EVALUATION OF COATINGS FOR HORIZONTAL DIRECTIONAL DRILLBORES

MIKE SURKEIN / GREG RUSCHAU
ExxonMobil Development Co.
Houston, TX

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

- Reamer
- Anti-Abrasion Coating
- Steel
- Anti-Corrosion Coating
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

- 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

- 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

- 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

Polyurethane

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

AUCSC 25 May 2012

Gouging from HDD

AUCSC 26 May 2012
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

• ASTM D4060
  Taber Abrasion

ABRASION WHEEL

• 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)

BENT RING TEST
PENETRATION RESISTANCE

IMPACT TEST

- ASTM G14
- Test temperature variable
- Drop weight on coating, examine for holiday creation
Example of Impact Testing

<table>
<thead>
<tr>
<th>Granular Backfill Size</th>
<th>Coating Thickness (3LPE)</th>
<th>1.4mm</th>
<th>2.0mm</th>
<th>3.0mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>50.8mm to 76.2mm (2” to 3”)</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>76.2mm to 127mm (3” to 5”)</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Less than 8.0lbs</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>152mm to 203.2mm (6” to 8”) Approximate Weight 8.6lbs to 16lbs</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>203.2mm (8”) Approximate Weight 22lbs to 32lbs</td>
<td>Failed</td>
<td>Failed</td>
<td>Pass</td>
<td></td>
</tr>
</tbody>
</table>

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

• 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

MIKE SURKEIN
ExxonMobil Development Co.
Houston, TX
281-654-4821
michael.surkein@exxonmobil.com