

# *DeepGel*

## **Gelled Fluid Insulating Media for Deepwater Subsea Applications**

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## Concept

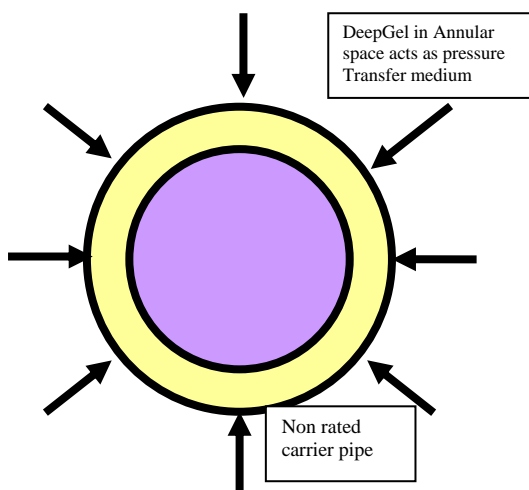
DeepGel is a novel depth independent insulation solution for flow assurance developed by Aubin Ltd.

DeepGel is not just chemicals but an enabling technology that offers new engineering solutions for deep water flow assurance.

DeepGel technology has the following key features:

- ✓ Depth independent insulation performance capable of achieving long cool down times.
- ✓ DeepGel eliminates the need for a rated carrier pipe rated for external hydrostatic pressure thereby reducing weight and lay tension.
- ✓ DeepGel can substantially reduce pipeline costs and enhance operability.
- ✓ DeepGel can be tailored to give different thermal properties allowing use in a wide variety of deepwater oilfield applications.
- ✓ DeepGel applied by ROV providing operators with the capability to insulate subsea structures in place or retrofit insulation to existing subsea structures.
- ✓ DeepGel can be made on site using readily available oilfield equipment and offering the potential of significant local content.
- ✓ DeepGel uses commercially available chemical constituents.
- ✓ DeepGel is non-hazardous and environmentally responsible.

## Depth Limitations



**DeepGel** will act as an incompressible medium transferring pressure from the external carrier pipe to the internal pipe. This means that **DeepGel** systems do not require a rated outer carrier pipe.

This affords to opportunity to use thin wall steel or even HDPE as a carrier pipe resulting in substantial weight and cost reductions making it highly suited to deep water applications.

Since it is a continuous medium it does not suffer depth limitations.

## Performance

DeepGel has been tested according to the current Inspec specification for insulation and buoyancy material by Robert Gordon University and test certificates can be made available if required. Long Term stability studies are ongoing with gel heated to a continuous 120°C (248°F) for a period of six months, results to date are encouraging.

### DeepGel Typical Thermal Properties

Requirement	Related material property	Details	Test Method	DeepGel Typical properties	
				Imperial	Metric
Primary	Thermal conductivity	Tested to a specified K conductivity value. Measured by transient heat probe	ASTM D 5930-01 or equivalent	0.90 Btu.in/ft <sup>2</sup> .hr.°F	0.13 W/m.K
	Specific heat Capacity	Measurement of specific heat capacity by DSC techniques performance linked to bulk properties.	ASTM C351, E1269 DSC techniques	551.6 Btu/lb.°F	2310 J/kg.K
	Service Life/ Aging	Thermal aging resistance, Chemical / oxidation aging, thermal shock resistance	ASTM D2126, ISO 2440	Currently being determined*	
Secondary	Density	Required to establish cool down and diffusivity	ASTM D792, D1505, D1622, ISO 1183, 1183-3	49.3 lb/ft <sup>3</sup>	790 kg/m <sup>3</sup>
	Thermal Expansion	Effect on pipeline stress	ASTM E228, ISO 4897, or equivalent	0.00047/°F	0.00085 /K

- Stable at 120C over 30 days

### Comparison with Syntactic Materials

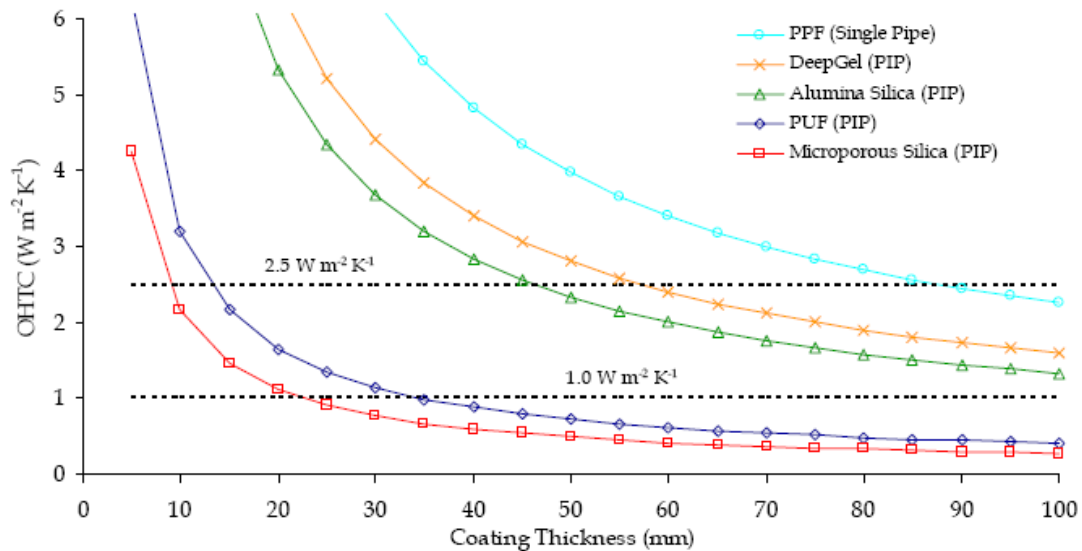
Insulation material	Maximum depth		Thermal conductivity	
	(ft)	(m)	Btu.in/ft <sup>2</sup> .hr.°F	W/m.K
Epoxy Syntactic	6,000-10,000	2,000-3,000	0.69 -0.94	0.1 -0.135
Polypropylene – reinforced foam combination	2,000-10,000	600 – 3,000	1.11 – 1.25	0.16 – 0.18
Polyurethane syntactic (plastic beads)	300-1,000	100-300	0.83 -1.04	0.12 -0.15
Polyurethane – Glass syntactic	6,000-10,000	2,000-3,000	0.83 -1.18	0.12 -0.17
<b>DeepGel</b>	<b>Depth Independent</b>		<b>0.69 -0.90</b>	<b>0.10 -0.13</b>

## OHTC Characteristics

The figures below are the result of independent studies to compare DeepGel OHTC “U” values and cooldown performance with other potential deepwater technologies for a base condition of a 10.75” pipe.

### Design Parameters

Parameter	Value
Hot-end Flowing Temperature	75°C
Ambient Temperature	5°C
System Length	7.5 km
Inside Film Coefficient (flowing conditions)	2000 W m <sup>-2</sup> K <sup>-1</sup>
Inside Film Coefficient (shut-in conditions)	500 W m <sup>-2</sup> K <sup>-1</sup>
Outside Film Coefficient	500 W m <sup>-2</sup> K <sup>-1</sup>
Fluid Density	825 kg m <sup>-3</sup>
Fluid Heat Capacity	2000 J kg <sup>-1</sup> K <sup>-1</sup>
Fluid Volume Flow Rate	12 Mbd
Minimum (Critical) Fluid Temperature	28°C
Required Survival Time	24hr

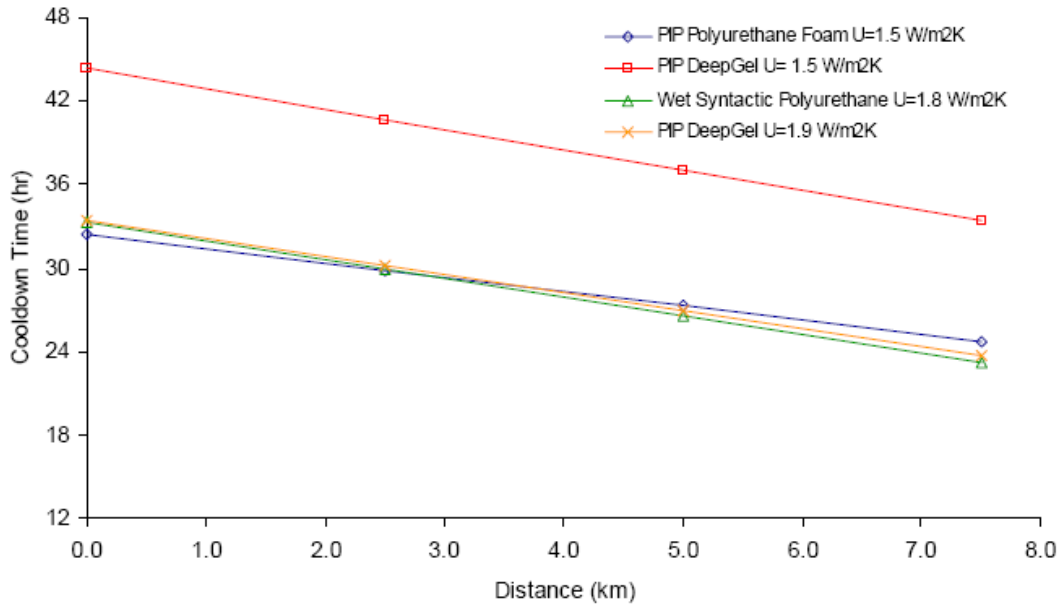


Note:  
Thermal conductivity for single pipe SPU is the same as DeepGel and therefore the curve for SPU is coincident with that for DeepGel.

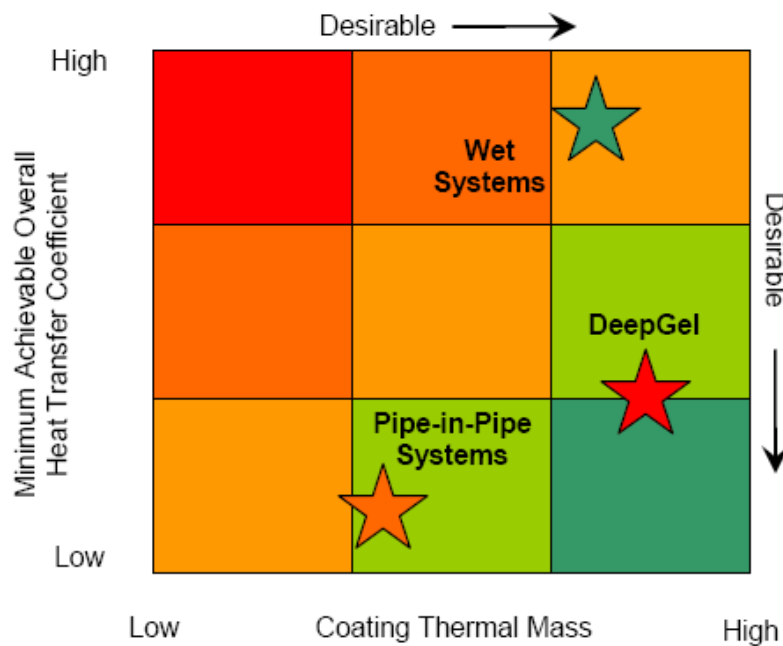
## Results

	Polyurethane Foam PIP	DeepGel 20-inch Carrier	Wet Syntactic Polyurethane	DeepGel 18-inch Carrier
Outer Pipe OD (inch)	14	20	n/a	18
Outer Pipe WT (mm)	19.1	12.0	n/a	12.0
Insulation Thickness (mm)	22.2	105.5	85	80.1
OHTC (W m <sup>-2</sup> K <sup>-1</sup> )	1.5	1.5	1.8	1.9
Initial Cold End T (°C)	59	59	56	55
Cool-down Time (hr)	24	33	24	23

## Cool down Performance



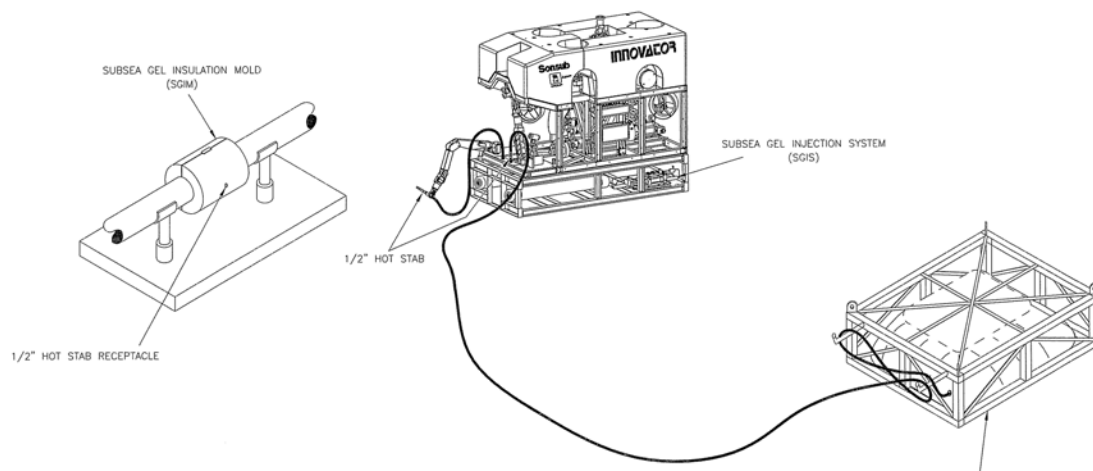
From the above results, it is clear that a gel based system with the same overall heat transfer coefficient will significantly out perform a low density insulation pipe-in-pipe system in terms of cool-down time. If the OHTCs are the same in both cases, then the starting temperatures will be the same, since the steady state performance of both systems will be identical. However, the additional thermal energy stored in the gel will contribute to the cool-down time, hence the gel based system takes nearly 40% longer to cool than the equivalent low density insulation. The schematic below compares DeepGel performance with that of other existing insulation technologies, DeepGel's combination of high thermal mass and low U values offers real benefits when compared to existing technologies.



These thermal characteristics highly suited to infield lines up to 10 km, bundles and the insulation of subsea components.

## Application via ROV

Working closely with SonSub YES has developed a variant of DeepGel suitable for application via ROV. DeepGel ROV consists of a base thixotropic easily pumped non drip fluid and a catalyst which when combined in situ will form a deformable self healing gel. DeepGel ROV is then pumped into a prefabricated housing which fills from the top by displacing water.



This fully engineered system offers the capability of installing insulation subsea or retrofitting insulation at a later date.

## Other Information

DeepGel is made from commercially available materials and can be sourced within a normal commercial time span. The components of the system are classed as either non hazardous or irritant under current EU legislation.