Elastomeric-lined glass reinforced plastic piping systems for improved abrasion-erosion performance

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What we will cover …

- Amiblu – a new name in the glass-reinforced plastic pipe world
- Continuous filament winding - Flowtite
- Elastomeric lined pipes for improved abrasion/erosion performance
  - Technology targets
  - Wear
  - Elastomer chemistry
  - Abrasion and erosion laboratory performance
  - Long term pipe performance
- Case studies
  - Rehabilitation for hydropower, Iceland
  - Stormwater applications in Colombia
  - Slurry pilots in Tunisia
Amiblu – who are we?
Two powerful brands coming together

- New company combining European and global businesses of Amiantit/Flowtite and Hobas
- Competencies in filament winding (continuous and discontinuous), centrifugal casting and associated GRP processes
Manufacturing facilities – an overview

- Ca. 3,000,000 tonnage of pipes made since 2002
- 35,000 km pipes made since 1996
- Longest in-service Flowtite pipe with no corrosion is 50 years
- 40 production lines running
Elastomeric lined pipes - technology targets

• Manufacturable on Flowtite continuous winder – no post coating processes
• Approvable to ISO, ASTM and EN standards
• Excellent wear and impact resistance
• Excellent field handling and lifetime in service
• Pilot cases and installations to build confidence

• Match to thermoplastic pipe performance with the benefit of temperature resistance, light weight pipes and extensive product range (to DN4000)
Wear modes – abrasion and erosion

**Abrasion**
- Velocity
- Particle size and shape
- Particle concentration
- Material of the substrate
- Coefficient of friction

**Erosion**
- Velocity
- Particle size and shape
- Particle concentration
- Material of the substrate
- Impact angle
Brittle versus ductile transition

Brittle erosion can have very high unpredictable wear rates!
Elastomeric materials for GRP liners

- Isocyanate and amine/glycol fast reaction
  - Magnitudes faster than isocyanate – water reaction → not sensitive to humidity
  - Gel time 5 – 15 sec
  - Tack free 15 – 30 sec
  - Fast cure
    - Walk on 1 – 4 h
    - Mechanical loads 2 – 12 h
    - Chemical resistance 12 – 24 h
- High tensile strength: up to 30 MPa
- Elongation at break: 200 – 400%
- Elastomeric – low stiffness
- Chemical resistance
- Extreme wear resistance
Elastomeric coatings – urethane/hybrid technology

OCN \( \text{R} \) \( \text{N} \) \( \text{C} \) \( \text{O} \) \( \text{R}' \) \( \text{O} \) \( \text{C} \) \( \text{N} \) \( \text{R} \) \( \text{NCO} \)

Diol

\( \text{O} \) \( \text{R}'' \) \( \text{O} \) \( \text{C} \) \( \text{N} \) \( \text{H} \) \( \text{O} \) \( \text{O} \) \( \text{H} \)

Polyurethane

\( \text{N} \) \( \text{R}'' \) \( \text{N} \) \( \text{C} \) \( \text{N} \) \( \text{H} \) \( \text{O} \) \( \text{H} \) \( \text{O} \) \( \text{H} \)

Polyurethane-urea

Diamine
Slurry Jet Erosion (SJE)

Test speed: 10 m/s
Silica sand: d(10) 200 µm; d(50): 275 µm; d(90): 390 µm SPHT: 0.9; b/L: 0.74
Distance to target sample: 10 cm
Sand content: 10 wt%

Cross-sectional profile of erosion scar over time

Slurry Jet Erosion
Mining Wear and Corrosion, National Research Council Canada
Material comparison with slurry jet erosion (silica sand)

**Slurry Jet Erosion**

- **Duration:** 60 min
- **Jet angle:** 45°
- **Erosive medium:** 10 wt% quartz sand (fine, D50: 293 μm, D90 415 μm in water slurry)
- **Jet velocity:** 10.2 ± 0.2 m/s

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**Baseline (prior erosion)**

Penetration depth [mm]

- HDPE pipe (PE-100)
- FTEC wear resistant PUR/PU
Darmstadt testing – corundum gravel 100 000 cycles
CEN-TR 15729

Pipe segment (trough) tilted 45° to both sides
Forth and back → 1 cycle
Min. 100 000 cycles
5 kg abrasive material (e.g. corundum)

CEN-TR 15729
Plastics piping systems - Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) - Report on the determination of mean abrasion after a defined number of test cycles
Comparison of materials

Elastomeric lined Flowtite GRP on par with HDPE

External impact and pressure capability

**Further robustness for field handling**

DN400PN10 pipe

- External impact 6 kg from 2.7 m (158 Joules)
- Some external evidence of impact
- No internal visible damage

Hydrostatic design basis testing

- 34.5 bar for 10 bar pipe
- 1000 hrs (0.91 % strain-restrained ends)
- No weep or leak or burst

ISO7509/ASTM D1598/D2992
Strain corrosion in acidic media

Ensuring suitability to acid media for ambient temperature applications

*ISO 10952/ASTM D3681*

1N Sulphuric acid
All samples still in test – no failure

1N Phosphoric acid
No failures > 10,000 hrs – test stopped
Laxá II is a 10 MW hydropower station located in northeast Iceland, 85 kilometres east of the town of Akureyri. Laxá II has been in operation since 1953 and consists of a small dam with a wheel gate from which the water enters a wood stave penstock, 4.0 m in diameter and approximately 350 meters long.
Laxa, Iceland: before repair

Eroded pipe at the invert

For comparison:
Eroded epoxy coating (3 layer system) on the steel coupling to the surge chamber
Material comparison with slurry jet erosion

*Laxa volcanic sand*

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**Slurry Jet Erosion**
- Duration: 60 min
- Jet angle: 45 deg
- Jet velocity: 10 m/s
- Erosive medium: 10 wt% volcanic sand (D10: 193 μm; D50 280 μm; D90 459 μm) in water slurry

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**Graph**
- Horizontal position [mm]
- Penetration depth [mm]
- HDPE pipe (PE-100)
- FTEC wear resistant PUR/PU
Laxa, Iceland: field rehabilitation

- 400 kg abrasion resistant liner spray-up
- Repair scenarios: pipe invert, over coupling, patches
- Confined space – poor ventilation
- Humid
- Often cold
- Return to service - days

Field repair partner:
Laxa, Iceland: field monitoring after rehabilitation

- DFT monitoring >90% of liner remaining after 3 years in service
- Excellent abrasion resistance
- Life time of pipeline is extended significantly

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Flowtite continuous filament winding

*Drostholm process*

Flowtite pipes are produced by continuous filament winding
- advancing mandrel system
- continuous material application
- any pipe length

Materials:
- continuous and cut glass fibres
- thermosetting resin
- silica sand

Product range:
- DN250-4000, PN1-40
- SN2500-500 000
Production on the continuous winder

- Spray application of PU on winder – liner zone
- Liner thickness customized for demands in service
- Flowtite laminate structural composition as standard product ranges (determines stiffness and pressure)
Colombia storm-water applications
Adhesion of elastomeric liner to GRP

DN1700 Pipe with elastomeric liner

Adhesion Pull-off Test values > 5 MPa

Deflection to crack test
Tunisia pilot: Phosphogypsum 2017

Gabes – aerial installation

M’Dhillal installation
Elastomeric lined pipes - summary

- Manufacturable on Flowtite continuous winder – no post coating processes
  - Proven with robustness on pilot and full industrial scale
  - Production effectivity and adhesion to GRP
- Approvable to ISO, ASTM and EN standards
  - Flowtite pipe performance superior
- Excellent wear and impact resistance
  - Equivalence to HDPE confirmed
- Excellent field handling and lifetime in service
  - Excellent impact performance and long term confirmed
- Pilot cases and installations to build confidence
  - Underway!