Insulation for Flowlines and Risers

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PETRONAS –ETRAD-INTSOK-CCOP
WORKSHOP ON DEEPWATER SUBSEA TIEBACK
Kuching, Malaysia, January 26, 2011





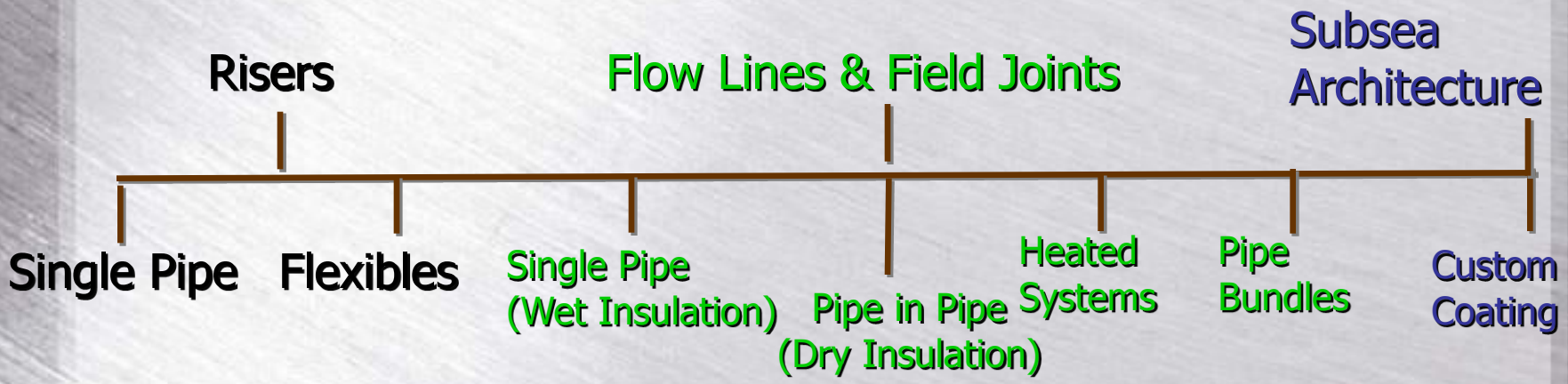
Bredero Shaw

- An example of joining Norway and Malaysia together

- Bredero Price in Kuantan since 1981
- First Norwegian coating facility in 1982 (Aandalsnes – with Norwegian Contractors)
- Bredero Shaw Farsund facility in 1993
- Thermotite (Orkanger) joining in 2001
- Name changed to Bredero Shaw in 2003
- The global leader in pipe coating solutions with over 27 global plants

Background

- Subsea tiebacks with multiphase flow require flow assurance
- Thermal insulation is a key tool to ensure reliable operation of subsea flowlines and risers
- 'Dry' and 'wet' insulation systems available



Industry Trends

- Lower U-values
- Deeper water
- Higher operation temperatures
- Longer tie-backs:
  - Maximize the number of satellites that can be tied back to a host
  - Encompass sufficient reserves to improve economic viability
  - Burial and electric heating are current solutions

Examples of difficult insulation projects

• Statoil Åsgard	- 140°C, 350 m
• Statoil Kristin	- 155°C, 350 m
• BP Thunder Horse	- 132°C, 2.200 m multi-layer on very heavy pipe
• Chevron Blind Faith	- 150°C, 2.000 m, complex composite multi-layer
• Woodside Pluto	- Complex composite multi-layer on heavy pipe
• Shell Kizomba B SHRs	- Intricate PiP construction
• BP Block 31	- Extreme thickness on heavy wall pipe
• Total Pazflor	- High thickness
• BP Skarv	- Low U-value, multi-layer coating

Main Insulation Coating Types

- Polyurethane Foam (PUF) *Pipe-in-Pipe*
- ThermoFlo®
  - Syntactic and solid PU systems
- Thermotite®
  - Multi-layer solid, foamed and syntactic Polyprolylene (PP) products
- Other:
  - Solid Elastomer (Neoprene, EPDM)
  - Epoxies
- Newest development: Thermotite® ULTRA™

PUF "dry", the rest

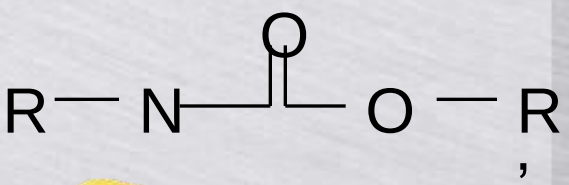
"wet"

ThermoFlo®

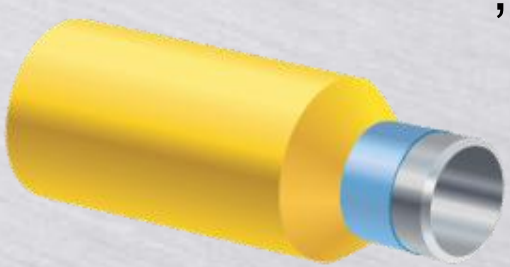
All materials based on polyurethane

- Cast applied – flexible constructions
- Global availability

Operation up to 90°C



Good depth capability



- Solids >3000m
- Glass based syntactics <3000m
- Polymer based syntactics <250 m

Moderate U-value >2.8 W/m²K

Reelable system w. high integrity field joint

ThermoFlo®

FBE corrosion protection layer
Single cast for all thicknesses

Solids
- Density 1020 kg/m^3
- K-value 0.195 W/m.K

GsPU (ThermoFlo®-D)
- Density 780 – 840 kg/m^3
- K-value 0,155 – 0,175 W/m.K

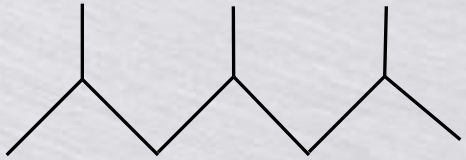
sPU (ThermoFlo®-S)
- Density 640 kg/m^3
- K-value 0,115 W/m.K

Gumusut-Kakap Project: 40.5 km of 18” OD, ThermoFlo®

Thermotite®

All materials based on polypropylene

- Not attacked by water
- Extrusion applied
- Global availability



Operation up to 140°C

Good depth capability

- Solids >3000m
- Syntactics <3000m
- Foams <2200 m

Moderate U-value >3 W/m²K

Reelable system w. high integrity field joint

Thermotite®

FBE corrosion protection layer
Single or multiple cast construction

Solids
- Density 900 kg/m^3
- K-value 0.21 – 0,24 W/m.K

Syntactics
- Density 660 – 710 kg/m^3
- K-value 0,155 – 0,17 W/m.K

Foams
- Density 620 – 850 kg/m^3
- K-value 0,125 – 0,2 W/m.K

Summary of Thermal Insulation Properties of Current Systems

Material group	Insulation material	Insulation type	Temp capability (°C)	Depth capability (m)	K-value (W/m.K)	U-value (W/m².K)
thermo-plastics	3LPP: three layer polypropylene	solid	140	2000+	0.22	10.0
	4LPP: four layer polypropylene	foam	115 (125)	600 (50)	0.17	3.0 - 4.0
	Multi- layer polypropylene	foam	140	600	0.17	3.0 - 4.0
	sPP: syntactic polypropylene	glass syntactic	140	2000+	0.185	3.0
thermo-setting elastomers	PU: solid polyurethane	solid	140	2000+	0.19	10.0
	PUF: polyurethane foam	foam	140	2000+	0.03 - 0.04	0.7
	sPU: syntactic polyurethane	polymer syntactic	115 - 125	300 - 600	0.12	2.0
	GsPU: glass syntactic polyurethane	glass syntactic	90 - 100	2000+	0.16	2.0
synthetic rubbers (elastomers)	PCP: polychloroprene (neoprene)	solid	95	2000+	0.35	30.0
	EPDM: ethyl propyl diene monomer	solid	150	2000+	0.35	30.0

Limitations in Existing Materials

- High thickness
- Hydrostatic pressure limitations
- Subsea stability
- Temperature limitations

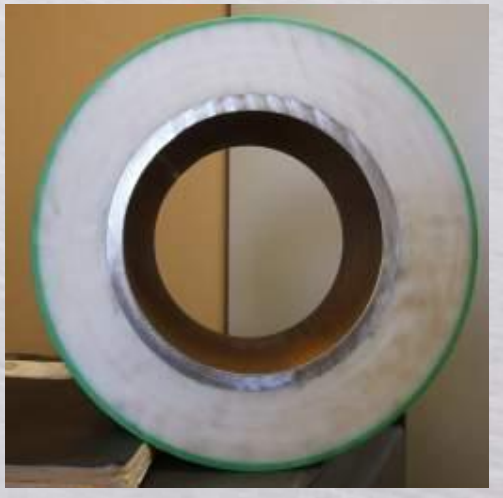
Novel System - Thermotite® ULTRA ™

- In response to industry trends, Bredero Shaw has developed a specially engineered blend of materials with improved mechanical and thermal properties.

- The Thermotite® ULTRA™ family of products utilizes foamed, flexibilized and solid styrenic based thermoplastic materials to lower U values in deep water.

Thermotite® ULTRA™

- Thermotite® ULTRA™ is:
  - A NEW novel flow assurance insulation system based on styrenic materials
  - No glass bubbles are used. Capable of being deployed to any ocean depth
  - Able to provide low thermal conductivity with thinner insulation
  - Denser than current products resulting in increased seabed stability
  - Suitable for pipelines operating up to 130° C (products for higher temperatures under development)



Thermotite® ULTRA™

- Thermal insulation and corrosion protection system based on FBE and styrenic alloys.
  - Multi-layer ULTRA system comprised of a base 3 layer:
    - FBE
    - ULTRABond adhesive to bond FBE to "ULTRA"
    - Solid ULTRA
  - One or more insulation layers of solid or foamed ULTRA
  - ULTRAShield high ductility outer shield

Solids
- Density 1030 kg/m^3
- K-value 0.156 W/m.K

Foams
- Density 740 – 850 kg/m^3
- K-value 0,115 – 0,145 W/m.K

Thermotite® ULTRA™

Corrosion system testing:

- Corrosion function ✓
- Integrity ✓
- Durability ✓

Insulation system testing:

- Integrity ✓
- Thermal performance ✓
- Fatigue ✓
- Reel bend ✓
- Shear capacity ✓
- Impact toughness ✓

Thermotite® ULTRA™

System advantages:

Significant improvement in thermal efficiency
ca. 30% reduction in thickness for given U-value

Excellent low temperature reelability
Tested at 2.4% strain at -10°C after thermal cycling

Highly impact resistent
12.7 kJ on 50 mm impinger at 40°C

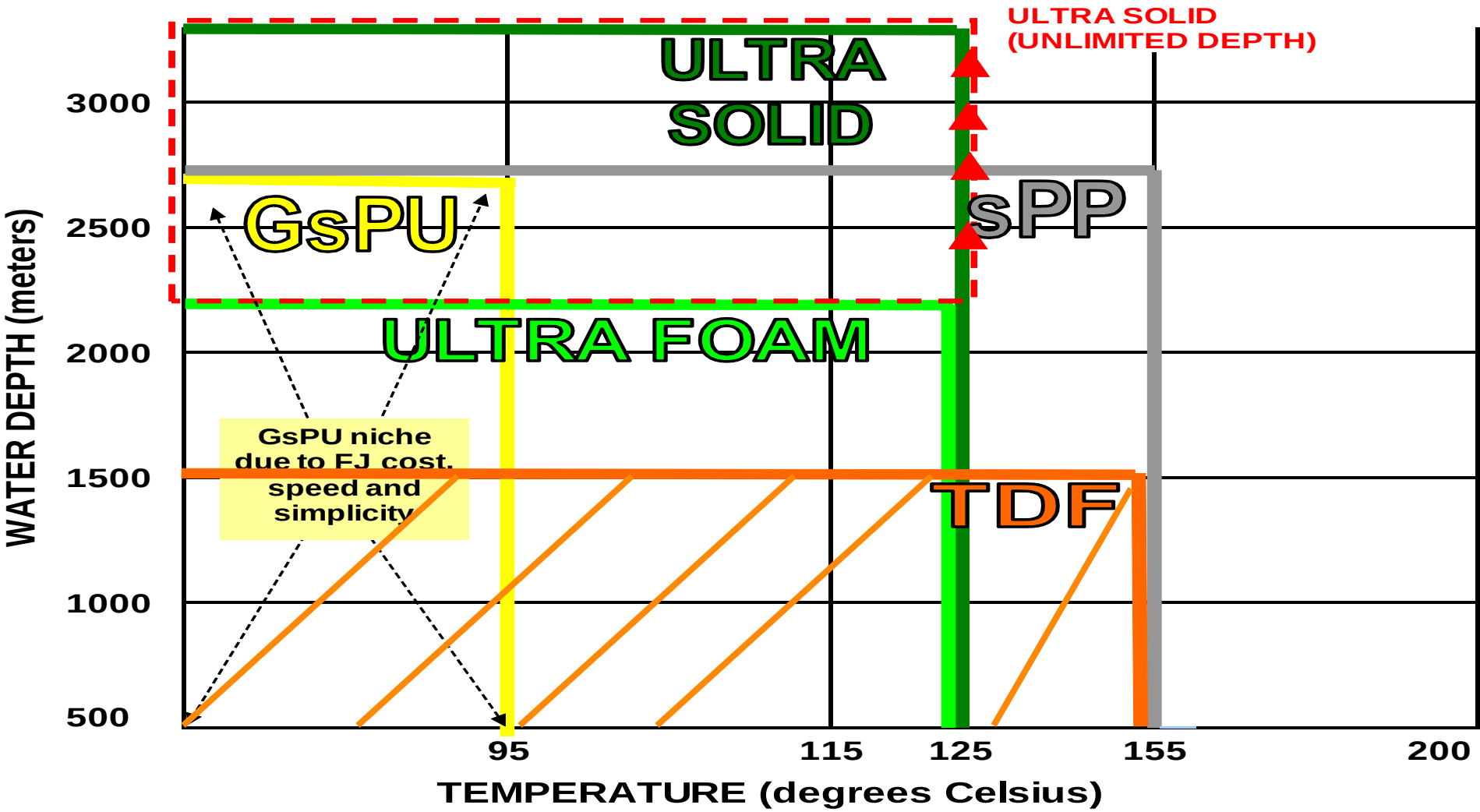
Integral fused field joint

Immune to water attack

Thermotite® ULTRA™

- Winner of the Spotlight on New Technology Award at the Offshore Technology Conference 2010
- Balboa subsea tieback project in GOM: Mariner Energy and Ocean Flow International ("OFI")
  - 10 km flowline in 975m WD
  - 47.6 mm foam system on 5.5625"X0.500" line pipe
  - Coating completed at Bredero Shaw in Pearland, TX in Q2 2010
  - Reel lay with Ultra Field Joint
- ENI Goliat: Technip, OD 12" and 40 mm Ultra Foam, 2011

Flow Assurance Capability (Wet Insulation)



ShawCor SSV Subsea Test Facility in Toronto, Canada Available in Q1 2011

The Most Advanced Dedicated SSV Subsea Test Facility for Flow Assurance Coatings

- Ability to test insulated pipe at ultra deep water, high pressure conditions
  - Designed for rigorous deepwater testing simulating water depths to 3,000m (300 bar rating), external temperatures of 4^0C and internal temperatures up to 180^0C
- Accommodates project pipe with field joint, multi-pipe configurations and custom fittings
  - With an internal diameter of 1.2 m., it is much larger than most test vessels and capable of testing pipe up to 40" (1 m.) in diameter
- Accurately simulates deep offshore environments with minimal temperature gradient
  - Chilled water circulates though vessel around closed pipe section
- Performance of the insulation can be determined rapidly resulting in quicker qualification
  - Heat flow and creep of insulation are monitored in real time using sensors
- Precise control of temperature ensures reliable results
  - Uses multi-zone electrical heating

The Most Advanced Dedicated SSV Subsea Test Facility for Flow Assurance Coatings

- Test schedule is assured through back-up systems
  - Multiple sensor measurements ensure test reliability
- Remote and timely access to data and reporting
  - Uses advanced real-time monitoring systems to capture data accurately
- End effects are eliminated so cool-down can be measured precisely
  - Pipe length is 6 m., multi-zone electrical simulates shut down of line
- Test results establish predictors of long term performance
  - Further tests such as triaxial creep tests and FEA modeling of the insulation can be run in parallel with the SSV tests to build a comprehensive data library for deep sea environments

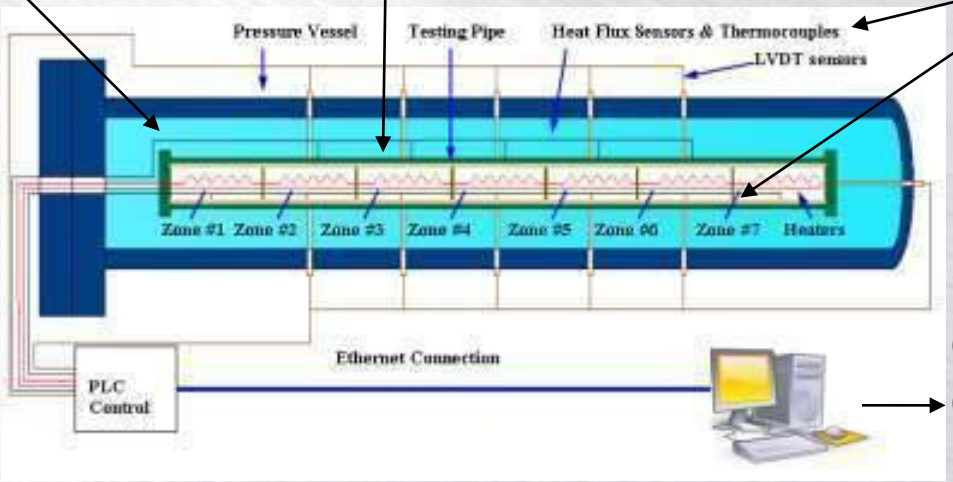
Testing Features to Simulate Deepwater Conditions

Long term performance is verified by testing until no further creep of the insulation is observed.

Insulated pipe is surrounded by chilled water at 4 – 6ºC.

Insulated pipe is tested under precisely controlled subsea pressure and temperature conditions.

Multi zone controls and instrumentation provide accurate, real time measurements.



Creep
Cool Down
k factor

SSV testing ensures that the insulated pipe will meet the performance requirements while in service