Trends in Pipe Coating – An Operator’s Perspective

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Overview – Exxonmobil Corporation

• Company Overview
  – ExxonMobil is the world’s largest publicly traded integrated petroleum and natural gas company
  – Company holds exploration and production acreage in 36 countries
  – Production operations in 24 countries around the world.
  – In 2007, seven major upstream projects started production.
  – ExxonMobil sells natural gas in almost all major and developing markets to power companies, industrial users, and distributors.
  – Total 2007 oil and gas production available for sale averaged 4.2 million oil-equivalent barrels per day.
In Service Pipelines

Legend
(Total Miles)

100
500
1000
2000
3000

EMCE
EMCW
IOL
USP
MNSL
NAS
ENAS
EMPG
MPN
COTCO-TOTCO
EEPML
MEGI
EEAL
MEG
ENAS
ENL
EMEPMI
EMOI
EAPL
EAEN
Where are We Working

- Oil
- Heavy oil / sand
- GTL
- Pipeline (gas)
- LNG Terminal
- LNG
- Power (gas)
What’s Next

Map showing locations such as Canada Beaufort, West Greenland, UK North Sea, Germany, Hungary, Romania, Libya, Italy, U.S. Gulf of Mexico, Nigeria, Angola, Madagascar, Brazil, Australia, Philippines, Indonesia, Cepu, Makassar, New Zealand.
Pipe Tonnage

• Total Since 1996 = 1,160,152 Metric Tons
International Business

• **Mix of EPC and Direct Contracting**
  
  – Challenges for each approach
  
  – **EPC**
    + Working with EPC contractor to ensure Company requirements are met
    + One more cook in the kitchen
    + Open lines of communication between pipe coater and end user
    + Transparency during bidding
  
  – **Direct Contracting**
    + Typical when pipe procurement is a long lead item
    + Allows direct communication between pipe coater and end user
Joint Venture Projects

- **OBO Challenges**
  - “Operated by Others”
  - Partners must align on both technical and commercial issues
Health, Safety & Environmental

• Importance
  – Nothing is more important
  – New mills = new workforces
Health, Safety & Environmental – Yard Safety
Health, Safety & Environmental

• Mill Safety
  – Engineering for safety
  – Access to moving pipe
  – Interlocking gates
Technical Challenges – Arctic Pipelines

- **High demand for energy**
  - Remote – requiring transport
  - Harsh environments

- **Arctic development – high strain**
  - Ice scour
  - Frost Heave
  - Thaw Settlement

- **Coating drivers**
  - Low temperature FBE compatible with strain based pipe metallurgy
  - Backfill protection
Technical Challenges – Multilayer Systems

• **End Disbondment**
  – Common problem
  – Many Causes
    + Surface prep
    + Line speed
    + Cutback configuration
  – Potential Corrosion Problem
  – Impedes field joint coating application
Technical Challenges - Insulation

• **Insulation Systems**
  – Multi-layer polypropylene
  – Molded Polyurethane
    + Solid and syntactic

• **Multi-layer PP**
  – Commonly used for high temperature subsea insulation
  – Cut back configuration is project specific
  – Field jointing can be challenging

• **Molded Polyurethane**
  – Highly adaptable material, installation friendly
  – Temperature limitations
    + Susceptible to degradation by hydrolysis
  – Compatibility as a field joint coating on mill applied polyolefin is a concern.
Field Joint Coatings

- **Quality & Integrity**
  - Typically the weak point in a pipe coating system
  - Aligning field joint coating requirements with mill applied coatings
    - Cutback configuration and integrity is important
    - Multi-layer systems are often challenging
  - Employing skilled field joint coating contractors is critical.
Pipe Coating Purpose

- Prevent corrosion of pipe steel
- Reduce cathodic protection current demand

- Easy to apply pipe coating
- Availability
- Performance
  - Handling
  - Cathodic disbondment
- Long life
- Simple field joint

- References
  - API
  - NACE
  - ISO
  - AFNOR
  - ASTM
  - CSA
Pipe Coatings of Choice

Main Line Pipe Coatings - Selected from XOM Global Practices

- **Fusion Bonded Epoxy (FBE)** - mostly in North America
  - Single or dual layer up to 95 C (200 F)
  - Dual layer for HDD’s
- **3 Layer Polyethylene (3LPE)** - up to 80 C (175 F) - common outside US
- **3 Layer Polypropylene (3LPP)** - up to 110 C (230 F)

Field Joint Coatings

- **FBE**
- **3LPE**
- **3LPP**
- **Liquid**
  - Epoxy
  - Epoxy Urethane
  - Tar Urethane
Pipe Coating Qualification / Application Process

- Coating System Pre-Qualification
- Application Procedure Qualification
- Quality Control Testing

Why do we do it?
- Help assure mill can apply specified coating to specific project pipe

Benefits
- Right coating system
- Help project meet schedule
- Help assure high quality coating system

Common Issues
- Change over from previous job
- Line speed change

Goal
- Assure long term corrosion protection

Is it easy to complete?
Lessons Learned from Qualifications

- **Coating System Pre-Qualification**
  - Includes information from coating manufacturer

- **Application Procedure Qualification**
  - Includes applying specified coating to project pipe for testing
  - Normally around 10 joints but better mills need less
  - Often difficult for busy mill
  - Often difficult to get project pipe
  - For FBE standard testing as per NACE RP0394 with some ISO tests
  - For 3 Layer coatings testing mostly Canadian Standard with AFNOR NF A49-711 for 3LPP testing
  - Longest test is 28 day CD
  - Flexibility to use mill standard via deviation or concession
  - Line speed is an essential variable
  - Mills often request to conduct in conjunction will full mill run of pipe coating
  - Risk is with mill. If tests fail what now???? Do these test ever fail??????
  - Do we over test??????????? More later

- **Quality Control Testing**
  - For FBE standard testing as per NACE RP0394 with some ISO tests
  - For 3 Layer coatings testing mostly CAN/CSA-Z245.21-M92 with AFNOR NF A49-711 for 3LPP testing
  - Flexibility to use mill standard via deviation or concession
Subsea Pipeline Quality - Lessons Learned

Background

- 92 km (out of 168 km total) of FBE coated pipe with concrete weight coating
  - Sizes range from 18” to 36”
  - All 92 km to be installed by offshore lay barge (6 months after field joint qualification)
- FBE coating performed at pipe coating mill over 3 month timeframe (June to August)

Issue

- Original pipe coating (FBE) blistered during field joint application
  - Problem discovered during field joint coating trials in Sept
**Offshore Field Joint**

- **12.2 m long pipe joint**
  - 16 mils (400µ) FBE coating applied at pipe coating mill
  - Field Weld – to be made offshore

- **20 mils (500µ) FBE field joint coating to be applied offshore**

- **Concrete weight coating applied at pipe coating mill**

- **FBE blistering observed during field joint trials**
Subsea Pipeline Coating – Lessons Learned

Investigation

- Coordinated testing Initiatives to investigate
  - In-house pipe coating mill quality testing reviewed (Table 1c)
    + All results documented as acceptable
  - Contractor conducted independent testing in in-house lab
    + CD results failed to meet specified requirement
  - Contractor conducted additional tests at 3rd party lab
    + CD results failed to meet specified requirement
  - Project engaged 3rd party lab / coating consultant to test
    + CD results failed to meet specified requirement
  - All additional CD tests failed to meet specified requirement
Possible Solutions

Solution Plan

• Determine why CD results conflict and fail to meet specified requirement
  – Contractor engaged a Certified Agency to audit of pipe coating mill
  – Project conducted an independent audit
• Determine why coating blistered
• Develop optional approaches to keep Project on schedule without impacting

Examined various options:

• Slower FBE field joint heating cycle time
  – Significant offshore time impact - too slow???
• Lower temperature field joint application
  – Use liquid system
  – Significant offshore time impact due to Liquid cure time
• Total pipeline replacement
  – Place new order would miss installation window. Possible year delay
• Stripping and recoat of pipe
  – Unlikely outcome (long schedule hit)
• Bare field joints with additional anodes (bracelets or sleds)
Why did the CDT’s pass if the coating had inadequate properties?

- Test lab certified by Agency
- Mill position was that QC testing indicated pipe coating had sufficient properties
- Lab visit revealed thermocouple inserted into sand
- Electrolyte temperature significantly lower than required (40-42°C)
- After temperature adjustment CDT’s failed
**Why Did Coating Blister?**

- **Foaming**  
  - Rapid quench did not allow for proper gas evolution  
  - Trapped air lead to significant porosity/foaming
- **Night shift versus day shift quality?**
- **Moisture contamination of powder?**
- **Low preheat temperature?**
- **Recycle system inhale moist air?**
Plan Forward

- Selected use of bare field joint with additional anodes
- Either discrete bracelet anodes or sleds

- Contractor proposed to use additional bracelet anodes
  - Provided calculations acceptable to Project
  - Provide a procedure to Project for approval
    + Required concrete removal
  - Project to witness an approve procedure

- Project accepted approach
  - Permitted no schedule slippage
Concrete Removal
Summary of Pipeline Example

- Clearly written Project Specification
  - Required qualification of field joint application with project coated pipe
- Tests required to be witnessed by experience Corrosion / Materials Engineers
- Root cause was problem how coating mill conducted test
  - Mill improved testing procedure
- Several solutions developed trying to not impact schedule & maintain pipe corrosion integrity
- Solution agreed – install more cathodic protection anodes
  - Work procedure developed & trial witnessed by Materials Engineers
  - Procedure approved by Materials Engineers and construction personnel
- Work completed and pipeline installed
- Periodic cathodic protection surveys to be conducted in accordance with ExxonMobil Facility Integrity Management System requirements

Major Lesson Learned
- Follow requirements of Specification
  - Details in Specification for a reason
- Work needs to be witnessed by qualified personnel
3LPE PQT Requirement - Lesson Learned

- Part of pipeline coating procurement includes Production Qualification Testing “PQT”
Importance of Pre-Qualification Procedures

Background
- World class experienced coating mill to supply standard 3LPE
- Contractor bid job with minor exceptions
- All exception agreed to and contract let
  - Major exception agreed to is to eliminate chemical surface treatment
- GP for 3LPE - Table 1b requires a procedure qualification test program (PQT)
  - Coating mills typically want to conduct PQT at production start up
  - Often times accepted at mil risk
- This case mill decided to conduct PQT well in advance of actual coating
**Timeline**

- Mill coated several lengths of Project specific pipe for testing
- All short term tests passed as per specified requirement
- Long term (28 day) CD test failed to meet specified requirement
- Questions as to why standard 3LPE not pass industry standard test
- Mill decides to re-test as failure portrayed as an anomaly
- Project concerned but still has schedule
- Corrosion / Materials specialist suggests that mill equipment has contaminated pipe resulting in unacceptable result
  - Rollers dirty & mill dusty
- **Mill agrees to fix problem**
- Second 28 days CD test conducted with CD result still unacceptable
- Corrosion / Materials specialist visits again and finds out mill did not replace rollers or eliminate dust although Project quality personnel present during recoating
- Mill agrees to replace roller and upgrade ventilation and request approval to use phosphoric acid wash
- Project staff witness all activity
- Acid wash used after midline inspection just prior to induction heating
- 28 days later CD result is acceptable
- Elapsed time nearly 4 months
Major Lesson Learned

- Follow requirements of Specification
- Details in Specification for a reason
- Need to have schedule time to conduct all required qualifications
- Work needs to be witnessed by qualified personnel

People Do What you Inspect Not What You Expect
Final Thoughts!!

- Graying of Workforce
- Problem???

Thanks For your Attention