

SIMULATION OF COATING BEHAVIOR IN BURIED SERVICE ENVIRONMENT

A. Andrenacci & D. Wong
ShawCor Research & Development

The Paper comprises :

- Description of the coating systems under evaluation
- Test apparatus used for their evaluation
- Results of the investigation

General Corrosion Prevention Methods

- Prevent Corrosive species to get to the metal by having the coating maintain its integrity when buried
- Use of Inhibitors
- Use of Cathodic Protection
- etc...

The Coating Integrity depends on:

- Type of soil
- Soil compaction
- Wet & Dry Cycles
- Burial depth
- Freeze & Thaw Cycles
- Operating temperature
- Pipe size
- etc..

Mechanically Induced Stresses are classified into four categories

- Static Stress (Load - Soil type & pipe wt)
- Axial Stress (Expansion / Contraction of pipelines)
- Circumferential stress (Lateral Movement of the Pipe at bends)
- Random Stress (soil swelling and shrinking)

Coating Systems Evaluated

- Extruded Polyethylene (2LPE)
- F.B.E.
- 3-Layer Polyethylene (3LPE)
- Cold Applied Tapes
- Heat Shrinkable Sleeves

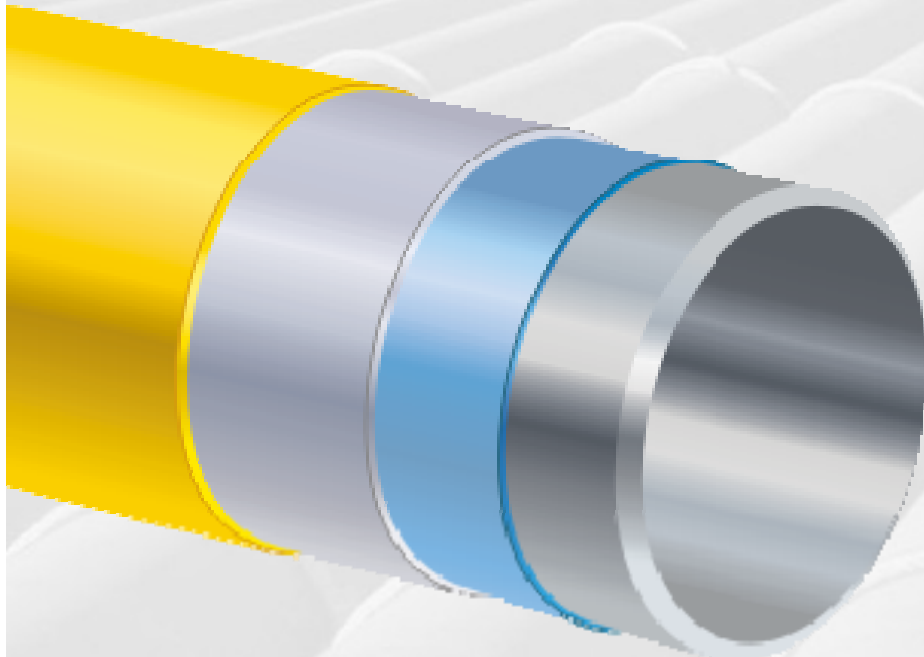
Extruded Polyethylene (2LPE)

- In use since the 60's
- Generally Soft Adhesive/Sealant
- High Density P.E.
- Very well suited for Small Diameter Pipes

FBE (Fusion Bonded Epoxy)

- In use since the 70's
- Good properties at low and high temperatures
- Hard Coating
- Suitable for any pipe size – most commonly large diameter

3 Layer Polyethylene (3LPE)



- In use since the 80's
- Extensive use in Europe / Asia & increasing in North America
- A combination of the previous two coatings
- Adhesive is a Hot Melt
- Can be used for any pipe size

Cold Applied Tapes



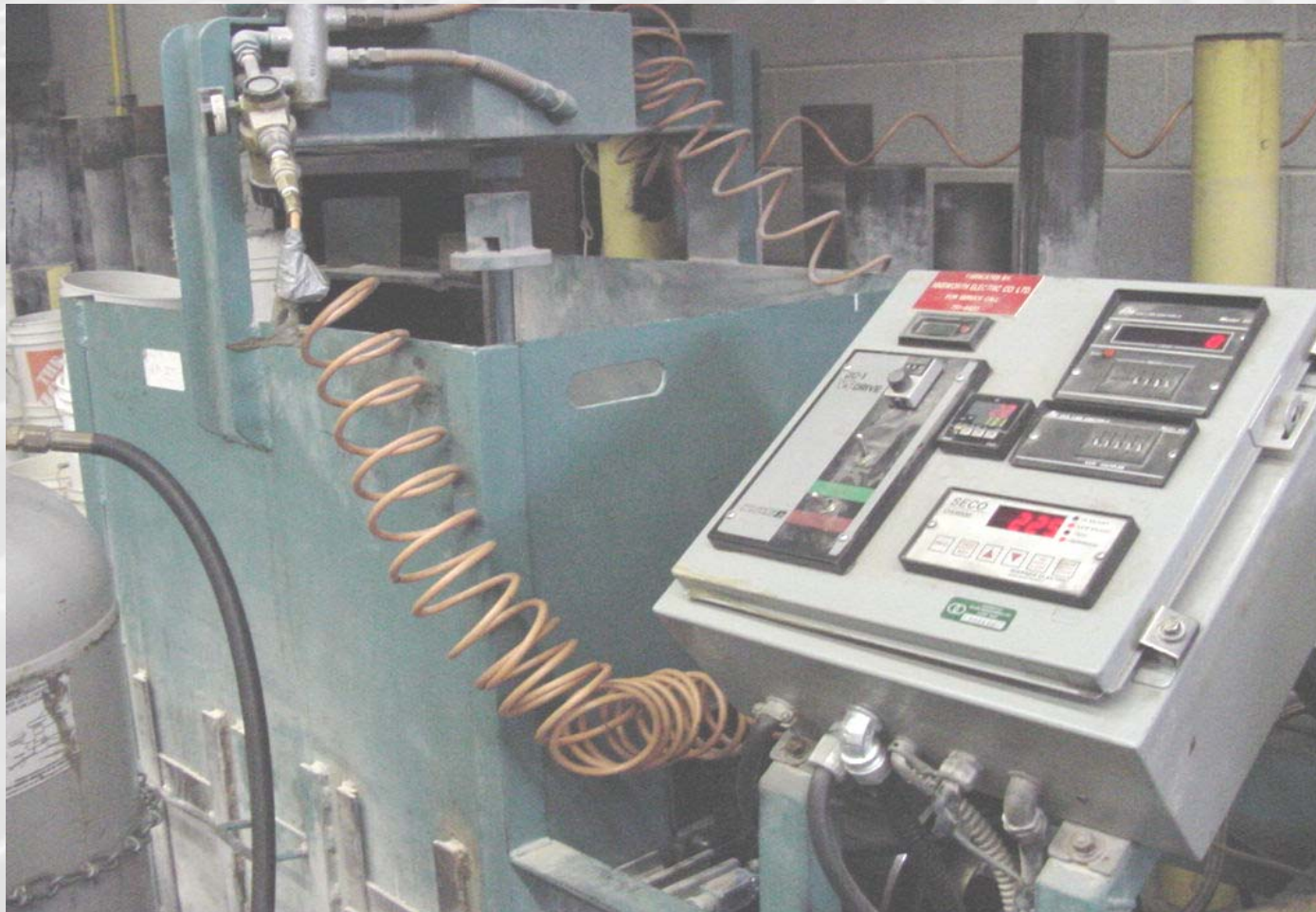
- An early method of protecting pipelines
- Rubber-based adhesives
- Most common for:
 - Low Operating Temps.
 - Small Size pipes

Heat Shrinkable Sleeves

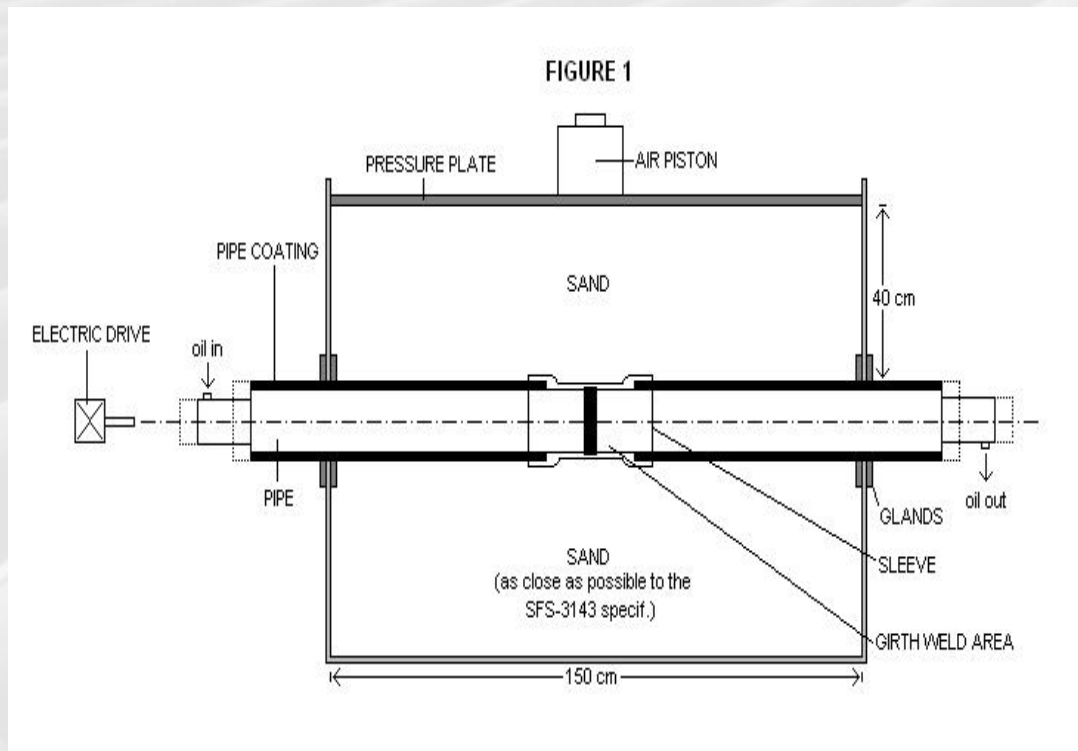


- In use for >30 Years
- Uses a variety of adhesives and PE's
- PE topcoat is cross-linked and stretched
- Shrinking develops continuous hoop stresses

Test Apparatus



Soil Box



- Box (1.5 x 1.0 m)
- Pump (circulates heated oil)
- Reversible Electric Drive with Limit Switch
- Main Panel
- Pressure plate
- Air Piston

Sample Preparation

- Coated pipes – 54" (1.37m) long
- Samples are applied at the mid-point of 54" pipe

Type of Soil

- Any type is possible
- For this testing, a mixture of dry soil and gravel was used

Procedure

- Place sample into the Soil Box
- Secure the Sample
- Fill the Soil Box
- Install Pressure Plate
- Set the key variables:
 - Number of cycles
 - Speed of movement
 - Distance of travel
 - Temperature of Circulating Oil

Sample Evaluation

Sleeves	Tapes	Coatings
Penetration of sand under the sleeve	Penetration of sand under the seams	Abrasion Resistance
Displacement of sleeve	Integrity at Overlaps	Wrinkling
Wrinkling/Tearing	Wrinkling	Tearing
Closure Integrity	Tearing	Shifting
Disbondment	Disbondment	Disbondment

Results at 23°C

(X = No Changes observed)

# of Cycles	2LPE	3LPE	FBE	Tapes	Heat-Shrinkable Mastic Sleeves	Heat-Shrinkable Hot Melt Sleeves
20	X	X	X	X	X	X
40	X	X	X	Minor Lifting	X	X
100	X	X	X	Major Wrinkling	Some soil penetration	X
150	X	X	X		Wrinkling and Shifting	Closure Lift-up
250	X	X	Minor Scratches			Minor soil Penetration
500	Minor Scratches	Minor Scratches	Minor Scratches			Major soil Penetration
1000	A few major scratches	Minor Scratches	A few major scratches			

Results at 60°C

(X = No Changes observed)

# of Cycles	2LPE	3LPE	FBE	Tapes	Heat-Shrinkable Mastic Sleeves	Heat-Shrinkable Hot Melt Sleeves
20	X	X	X	X	X	X
40	X	X	X	Major Wrinkling	Some soil penetration	X
100	X	X	X		Wrinkling and Shifting	X
150	X	X	X			X
250	Minor Scratches	Minor Scratches	Minor Scratches			Minor soil Penetration
500	Minor Scratches	Minor Scratches	Minor Scratches			Major soil Penetration
1000	A few major scratches	Minor Scratches	A few major scratches			



BREDERO SHAW

A SHAWCOR COMPANY

The GLOBAL LEADER in Pipe Coating Solutions

Observations

- Most samples passed higher # of Cycles than expected
- “Continuous Coatings” (FBE, 2LPE, 3LPE):
 - Minimal effects of temperature (23/60°C)
 - Minimal effects on # of cycles
 - PE and FBE damage was abrasion-related with PE slightly better than FBE

Observations ... continued

- Sleeves:
 - Hot Melts performed better than Mastics, particularly at higher temperatures
 - Residual Hoop Stresses help the performance
- Tapes:
 - Wrinkling & sand penetration occurred at 23 & 60°C
 - Failure occurred at lowest # of cycles
- Profiles/Overlaps are the weak points

Failures Due To Soil Ingress Between Adhesive & Pipe



Probable Causes:

- Poor bond of adhesive to the pipe coating
- Poor coating application
- Poor surface preparation

Failure between Adhesive & Top Coat



- Adhesive did not bond well to PE Backing
- Clay Soils tend to bond tenaciously to the PE and cause the pipe to slide inside

Failure at Overlaps



- Too many overlaps
- Relatively low hoop stresses

Abrasion Failures



- Scratches
- PE slightly better than FBE

Failure of Low Cohesive Strength Adhesives



- Hot Melt vs. Mastic adhesive technologies
- Lower shear strength adhesive

Mastics vs. Hot Melt Adhesives

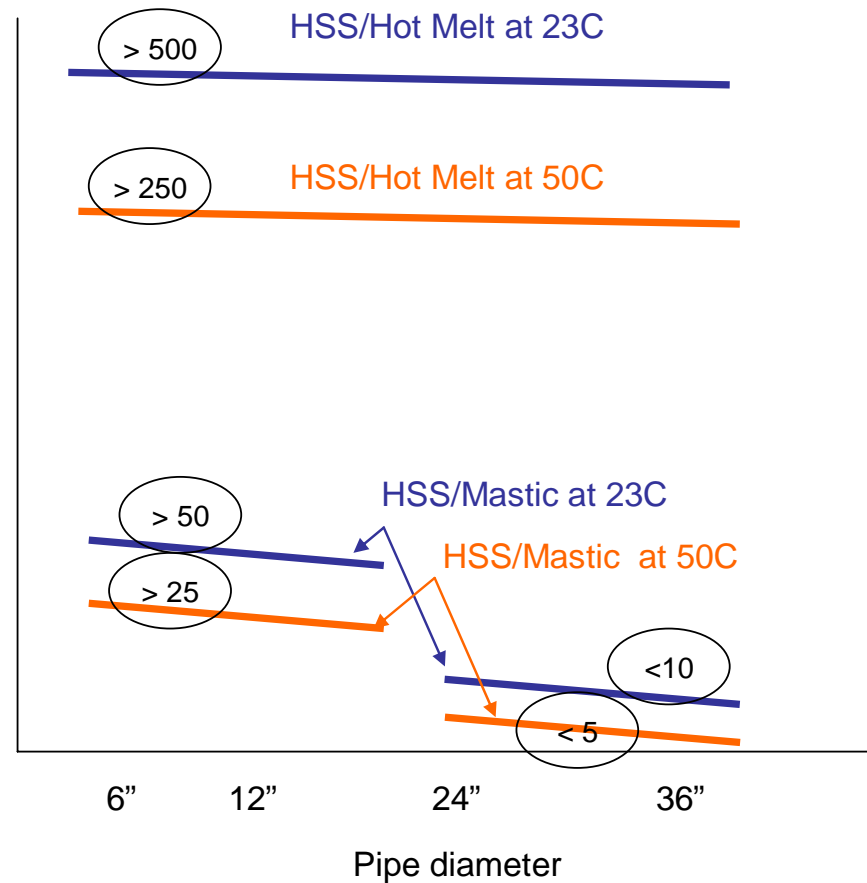
Soil Box Testing

Swedish DH Specification:

- Sand / Gravel mixture
- Simulated 3 or 6 ft. depth
- Travel 1 cm /minute
- Longitudinal 10 cm distance
- Pass = 20 cycles



cycles to failure



Words of Wisdom



Excellent coatings and girth welds protection systems are available but “always” a compromise

- Cost
- Surface Preparation
- Installation Time
- Pre-Heat
- Type of Backfill
- Equipment availability
- Crew size
- Inspectability
- Sensitivity to application conditions

Conclusions

- Coatings with smooth continuous outer sheath (2LPE, 3LPE and FBE) performed very well
- The greater the number of exposed edges, the more the coating is prone to soil penetration
- Mastic adhesives are more sensitive to temperature (Adhesive shear resistance at operating temperature is important)
- Given the same adhesive, coatings with X-linked Top-coats and High Hoop Stresses perform better than the coatings without X-Linking or Hoop Stresses.

FABRICATED BY:
AINSWORTH ELECTRIC CO. LTD.
FOR SERVICE CALL
751-4420

200

RED LION CONTROLS Model SCD

COUNT 0

RESET

PRESET 0 7 5 0

119
130

ESCC

RED LION CONTROLS Model RMX

RATE MULTIPLIER 0.1 2 5 5

DC-1
VS DRIVE

SPEED 0 10

FORWARD

REVERSE

RUN

STOP

RELIANCE ELECTRIC

SECO DS9000

225

- HI ADJUST
- LOW ADJUST
- TACH
- REFERENCE

PROG TACH REF ▲ ▼ HI LOW VALUE CODE

WARNER ELECTRIC SECO ELECTRONICS

PROPERTY OF SHAW INDUSTRIES LTD

