ContraTherm®
Subsea

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Alderley Materials Ltd, based in Berkeley, Gloucestershire, specialises in the manufacture and supply of unique phenolic resin based syntactic foam insulation and fire protection systems. Phenolic resins are widely used in high temperature applications such as brake lining and heat shields and are the acknowledged first choice resin system for elevated service temperature. Alderley insulation and fire protection products are marketed under the brand name ContraTherm®.

Alderley Materials has developed the ContraTherm® C55 Subsea System specifically to meet the need for a resilient insulation material capable of tolerating the temperature and pressure extremes required for high temperature developments. The system is engineered to withstand the particular service requirements demanded by offshore oil and gas production and comes into its own where high temperature high pressure field developments are concerned. The ContraTherm® Subsea System provides the user with the following major benefits:

- Excellent thermal insulation properties
- Excellent resistance to water ingress
- Excellent stability in water depths to 3,000 msw
- Excellent resistance to compression loads
- Excellent resistance to impact loads
- Long term high temperature stability
- Long term structural stability (30 years+)
- Ease of application, modification and repair

Flow Assurance & Insulation

The effective use of insulation materials on subsea pipelines and equipment assists flow assurance by maintaining flow rates which in turn optimises productivity and therefore lowers processing costs. Insulating subsea equipment reduces the cooling of reservoir fluids and maintains them at temperatures below which waxes and hydrates may form, thereby minimising the risk of diminished flow rates and blockages. Insulation may typically be applied to subsea equipment including but not limited to pipelines, Xmas trees, manifolds, jumper spools, pipe line end terminations and flange connections.

As oil and gas production extracts fluids of ever increasing temperatures from deeper waters and at longer tie-back distances from the host structure, the benefit of insulating subsea equipment becomes increasingly apparent. With fluid temperatures approaching 200°C (390°F) and at water depths approaching 3,000 msw (10,000 fsw) the need for a high temperature high pressure insulation material capable of withstanding such environmental extremes becomes a consideration of paramount importance.

The ContraTherm® Subsea System addresses the technology gap presented.
The ContraTherm® C55 Subsea System is a multi layer syntactic phenolic composite system with properties that can be tailored to meet specific subsea project requirements. Syntactic foams have been used in the offshore industry for more than 30 years and have become one of the key materials used in ever more demanding subsea applications. The low coefficient of thermal conductivity and robust mechanical structure of the ContraTherm® C55 Subsea System are ideally suited for subsea thermal insulation applications.

The individual elements of the multi layer system provide their own particular benefit and combine to provide a value for money solution. The D2004 phenolic composite provides an extremely robust, impact resistant, hard wearing outer skin with a surface finish tailored to suit project requirements. The composite consists of multiple glass fibre layers impregnated with phenolic resin to form a tough outer skin of nominal 4mm thickness. This phenolic top coat also provides a barrier to water ingress to limit water absorption in the insulation foam.

The C55 insulation foam consists of an optimised fill of glass microspheres dispersed and supported within a phenolic resin matrix which provides the necessary integrity and strength. The thickness of the core material is determined by the insulation performance requirements of the specific project. The ContraTherm® Tie Coat provides a tacky interlayer to hold the syntactic foam core material and to give good bond integrity to the substrate. The Tie Coat may be applied directly to shot blasted steel primed with the standard high performance primers widely used by the subsea equipment manufacturers.

The ContraTherm® C55 Subsea System’s cold curing properties (it does not create an exothermic reaction) makes the system ideal for direct application to equipment on construction or manufacturing sites globally. The pack in place application methodology combined with the minimum requirement for complex application equipment and the absence of mould tooling ensures ContraTherm® is a very flexible material to apply from a scheduling perspective; a benefit where complex equipment build programmes are involved.

The ContraTherm® C55 Subsea System does not require any further surface protection. From a solely cosmetic viewpoint the system may be painted in any standard RAL colour to suit the client’s purpose. Alternative resin systems are being developed by Alderley to produce additional stable surface colours to assist in underwater operations.

The ContraTherm® Subsea System is equally comfortable in ‘hot/wet’ or ‘hot/dry’ conditions and is therefore ideal for use in a retro-fitted insulation system for flange protection covers or doghouses. The temperature capability of the ContraTherm® Subsea System is not reduced in hot/wet conditions although for reasons of increased water absorption where bare foam products are used, Alderley reports a thermal conductivity of 0.20 W/mK for the bare foam. For hot/wet applications of the subsea system, a thermal conductivity of 0.151 W/mK proven through simulated service testing should be used.

The ContraTherm® Subsea System thickness will be determined by calculation from the thermal conductivity and/or specific heat capacity to meet the required overall heat transfer coefficient or cool down criteria. The ContraTherm® system is applied in layers until the required thickness is achieved. There is no practical limitation to the thickness of insulation that may be applied. The system will perform as an integrated system fully bonded at all interfaces under the anticipated exposure conditions. The composite layer is standard at a nominal 4mm thickness. Where pre-moulded ContraTherm® covers are used the complexity of the shape usually necessitates the manufacture of the internal faces in bare foam; as such the wet thermal conductivity value should be used.

Glass Microspheres

The excellent thermal performance and high hydrostatic pressure capability of the ContraTherm® Subsea System is provided by the presence of specially developed glass microspheres supported in the phenolic resin. The microspheres are microscopic closed cells of borosilicate glass which exhibit very stable insulation properties over long term environmental exposure. The phenolic binder does not absorb water and any voids between the microspheres and the resin represent an almost insignificant volume into which water can ingress. Alderley has tested for and established the maximum water absorption level of the ContraTherm® insulation foam which occurs when the bare foam is exposed to high temperature water.

Glass microspheres at magnification of 200x

Diameter = 177µ
Application Methodologies

The ContraTherm® Subsea System may be supplied either as a wet coating applied directly to the primed substrate in the field or as a pre-moulded engineered component. A combination of both methodologies may provide the best solution in certain applications.

Direct Application

The process of direct application involves mobilising materials, equipment and personnel to construction sites worldwide and applying the ContraTherm® system directly to the equipment substrate. The ContraTherm® Subsea System’s cold curing properties make it an ideal material for direct application at any stage in the build programme of the subsea equipment, including finished assembled packages such as Xmas trees and manifolds. This allows the EPC contractor to fit the application of thermal insulation into the overall delivery programme with a great degree of flexibility. The application methodology, not requiring the construction of any mould tooling or formers, makes it possible to apply ContraTherm® in areas which would normally prove difficult to access.

The core material in its wet state has a bread dough consistency and is designed to be easily applied to equipment and pipe work in layers of up to 20mm thickness at a time without sagging. The material does not experience shrinkage during curing enabling accurate thickness control. The application process ensures joints will become homogenous ensuring there are no weak points in the system. The process is relatively simple and makes the modification and adjustment to the insulation thickness and coverage during application quick and simple. The composite outer skin is applied after approximately 48 hours once the core material has cured. The individual glass fibre layers are wrapped onto the core material and impregnated with resin between each individual layer.

Once cured ContraTherm® is sufficiently robust to allow transportation without the need for further protection beyond that typically required for the equipment itself.

ContraTherm® does not require the fabrication of mould tooling nor does it require complex pumping equipment. ContraTherm® utilises simple mixing and application equipment which is readily available and does not require extensive maintenance or spares in the field. The relative simplicity of the application process makes ContraTherm® an ideal material for application using local labour with suitable training and under the supervision of Alderley technicians. The ContraTherm® Subsea System is supplied in pre-measured and pre-packaged kits to ensure ease of correct usage.

Where direct applied ContraTherm® is used the insulation foam may be shaped to suit detailed interface requirements prior to curing. The post cured composition and texture of ContraTherm® is ideally suited for machining using standard woodworking type equipment. This allows relatively simple procedures for the removal of ContraTherm® once applied, should this be required.
Pre-moulded Engineered Components

The ContraTherm® Subsea System may be moulded into pre-designed shapes to suit the equipment to be insulated. Such mouldings may be required to reduce application times and/or to provide for articulation or removable solutions where later access may required.

The use of pre-moulded components requires some pre-engineering but may increase operational flexibility by reducing the on-site insulation schedule and may shorten the overall equipment lead-time and critical path.

ContraTherm® components are produced by compression moulding and the material properties allow intricate single piece mouldings to be manufactured. This is advantageous in that large or complex mouldings need not be manufactured in smaller sub-assemblies and subsequently bonded together risking potential weak spots at the joint interfaces.

Pre-moulded components come in a range of shapes and sizes from relatively simple pre-designed and moulded panels, blocks or ‘half-shell’ C-sections up to the most complex connector cover arrangements such as ROV installed ‘doghouse’ mouldings. Each design is engineered to match the dimensions of the component to be insulated and produced in highly accurate compression moulds. The shapes are subsequently fastened to the structure by the most suitable means, from simple strap banding arrangements to complex ROV operated closure systems, and sealed as appropriate to minimise water flow and retain insulation performance. Whilst Alderley will mould very complex components individually, the bonding of subordinate pieces can be achieved by the use of proven subsea epoxy adhesives. These adhesives also allow the bonding of panels directly to the substrate as and when necessary.

A simple pre-moulded solution, such as a panel for subsequent bonding to a flow meter or valve body or a pair of C-section half shells for a pipe field joint arrangement, would be delivered to site in a kit form consisting of the insulation pieces, the epoxy adhesive and the strap banding or other form of mechanical fastening. The design of even simple components is engineered to suit specific demands, from jigsaw arrangement removable pieces to application time driven fast field joint covers for offshore pipe-lay operations.

More complex components would be delivered in their final assembled condition in advance of final installation. This may involve the fixing into position of subsea specification painted steel handling and closure frames and sealing arrangements to minimise the flow of water through the cover. Alderley is able to supply all associated bespoke steel fixtures, seals and other accompaniments required for specific insulation component designs whether surface or subsea, diver or ROV installed.

The design of connector covers is complex and usually individual to each application’s needs. Alderley engineers will therefore work closely with clients to develop the most suitable solution taking a holistic approach from manufacturing capability through to ease of installation whilst maintaining a specific focus on the project requirements.
Material Properties

The ContraTherm® C55 Subsea System has been developed through continuing investment in research and development within Alderley’s own laboratories and through qualification programmes often involving third party facilities. In developing the material a constant focus was maintained on the critical parameters required of a HTHP insulation material.

- Temperature Capability
- Hydrostatic Pressure Capability
- Thermal Conductivity
- Material Density
- Material Ruggedness
- Water Absorption Resistance

Research and development is continuing to seek further improvements in material properties with regard to the specific performance criteria required of future oilfield developments.

Thermal Expansion

The thermal expansion co-efficient and Young’s modulus for the ContraTherm® Subsea System has been carefully controlled to ensure the material exhibits properties similar to steel. Hence the system will expand and contract with the steel substrate during thermal cycling, ensuring no forces are generated which could affect the ContraTherm® System’s integrity or performance during service.

Chemical Resistance

ContraTherm® Subsea shows exceptional chemical resistance not only to seawater, oils and solvents but also acids and other aggressive chemicals. This is advantageous in that the ContraTherm® System will not be affected by accidental exposure to materials and liquids typically used in the production and installation phases of a project.

### Material Properties Table

<table>
<thead>
<tr>
<th>Parameter</th>
<th>D2004 Outer Skin</th>
<th>C55 Core Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>1300 Kg/m³</td>
<td>753 Kg/m³</td>
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<tr>
<td>C55 Foam Thermal Conductivity (Dry)</td>
<td>0.20 W/mK</td>
<td>0.14 W/mK</td>
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<tr>
<td>C55 Foam Thermal Conductivity (Wet)</td>
<td>0.22 W/mK</td>
<td>0.20 W/mK</td>
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<tr>
<td>Subsea System Thermal Conductivity</td>
<td>0.151 W/mK</td>
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<tr>
<td>Specific Heat Capacity</td>
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<td>2400 J/KgK</td>
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<tr>
<td>Maximum Service Temperature</td>
<td>200°C</td>
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<tr>
<td>Maximum Operating Depth</td>
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<td>Hardness</td>
<td>Barcol 75</td>
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<td>Tensile Modulus</td>
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<td>Compressive Strength</td>
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<td>Flexural Strength</td>
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<td>Flexural Modulus</td>
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<tr>
<td>Coefficient of Thermal Expansion</td>
<td>24.0 x 10⁻⁶/°C</td>
<td>20.7 x 10⁻⁶/°C</td>
</tr>
</tbody>
</table>

### Mechanical Stability

ContraTherm® Subsea insulation provides excellent mechanical stability which is characteristic of phenolic resins. Likewise the insulation properties of the ContraTherm® Subsea System will not significantly change with time even considering extended duration field design lives. Water absorption into the material will initially affect these mechanical properties however once the system reaches equilibrium in service the properties will remain constant. The ContraTherm® C55 insulation foam is a closed cell structure which is highly resistant to water permeation in the event of any accidental damage or exposure to water.

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