

A Novel Thermal Insulation System for Bonded Subsea Single Pipe Wet Insulation Applications



www.bhrgroup.co.uk



Contents

- Background
- Insulation Materials
 - Established materials in subsea industry
 - Novel insulation material – Thermotite[®] ULTRA
- Testing Performed
- Examples of competitive designs

- Conclusions

BACKGROUND

Industry trend toward:

- Lower U-values
- Deeper water
- Longer tie-backs

Limitations in existing materials:

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

INSULATION MATERIALS

Material	K-value (W/m.K)	Max. temp. (°C)	Max depth (m)
Rubber (Neoprene / HNBR)	0.26 – 0.28	90 / 140	Unlimited
Filled (Neoprene / HNBR)	0.12 – 0.14	90 / 140	Unlimited
Syntactic epoxies	0.12-0.17	110	2800
Polyurethane	0.19-0.20	90 wet /115 dry	Unlimited
Syntactic polyurethane*	0.13	90 wet /115 dry	300
Syntactic polyurethane**	0.14 – 0.17	90 wet /115 dry	2800
Polypropylene	0.21 – 0.26	145	Unlimited
Polypropylene foams	0.13 – 0.2	145	2000m***
Syntactic polypropylene**	0.17	145	2800m

*Polymeric microspheres

**Glass microspheres

*** Special formulations

Novel system – Thermotite ULTRA®:

Thermal insulation and corrosion protection system based on FBE and styrenic alloys.

- UltraBond adhesive to bond FBE to "Ultra"
- UltraShield high ductility outer shield
- UltraJoint field joint material for IMPS joint
- UltraRep repair material.

Novel system – Thermotite ULTRA®:

Material	Density (kg/m³)	K-value (W/m.K)		Specific Heat (J/kg.K)		Relative Diffusivity*
	30°C	30°C	60°C	30°C	60°C	30°C
Solid Insulation	1040	0.152	0.158	1250	1630	0.668
Foamed Insulation @ 18% foaming	850	0.121	0.13	1250	1630	0.650
Foamed Insulation @ 23% foaming	800	0.110	0.118	1250	1630	0.628
Field Joint Infill Material	1010	0.146	0.152	1380	1700	0.598
Outer Shield	1028	0.168	0.171	1350	1680	0.691
Repair Material	1010	0.146	0.152	1380	1700	0.598
Reference high mod. PP	900	0.26	0.258	1650	2200	1

Novel system – Thermotite ULTRA®:

Material	Property	Unit	Temperature (°C)		
			-10	0	20
Solid insulation	Strain @ yield	%	6	8	8
	Strain @ break	%	33	35	35
	Stress @ yield	MPa	23	23	22
	Stress @ break	MPa	26	25	24
Foamed insulation	Strain @ yield	%	4	4	6
	Strain @ break	%	18	18	20
	Stress @ yield	MPa	15	14	9
	Stress @ break	MPa	15	15	10
Field Joint Material	Strain @ yield	%	8	10	10
	Strain @ break	%	70	80	100
	Stress @ yield	MPa	18	14	14
	Stress @ break	MPa	25	20	20
Outer shield	Strain @ yield	%	7	7	9
	Strain @ break	%	40	50	50
	Stress @ yield	MPa	25	23	18
	Stress @ break	MPa	22	20	12
Repair material	Strain @ yield	%	8	10	10
	Strain @ break	%	70	80	100
	Stress @ yield	MPa	18	14	14
	Stress @ break	MPa	25	20	20

TESTING PERFORMED

CD Testing

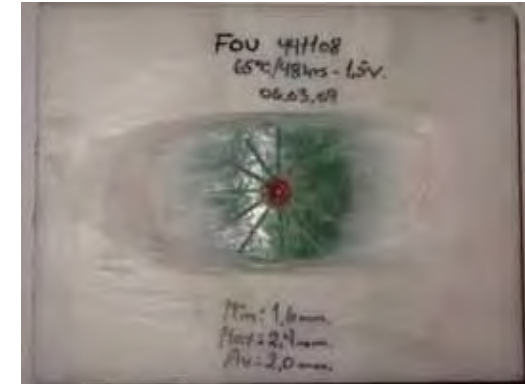
Scotchcote 226N from 3M, 0.3 mm

ULTRABond system, 0.3 mm.

65°C, 48 hours – average disbondment 2 mm

23°C, 28 days – average disbondment 3.8 mm.

No disruption of the FBE-ULTRABond adhesion.



TESTING PERFORMED

Hot Water Soak

Scotchcote 226N from 3M, 0.3 mm

ULTRABond system, 0.3 mm.

80°C, 7 days – no disruption of bond to steel or FBE



TESTING PERFORMED

Trawl Impact

12.7 kJ

DnV DNV-RP-F111

50 mm diameter impinger

4 x impingements.

Testing at 40C.



TESTING PERFORMED

Resonant fatigue

500,000 cycles

10 Hz

200 mstrains on steel

Uncooled



TESTING PERFORMED

Stinger roller

500 mm roller

6 tons on one wheel

No damage to insulation

No damage to field joint



TESTING PERFORMED

Clamping test

Loads up to 500 kN

Length 300 mm

Max. Load 25 MPa (60 mm touchdown)

No damage to system



TESTING PERFORMED

Axial shear

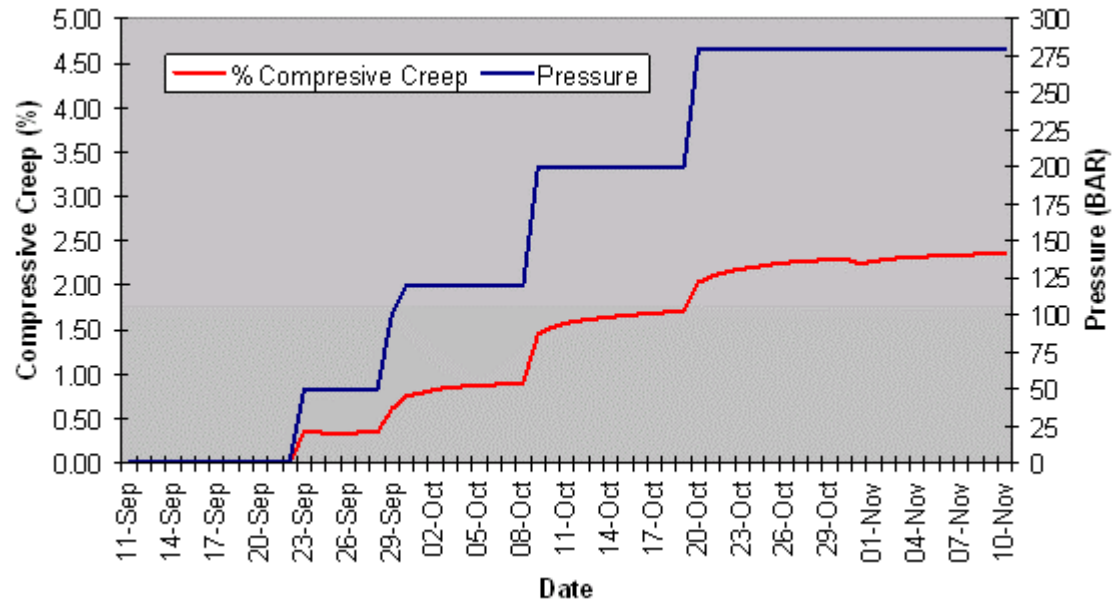
All variants of Thremotite ULTRA

Tested at:

Steel – 3-Layer	14 MPa @ RT / 7 MPa @ 95°C
Inter Layer	12 MPa
Within layer	15 MPa
Field joint to steel	14 MPa

TESTING PERFORMED

Simulated Service
 Temperature to 95°C
 Pressure to 280 bar
 Low compression
 Predictable k-value



Pressure	Operating Temperature (°C)	Duration (Days)	Compressive Creep (%)	System k-value (W/mK)
50 bar	77.40	6	0.35	0.159
100 bar	77.37	1	0.74	0.160
120 bar	77.36	9	0.91	0.161
200 bar	79.17	11	1.71	0.165
280 bar	79.12	11	2.30	0.167
280 bar	95.0	11	2.36	0.170

TESTING PERFORMED

Reeling test

10.75 x 14.3 pipe, 50 mm system

Bend radius 7.5 m

Test temp. 4°C

4 cycles

No disruption of any kind



DESIGN EXAMPLES

10.75" x 14.3 mm steel pipe,

U-value of 3 W/m²K on the OD,

production fluid with $C_p=2,300$ J/kg.K,

density 140 kg/m³ and a

k-value of 0.04 W/m.K,

cooling from 50°C to 20°C in a 40°C environment.

Field life 20 years.

Field operating at 95°C.

DESIGN EXAMPLES

Shallow water (<300m)

System	Total (mm)	Comp (%)	SG	T _{cool} (Hours)
PPF	91	3.5	1.05	12
sPU	65	8.5	1.07	8.5
ULTRA foam	60	2	1.2	10

Shallow water (300 - 500m)

System	Total (mm)	Comp (%)	SG	T _{cool} (Hours)
PPF	89	7	1.05	11
ULTRA*	62	3.5	1.2	10.5

DESIGN EXAMPLES

Deep water (500 - 1000m)

System	Total (mm)	Comp (%)	SG	T _{-cool} (Hours)
PPF	93	6	1.04	11
sPP	87	2	1.03	10.5
GsPU	75	2.5	1.1	10
ULTRA*	65	3.2	1.2	11

Deep water (> 1000m)

System	Total (mm)	Comp (%)	SG	T _{-cool} (Hours)
sPP	90	2.8	1.02	11
GSPU	87	2.5	1.1	10.5
ULTRA	75	2	1.3	12

Thermotite ULTRA is a thoroughly tested system:

- Corrosion aspects
- Deployment aspects
- Operational aspects

Thermotite ULTRA has unique properties:

- Low system thickness
- Unlimited water depth
- Improved cooling performance
- Low temperature flexibility
- Flexible production using established practices



A Novel Thermal Insulation System for Bonded Subsea Single Pipe Wet Insulation Applications

by

Jackson, A*. Jackson, P**. Wan, E.** and Hegdal, J.P*

* Bredero Shaw Norway a.s. Orkanger, Norway

** ShawCor LLC. Toronto, Ontario, Canada

www.brederoshaw.com