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

Presenting author: Dr. Jane Haavaldsen, Amiblu Technology

Authors: Jane Haavaldsen, Gudmundur Palsson, Frans Sorensen and Ralindo Alberto

Amiblu

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

HOBAS®

FLOWTITE®

Amiblu®

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

Amiblu

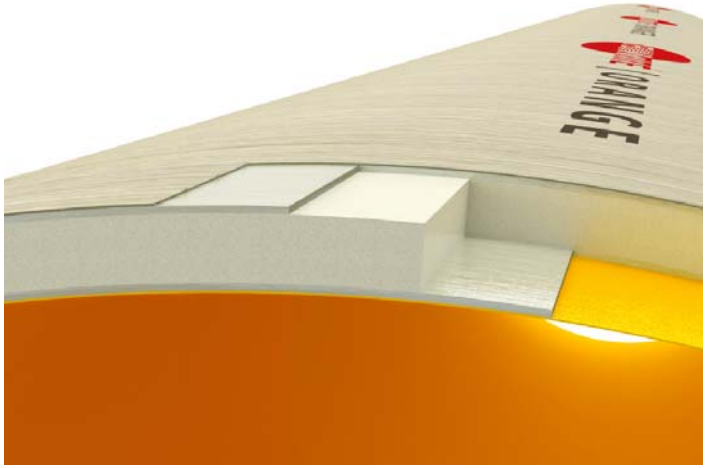
HOBAS®

THE FIRST CHOICE OF ENGINEERS FLOWTITE™ WORLDWIDE

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

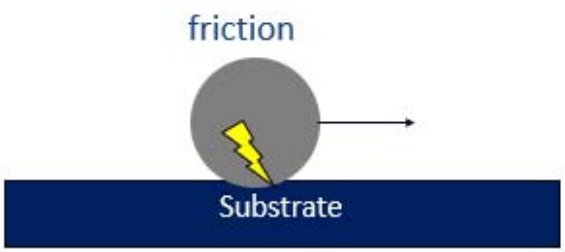
- Match to thermoplastic pipe performance with the benefit of temperature resistance, light weight pipes and extensive product range (to DN4000)



Amiblu

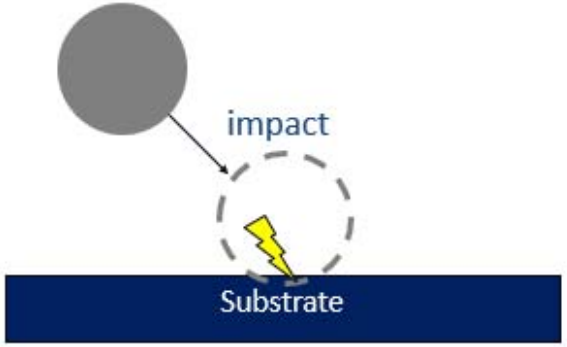
Wear modes – abrasion and erosion

Abrasion



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

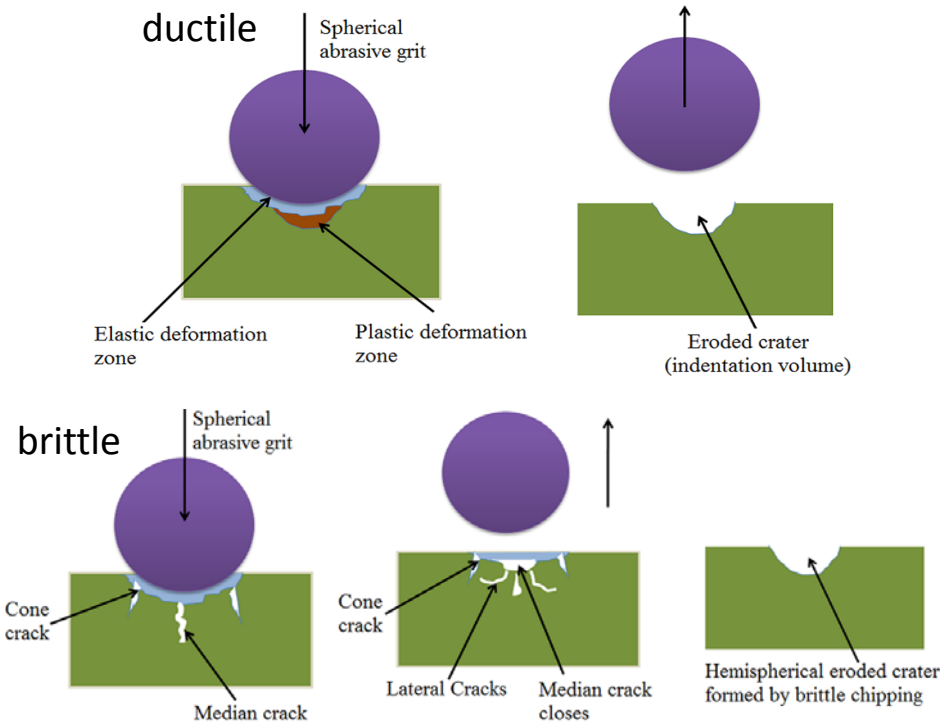
Erosion



Velocity
Particle size and shape
Particle concentration
Material of the substrate
Impact angle

Amiblu

Brittle versus ductile transition

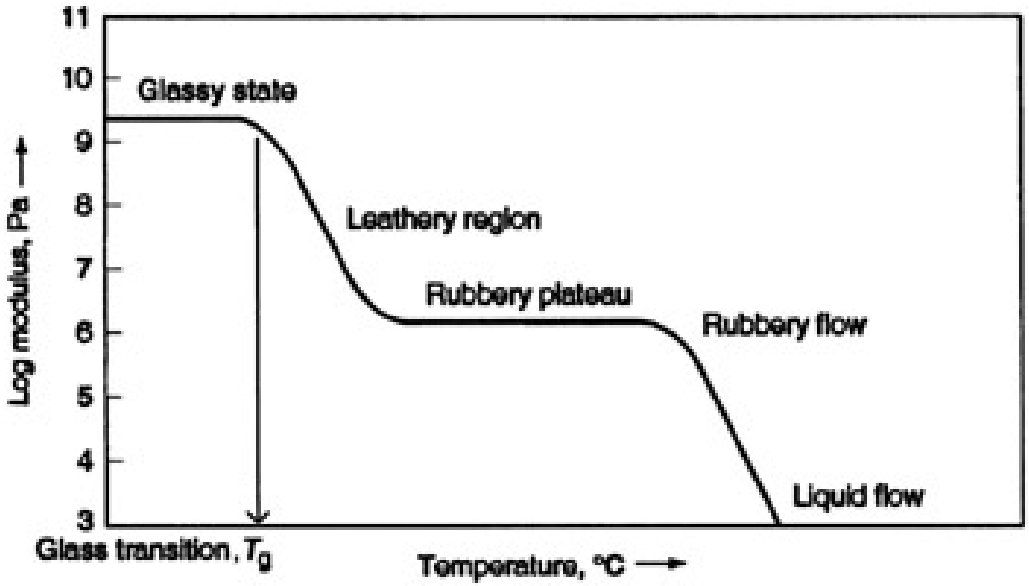


Brittle erosion can have very high unpredictable wear rates!

J. Manuf. Sci. Eng. 135, 2013, 051019

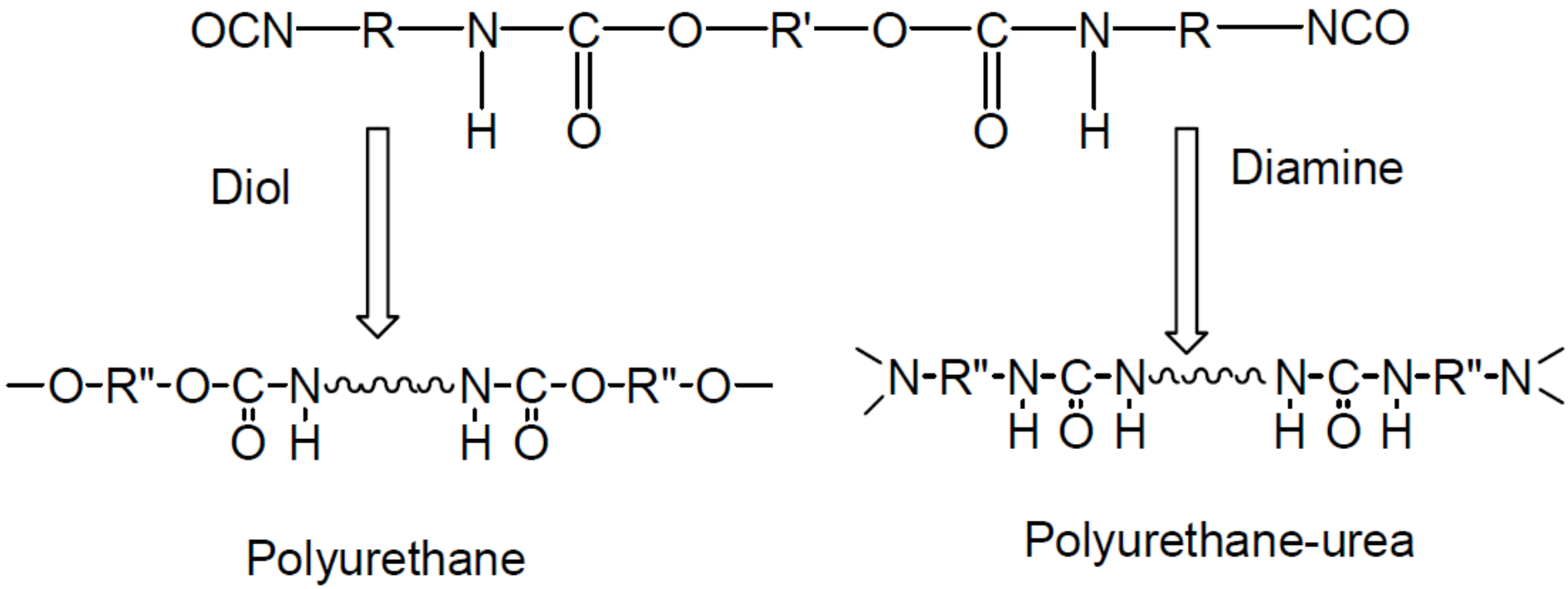
Elastomeric materials for GRP liners

- 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**



Amiblu

Elastomeric coatings – urethane/hybrid technology

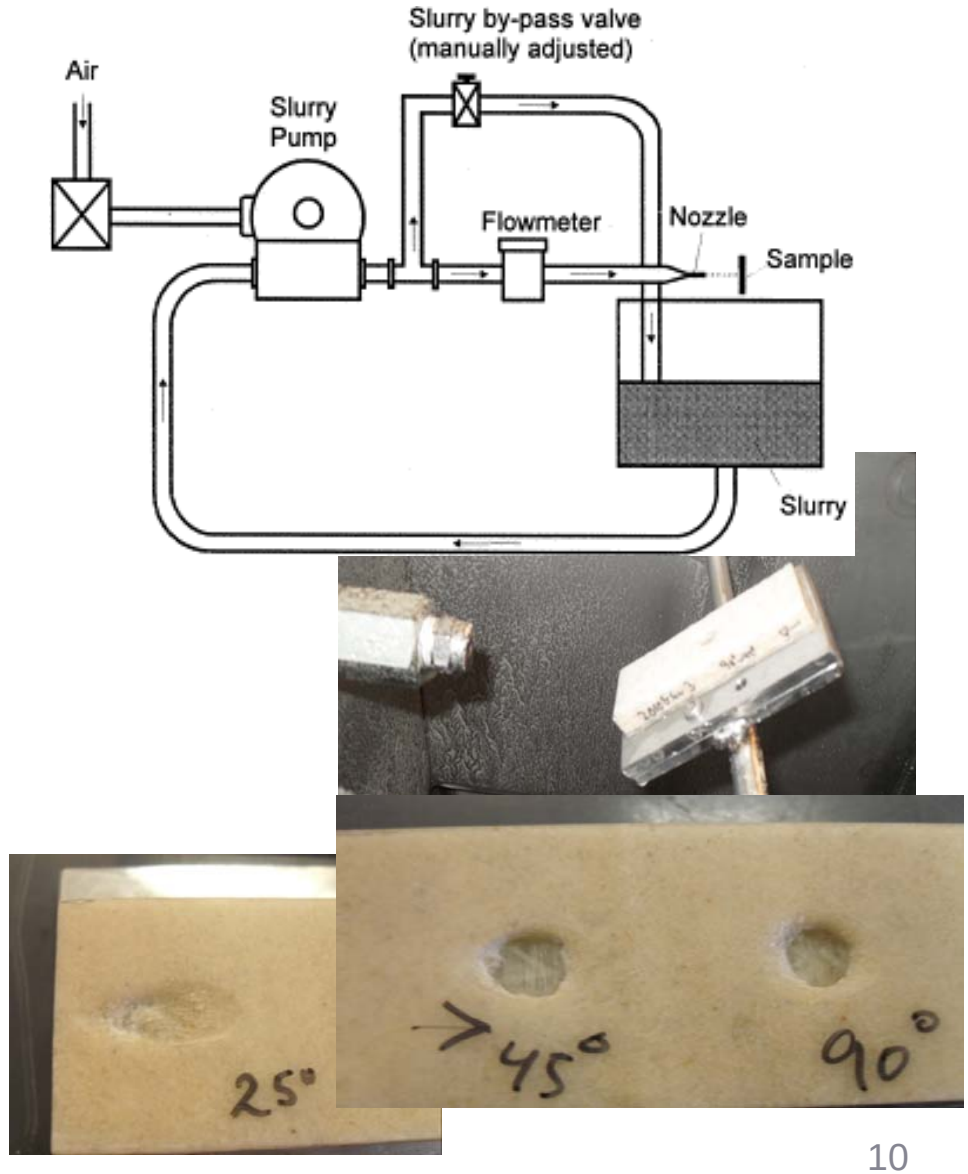


Slurry Jet Erosion (SJE)

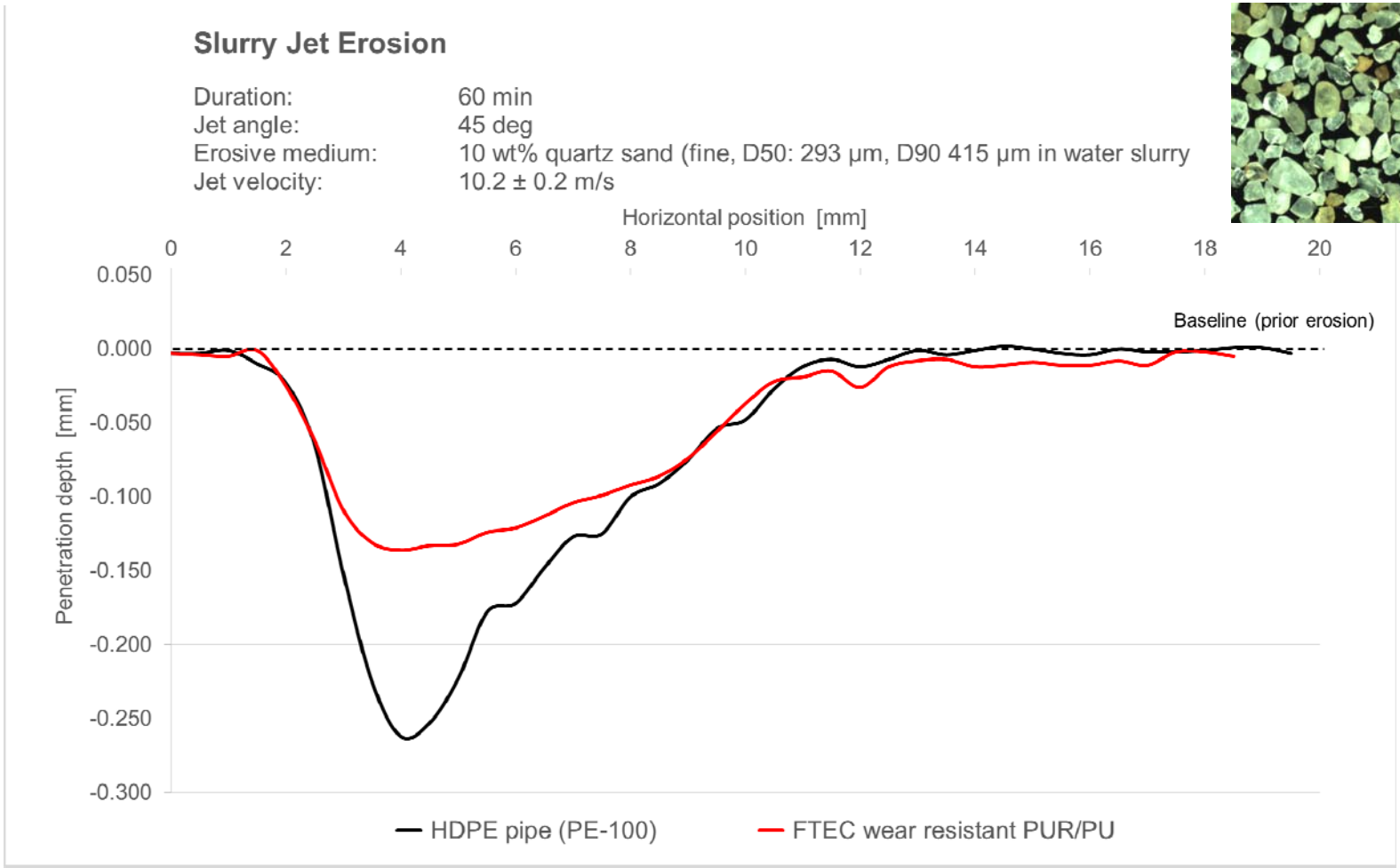
Test speed: 10 m/s
Silica sand: d(10) 200 µm; d(50): 275 µm; d(90); 390 µm SPHT: 0.9; b/L: 0.74
Distance to target sample: 10 cm
Sand content: 10 wt%

Cross-sectional profile of erosion scar over time

Slurry Jet Erosion
Mining Wear and Corrosion, National Research Council Canada

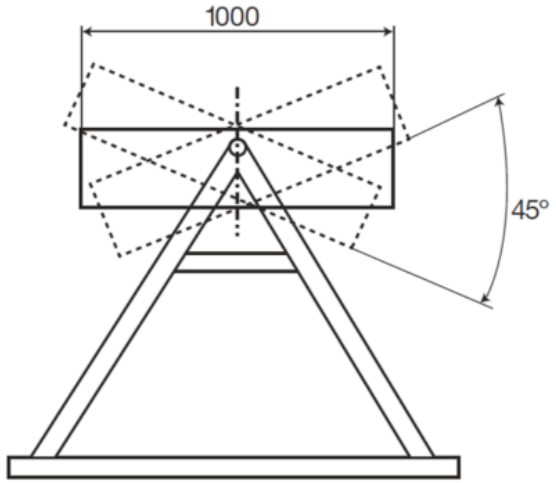


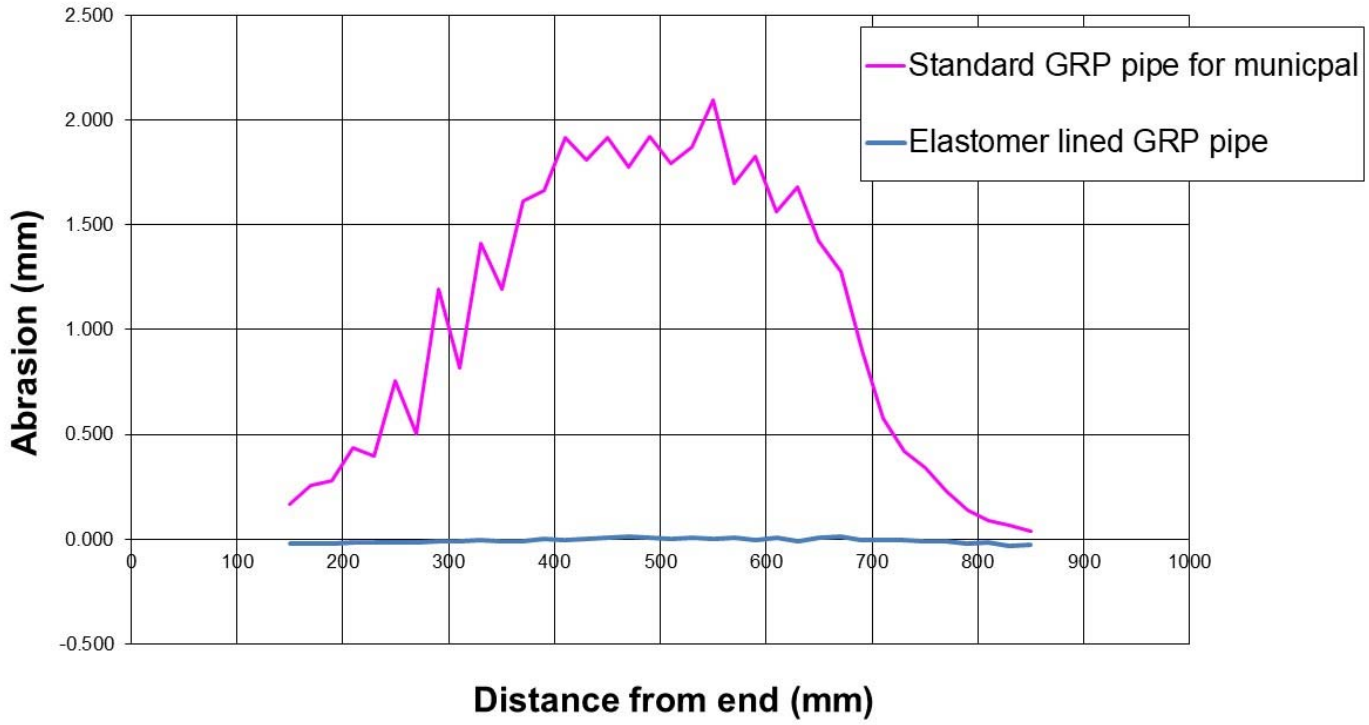
Material comparison with slurry jet erosion (silica sand)



Darmstadt testing – corundum gravel 100 000 cycles CEN-TR 15729

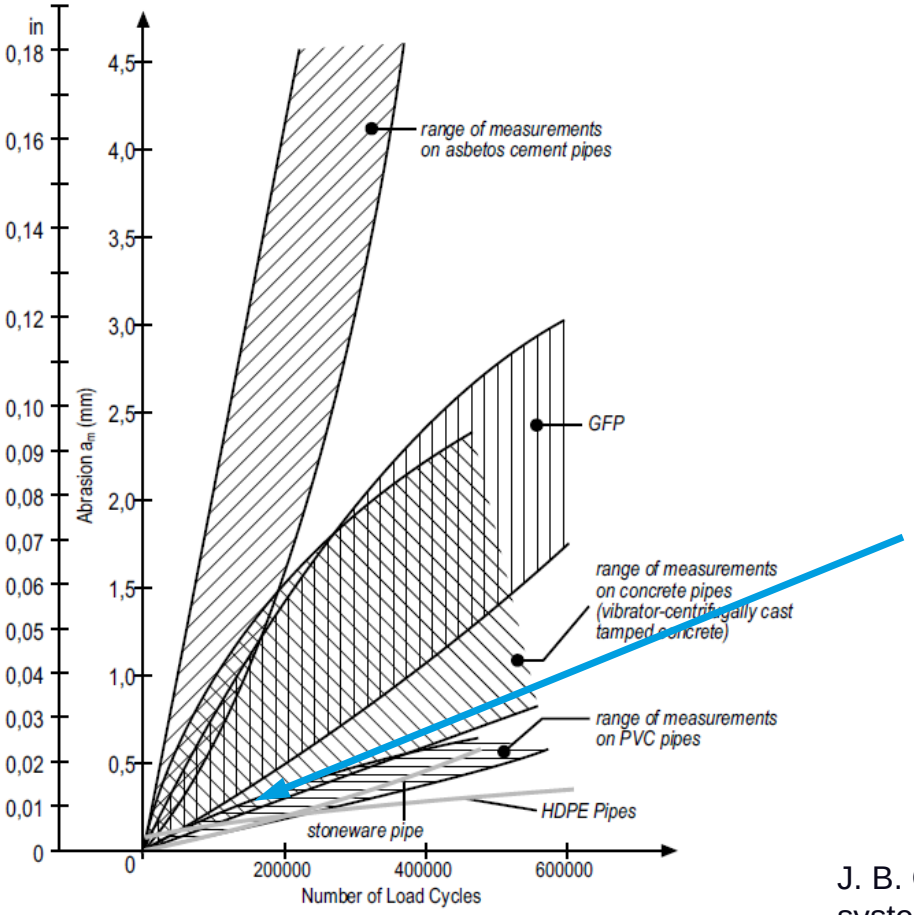
Pipe segment (trough) tilted 45° to both sides
Forth and back → 1 cycle
Min. 100000 cycles
5 kg abrasive material (e.g. corundum)





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

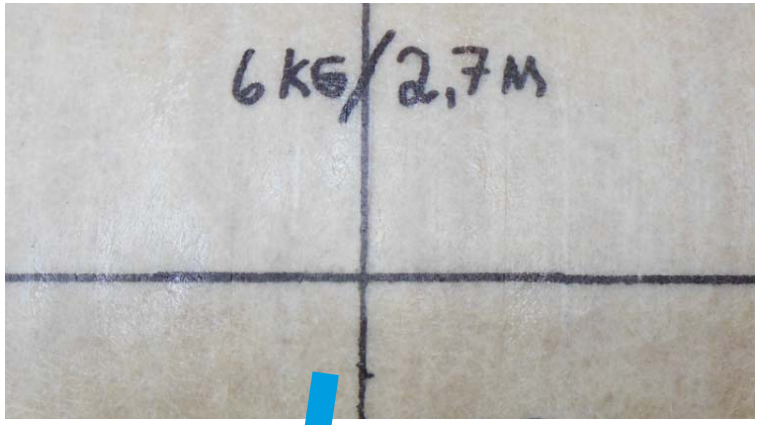


Elastomeric lined Flowtite GRP on par with HDPE

J. B. Goddard, “Abrasion resistance of piping systems, 1994 (Technical Note, ADS)

Amiblu

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

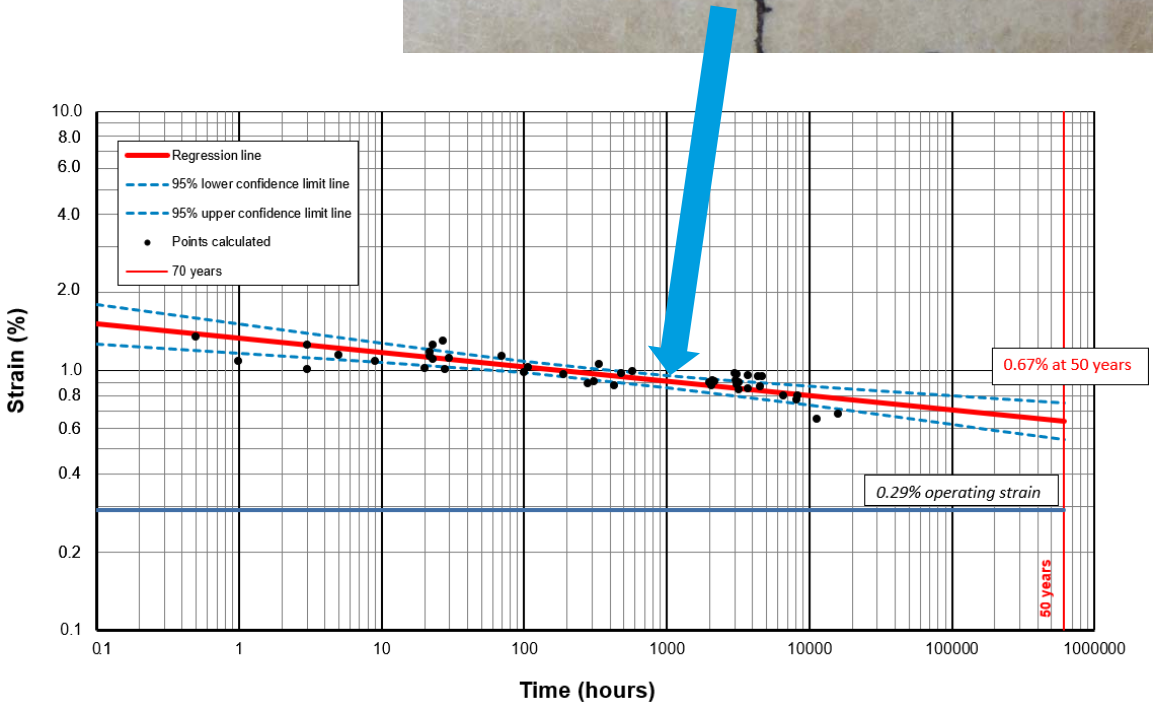
Hydrostatic design basis testing

34.5 bar for 10 bar pipe

1000 hrs (0.91 % strain-restrained ends)

no weep or leak or burst

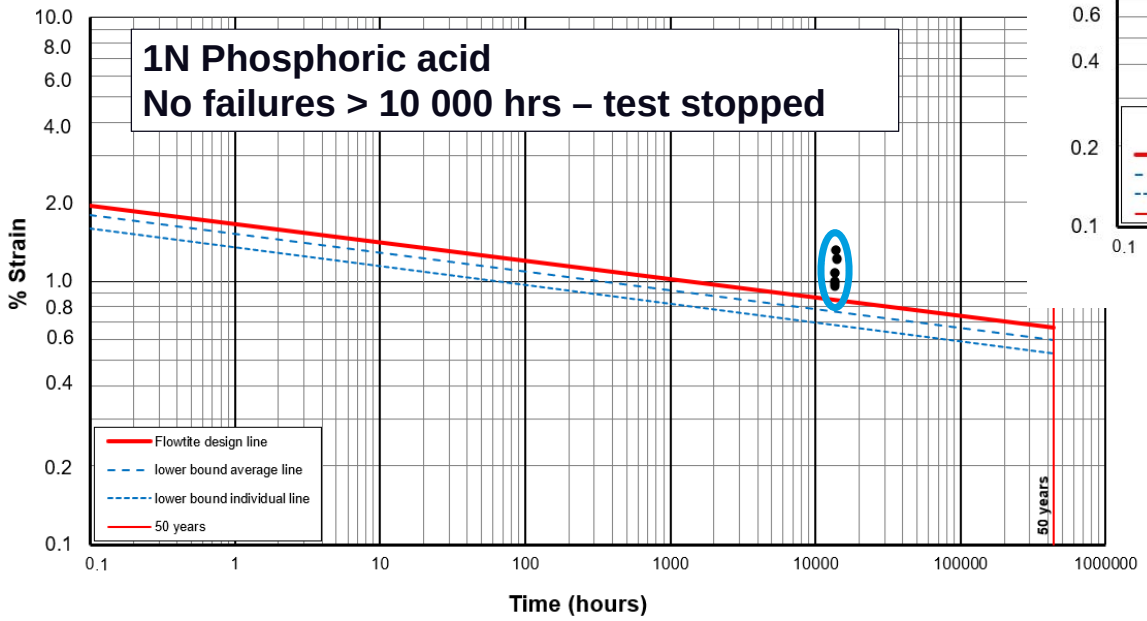
ISO7509/ASTM D1598/D2992

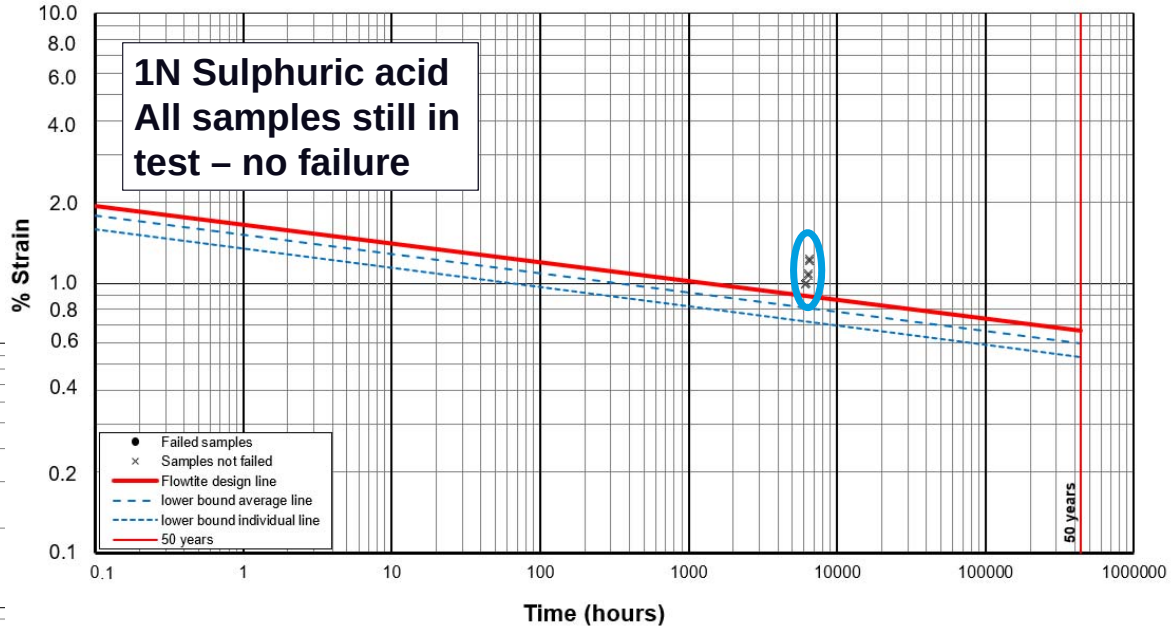


Amiblu

Strain corrosion in acidic media

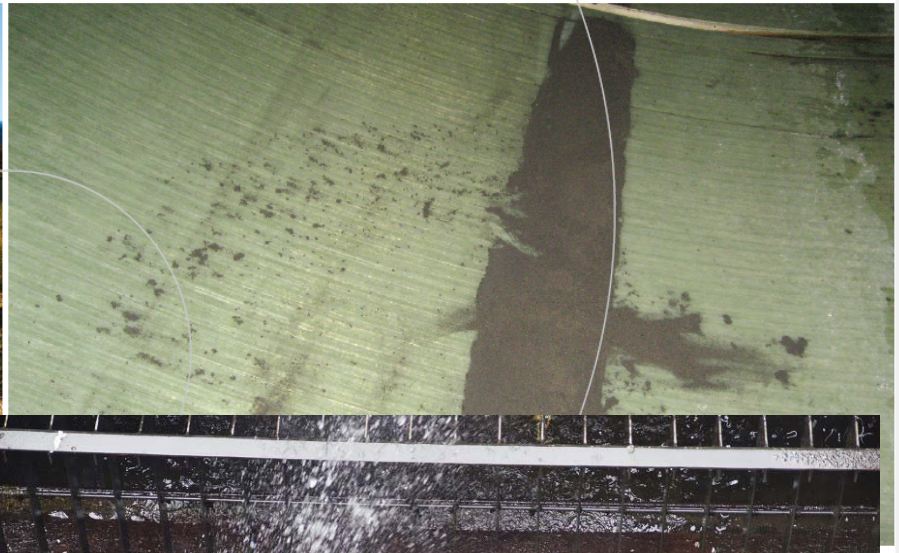
Ensuring suitability to acid media for ambient temperature applications
ISO 10952/ASTM D3681





Amiblu

Rehabilitation case study: Laxa, Iceland



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

Amiblu

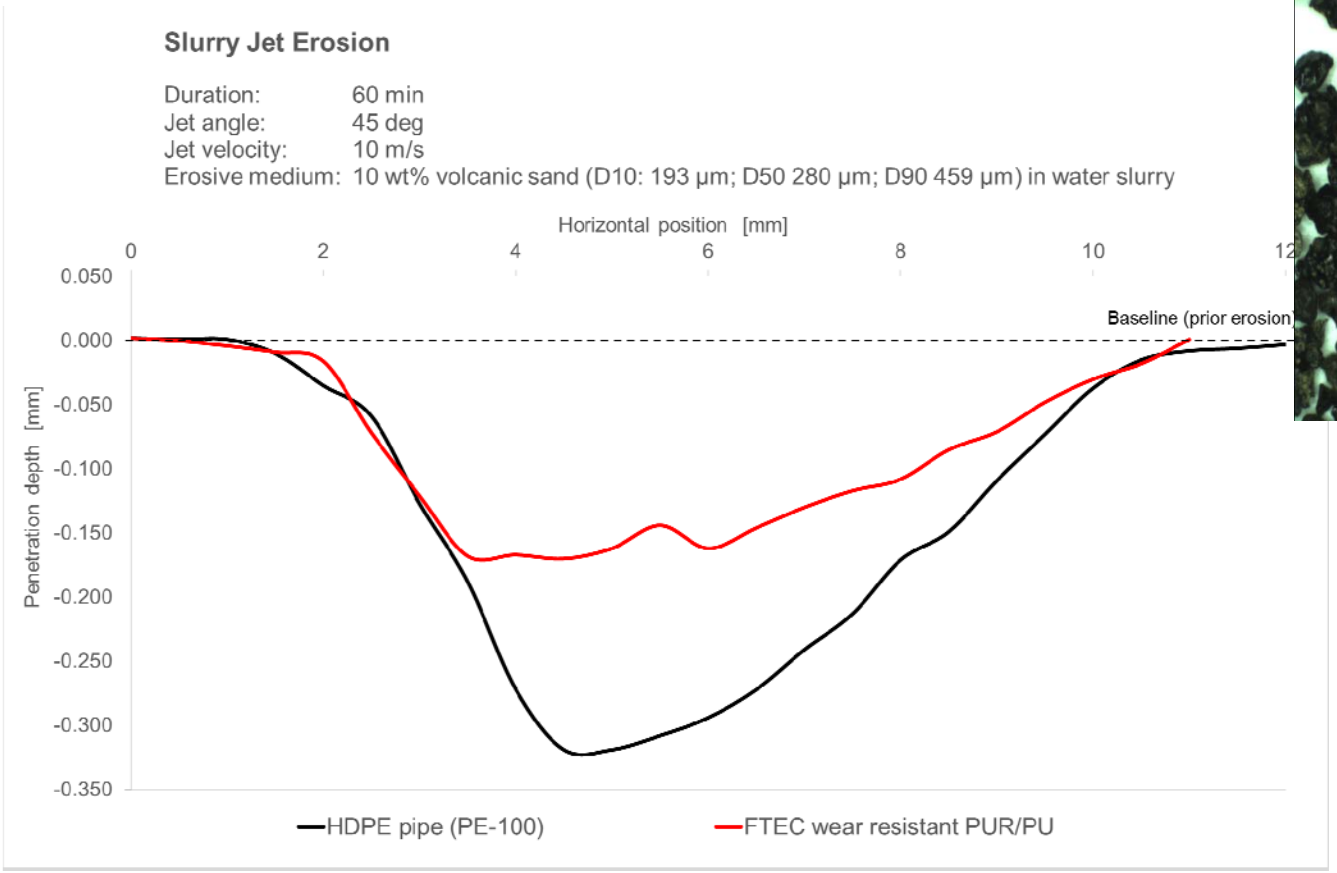
Laxa, Iceland: before repair

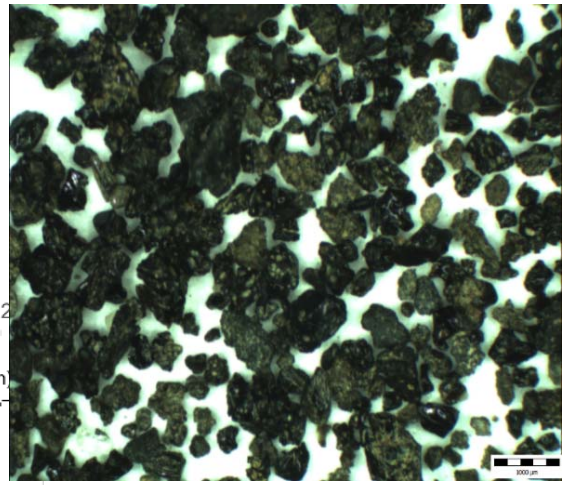
Eroded pipe at the invert

For comparison:
Eroded epoxy coating (3 layer system) on the steel coupling to the surge chamber

Amiblu

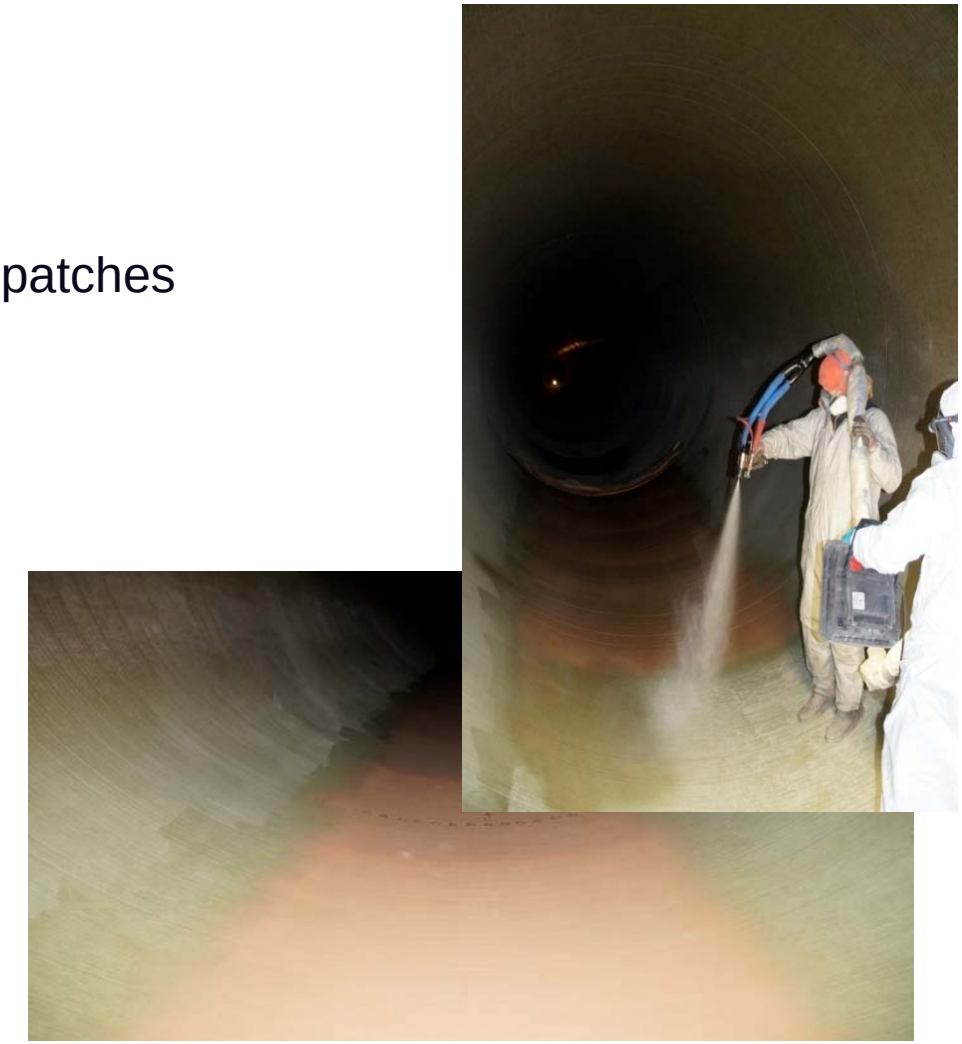
Material comparison with slurry jet erosion
Laxa volcanic sand





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



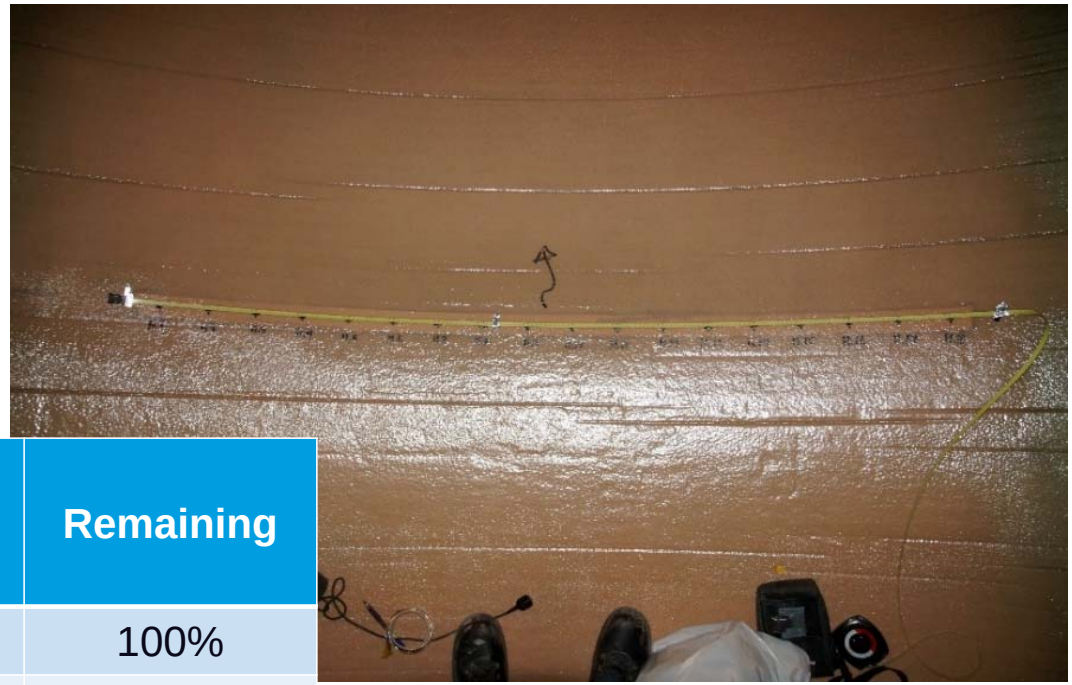
Field repair partner:

KINERA COATING OG BELEGG

Amiblu

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



No	Ø 2013 [mm]	Ø 2014 [mm]	Ø 2015 [mm]	Ø 2016 [mm]	Remaining
11	1.86	1.89	1.79	1.89	100%
12	2.00	2.03	1.90	n/a*	95%
15	2.53	2.53	2.42	2.46	96%
17	2.65	2.66	2.43	2.44	92%

Flowtite continuous filament winding
Drostholm process

Flowtite pipes are produced by continuous filament winding

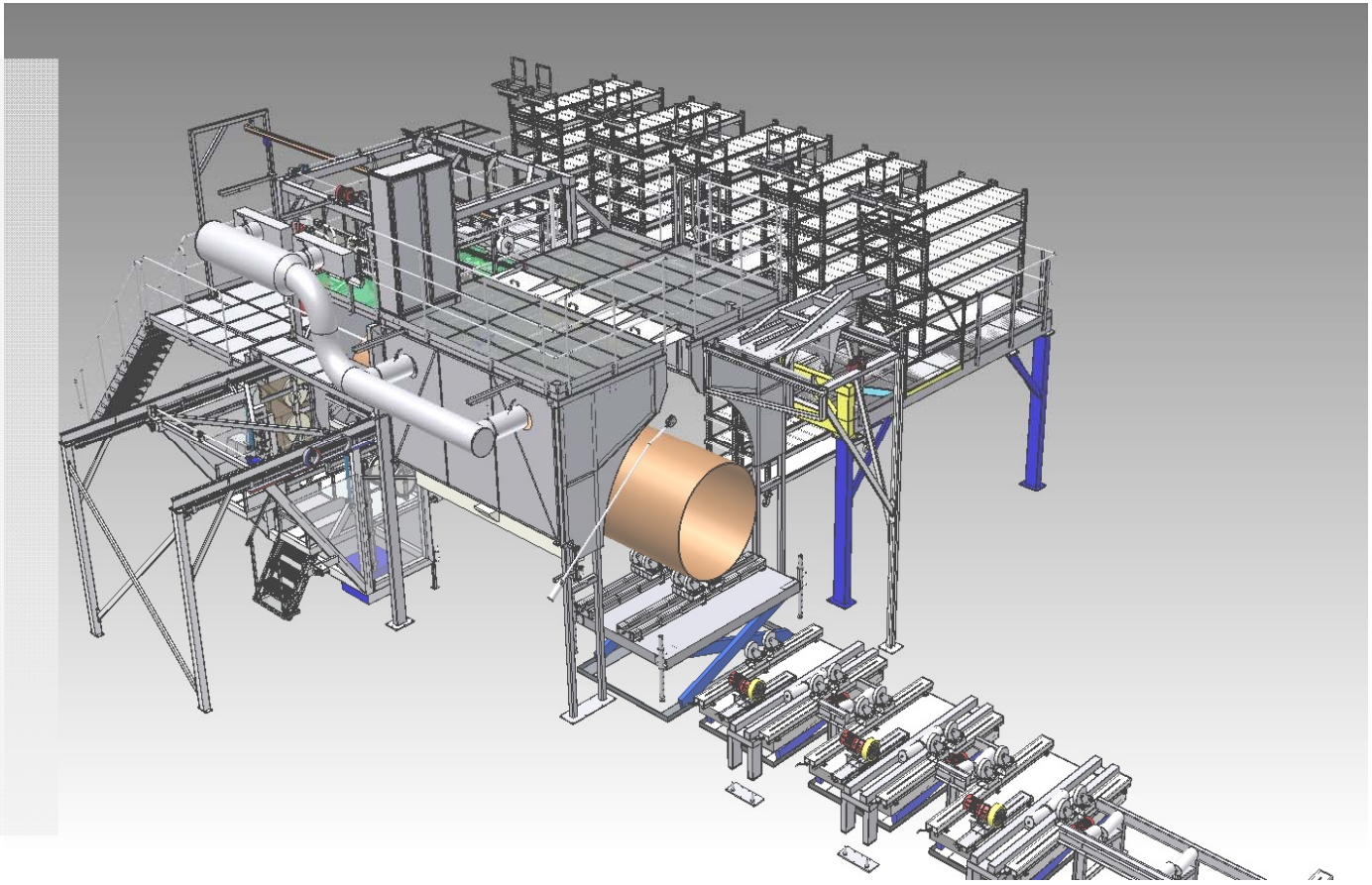
- advancing mandrel system
- continuous material application
- any pipe length

Materials:

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

Product range:

- DN250-4000, PN1-40
- SN2500-500 000



Amiblu

Production on the continuous winder

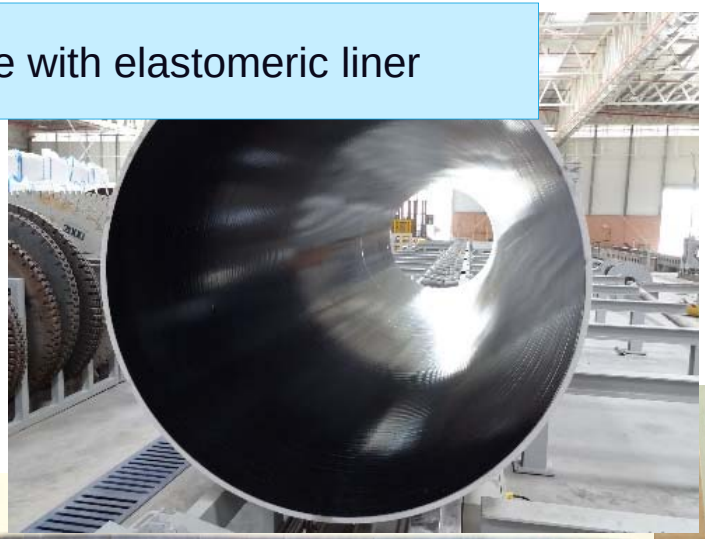
- Spray application of PU on winder – liner zone
- Liner thickness customized for demands in service
- Flowtite laminate structural composition as standard product ranges (determines stiffness and pressure)

Amiblu

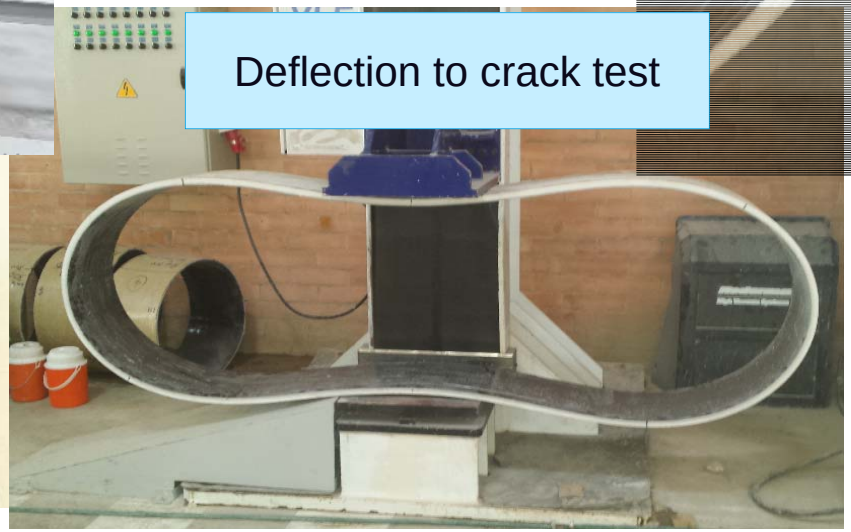
Colombia storm-water applications

Adhesion of elastomeric liner to GRP

DN1700 Pipe with elastomeric liner



Deflection to crack test



Adhesion Pull-off Test
values > 5 MPa

Amiblu

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!