NACE INTERNATIONAL

NON-METALLICS SOLUTIONS FOR OILSANDS

John Baron
J. Baron Project Services Inc

OCTOBER 12, 2006

CORROSION

- Ongoing problem but consequences of failure have increased due to increased monitoring and intolerance by public and regulators.
- Operating a piping system to failure is not an acceptable approach.
- In water systems, oxygen content, solids loading, bacteria, temperature fluid velocity, all influence ultimate internal corrosion rate.
- Operator costs increasing due to corrosion prevention and monitoring costs that never end over the life of a facility using chemical treatment and inspection.
- Corrosion of carbon steel results in significant deposits and fouling within piping resulting in significantly higher pressure drops and increased pumping costs.

Operators should analyze PV Operating Economics over life, not just initial CAPEX when examining alternate materials.

Flow Efficiency

- Non-metallic pipe or liners are much smoother than steel resulting in reduced pressure drop.
- No corrosion related deposits formed
- Other deposits may be lessened due to smooth surface.
- Pressure drops can be significantly reduced compared to corroded, scaled pipe.
- Significant operating costs savings in oilsands operations due to large volumes of water being pumped.

Typical Surface Roughness of Various Pipe Materials

Material	Typical Inner Surface Roughness, mm
Steel Pipe, new	0.04
Steel Pipe, rusting	0.4
Steel Pipe, very rusted or scaled	3.35
Steel Pipe- Plastic Coated	0.004
Polyethylene Pipe	0.001

Typical Hazen Williams Flow Coefficients

Material	Flow Coefficient
Steel Pipe, new smooth	130-140
Steel Pipe, rusted	100
Steel Pipe, very rusted or scaled	60-80
Steel Pipe- Plastic Coated	145
Polyethylene Pipe	155

Pipe Material	Flow Coefficient	Flow Rate	Velocity	Head Loss
	Hazen Williams	m^3/ sec	m/sec	kPa/7000 m
			36"	36"
Plastic	150	2.0	3.22	431
New Steel, smooth light rusting	125	2.0	3.22	608
Used Steel, average rusting	100	2.0	3.22	921
Used Steel Highly Corroded/Scaled	75	2.0	3.22	1568

Reinforced Composite Pipe

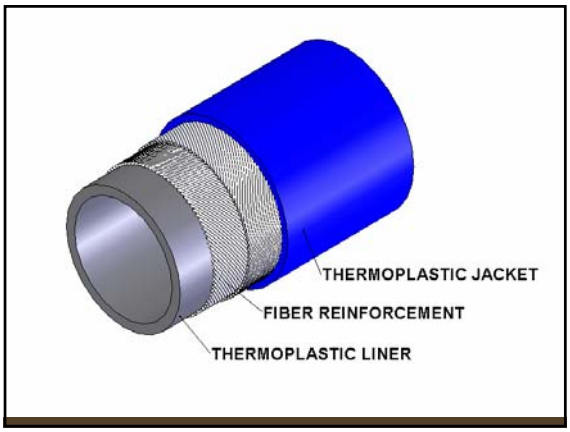
- Continued use of fiber-reinforced composite pipe at higher pressures and temperatures. 35 year history in conventional oil and gas flowlines.
- Larger diameter pipe available.
- Spoolable flexible continuous length composites, reeled pipe. Smaller diameters <6".
- Flexible composites: HDPE inner liner that is over-wrapped with fiberglass filaments (dry or wet), Kevlar tapes, or steel strip reinforcements.

Reinforced Composites

- Large diameter composite available
- Newer resins can offer pipe with temperature capability to 120C+

Potential Oilsands Applications:

-higher pressure fire water
-inter-site water pipelines
-cooling water systems
-flexible composites for smaller diameter water gathering, distribution systems




JB 1:30PM
MD
DB

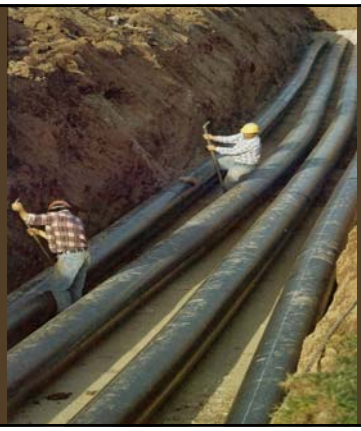
Polyethylene Piping

- Large diameters available up to 72”
- Excellent resistance to waters
- Affected by hydrocarbon liquids.
- Lower temperature capability than composite pipes, 65C
- Lower pressure ratings than composite pipe.
- Good toughness and easier to install than composite pipes.
- Fusion welded joints.

Polyethylene Piping

Oilsands Applications

- Commonly used for U/G firewater piping
- Low pressure water transmission pipelines
- Best suited for underground piping, difficult to support in pipe racks for above ground applications.

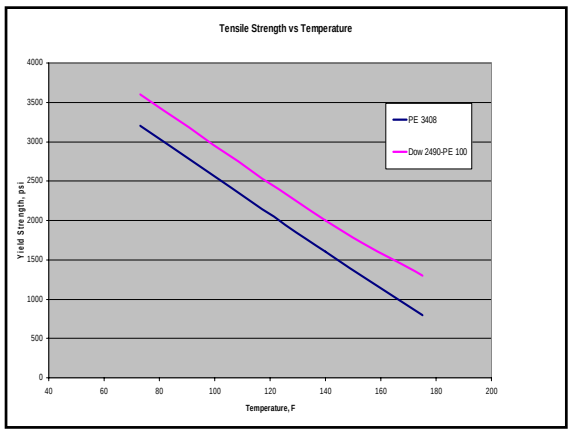


Pipe Liners

- Polyethylene Liners:
  - Fitted liners inside steel pipe continue to be used extensively in North America and some Middle East countries. Oil and gas production systems and oilfield water injection pipelines primary area of use.
  - Liners in Mine tailings pipelines have been installed.
  - Increased demand for larger diameter, tightly fitted, for oilsands projects, corrosive water systems. 30”++
  - 52” diameter largest size to date.
  - Fittings are epoxy lined or roto-molded plastic.

Pipe Liners

- Combine a highly chemically resistant liner with the high hoop strength of steel
- Have to be designed carefully
- Liners will allow gases to permeate through liner.
- Hydrocarbons acceptable but will weaken liner strength due to absorption.
- Lined piping may require periodic venting in gas services.
- Operation to prevent vacuum, temperature excursions, liquid hydrocarbon exposure is required.
- Vents may be used to monitor liner integrity.

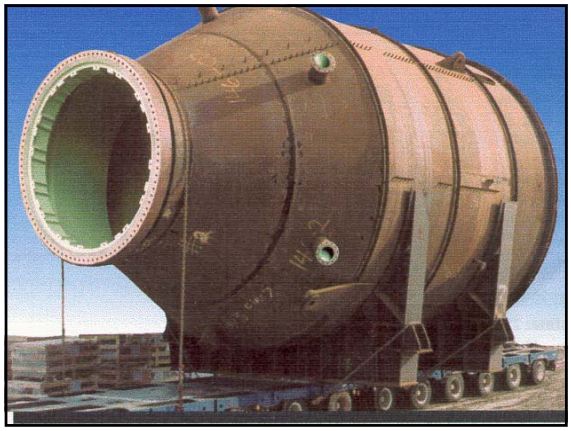

Tensile Strength vs Temperature
Yield Strength, psi
4000
3500
3000
2500
2000
1500
1000
500
0
40
60
80
100
120
140
160
180
200
Temperature, F
PE 3408
Dow 2490-PE 100

Pipeline External Coatings

- Internal/External Corrosion:
  - External corrosion normally controlled by combined coatings and cathodic protection.
  - Increased demand for higher temperature pipe coatings and thermal insulation for underground 140C+ for oilsands pipelines.
  - Industry need to transport undiluted bitumen requires high operating temperature. Limited supply of diluent is a challenge.
  - In general standard external pipeline coatings for pipelines up to 125C are available.
  - Insulated pipeline coatings up to 140-150C are actively being researched and developed in Canada.
  - European insulation systems also available to 150C from District Heating industry.

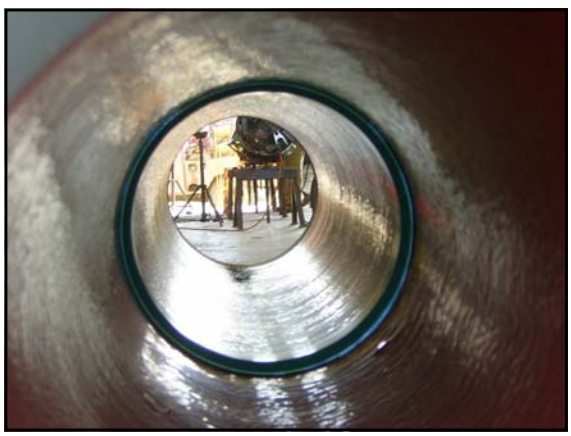
Equipment Internal Coatings

- Internal coatings based on high solids coatings are the norm, 98-100% solids.
- Allows higher build coatings with single coat application, 15-40 mils/coat
- Cure times can be reduced to 16 hours at 25C.
- 120C temperature capability with field-applied coatings for vessels, tanks.
- Specialized application equipment, plural component spray.



Pipe Internal Coatings

- Shop-applied Internal coatings to 120C are available based on epoxy novalacs
- Special welded connections are available for larger diameter pipe.
- Mechanical interference joints available for smaller diameter pipe.



Pipe Cement Lining

- Both Shop-applied and in-situ applications
- Use of standard 50% Portland Cements
- Alternate high quality specialty cements available in both shop and in-situ application
- Increased Chemical resistant alumina formulations available
- Example- Pre-krete G-8

Conclusions

1. Non-metallic material options are available for oilsands projects that provide options to bare carbon steel pipe.
2. The primary drivers are corrosion resistance, flow improvement considerations, and reduced operating costs over life.
3. Non-metallic piping capex is higher than bare carbon steel however economics should consider additional operating costs associated with corrosion of bare steel.
4. The primary technical challenges for non-metallic piping are to scale up existing technology due to larger diameter pipe used by oilsands industry and dealing with higher operating temperatures.
5. Contractor awareness of special requirements for design and construction of non-metallic pipe systems will be critical for success.