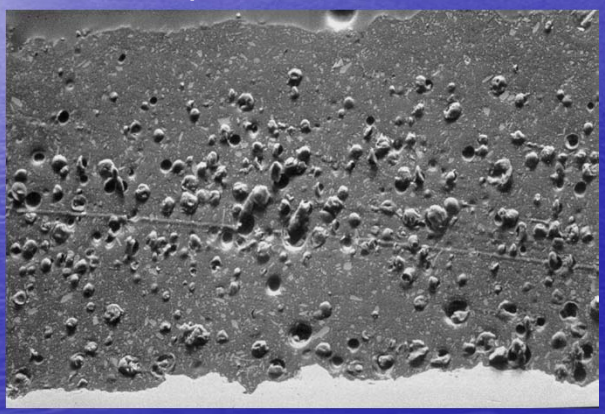
- Poor flexibility if applied too thick
- Not impact resistant

HDD Coatings

- Extra thickness (2x) FBE
- Dual powder FBE

DUAL POWDER FBE

- Extra abrasion protection added to outer layer



Advantages/Disadvantages

Dual Powder FBE

- More abrasion resistant than standard FBE because of tougher filler
- Formulated specially for ease of topcoating

- More expensive to apply
- Less lubricity for boreholes which are gravelly

HDD Coatings

- Extra thickness (2x) FBE
- Dual powder FBE
- Polyurethane

Advantages/Disadvantages

Polyurethane

- Can apply on-site to joints as necessary
- Fast curing – very thick coats possible
- Slick and lubricating

- Not very tough, must apply thicker to get protection
- Adhesion and compatibility not as good

HDD Coatings

- Extra thickness (2x) FBE
- Dual powder FBE
- Polyurethane
- Polymer Concrete

Advantages/Disadvantages

Polymer Concrete

- Very hard and tough, impact and abrasion resistant
- Can be applied after leaving coating plant

- Poor flexibility, can crack during straining
- Adhesion direct to steel not as good as FBE
- More difficult to apply (compared to liquid coatings) due to loading with aggregate

HDD Coatings

- Extra thickness (2x) FBE
- Dual powder FBE
- Polyurethane
- Polymer Concrete
- Polyethylene / Polypropylene (3-layer)

Advantages/Disadvantages

Polyethylene / Polypropylene (3-layer)

- Already a standard pipeline coating – no need for specialty application
- Very thick, smooth outer layer of polyethylene or polypropylene provides good rock shield

- Gouge resistance
- Field joint may be weak link

Damage to HDD Coatings

Generally one of 2 forms

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

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

Gouging from HDD

Gouging from HDD

Bending/Shear Disbondment

So, What to Use? Considerations:

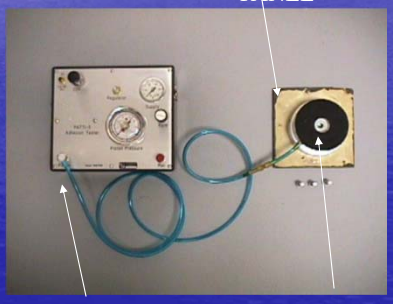
- Wholly dependent upon specific HDD
  - Geological information
  - Pipe size, pull length
- Pipeline contractor (and coating applicator) experience
- Initial corrosion coating selection
  - On site vs. plant application
- Cost

Tests Specific to HDD Coatings

- Adhesion to corrosion coating
- Gouge Resistance
- Abrasion Resistance
- Flexibility
- Penetration Resistance
- Impact Resistance

ADHESION TESTS

- ASTM D4541
- Pull-off test, measures force/stress
- Difficult to interpret sometimes because of cohesion failures

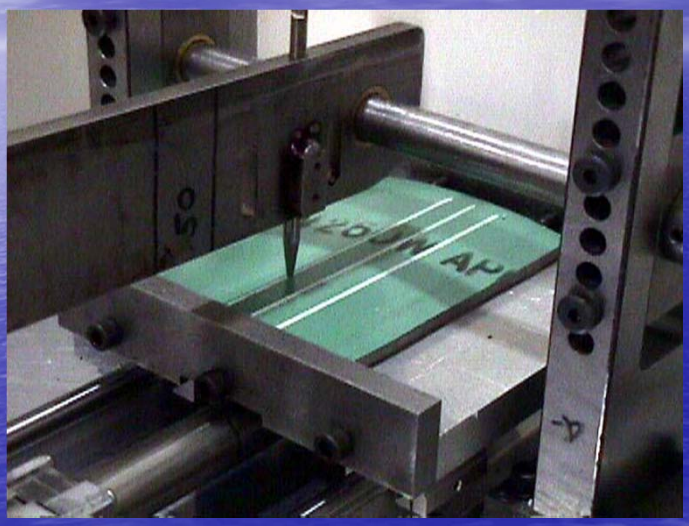


Example of Pull-Off Adhesion Test

GOUGE TEST

- Test panel pulled at controlled speed under weighted point, depth of penetration measured
- Weight increased until entire thickness of coating penetrated
- Problems with inter-lab reproducibility
- Pipe coating labs may have proprietary tests

GOUGE TEST



ABRASION WHEEL

- ASTM D4060 Taber Abrasion
- Abrasive wheel grinds at rotating coating, measure weight loss

DRUM ABRASION

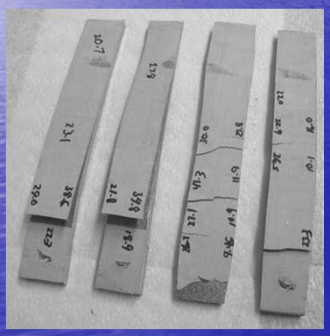
- ASTM G6 - Drum filled with sharp rocks, tumbles over sample, monitor resistance until holidays are created

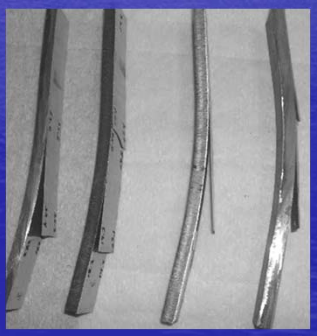
FLEXIBILITY

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

FLEXIBILITY

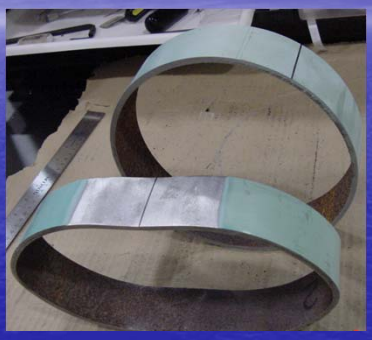
- DON'T WANT THIS! (shear disbonding)



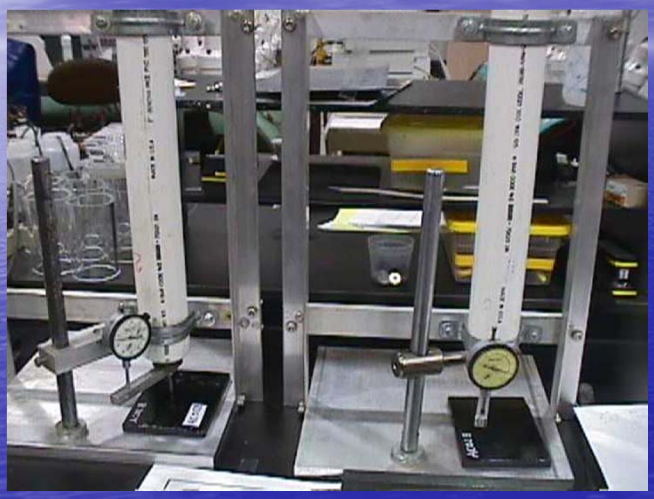


FLEXIBILITY

BENT RING TEST



PENETRATION RESISTANCE



IMPACT TEST

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

Example of Impact Testing

Coating Thickness (3LPE)	1.4mm	2.0mm	3.0mm
Granular Backfill Size			
50.8mm to 76.2mm (2" to 3")	Pass	Pass	Pass
76.2mm to 127mm (3" to 5") Less than 8.0lbs	Pass	Pass	Pass
152mm to 203.2mm (6" to 8") Approximate Weight 8.6lbs to 16lbs	Pass	Pass	Pass
203.2mm (8") Approximate Weight 22lbs to 32lbs	Failed	Failed	Pass

Granular Backfill Resistance Testing.

- ASTM G13-89 (Test method for Impact Resistance of Pipeline Coating)
- Temperature of test specimen during testing between –13°F and –49°F
- Height at which the granular backfill was allowed to free-fall @ 6 ft

Examples of Impacted Coatings

ALL PHYSICAL TESTS

EVALUATE ABILITY OF COATING TO WITHSTAND:

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

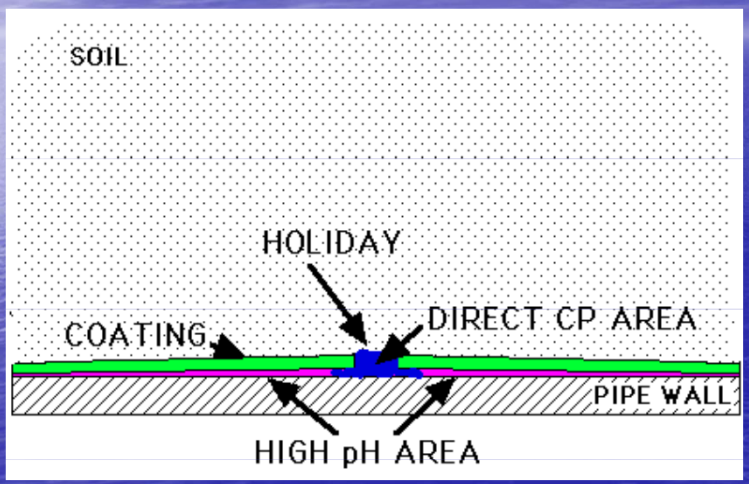
CONSIDERATIONS FOR IN-SERVICE PROPERTIES

- Coating must *still* perform as an anti-corrosion coating
- Cathodic protection interaction different
  - If impressed current system applied care to design properly as protection only possible on either side of HDD

CATHODIC DISBONDMENT

- Occurs at holidays only, disbonded area protected locally

CP IN DISBONDED AREA



CATHODIC DISBONDMENT

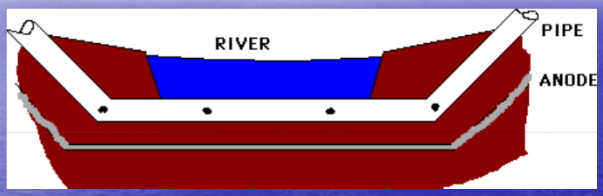
- Occurs at holidays only, disbonded area protected locally
- Creation of holidays during HDD installation

CATHODIC DISBONDMENT

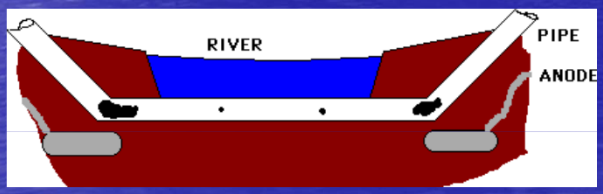
- Occurs at holidays only, disbonded area protected locally
- Creation of holidays during HDD installation
- Excessive disbondment in some areas if cathodic protection not uniform

CATHODIC DISBONDMENT

ANODE INSTALLED IN DRILLBORE



ANODES AT RIVER'S EDGE



ASSESSMENT OF HDD COATING CONDITION

- Usually estimated by pulling a sacrificial joint through prior to pullback

IN-SITU ASSESSMENT OF HDD COATING CONDITION

- 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 conditions
- Ordinary pipeline coatings do not hold up well to HDD installations, must use special system
- Selection of coating dependent upon specific HDD project
- No single HDD coating system has been proven superior, but several standard tests provide useful information

SUMMARY

- Because coating holidays are expected, cathodic protection system has to be adequate to protect pipe
- Accurate assessment of coating condition after installation difficult
- HDD installations are now commonplace and are part of every major pipeline construction contractor's skill set

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