Subsea Thermal Insulation
for high temperature and
high pressure applications

www.aisplc.com
Advanced Insulation specialises in the manufacture and supply of unique syntactic foam insulation systems designed for upstream oil and gas infrastructures. Focusing on phenolic and silicone based resin systems for high temperature environments, Advanced Insulation offers solutions to the most technically demanding subsea insulation challenges.

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 above temperatures at which waxes and hydrates may form, thereby minimising the risk of diminished flow rates and blockages. Insulation may 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 180°C (356°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.

Contents Page

Introduction...............................................2
Subsea Thermal Insulation Systems...3
C55 Phenolic Syntactic Foam............4-5
C55 Direct Application Method...........6-7
C55 Pre-moulded Components.........8-9
C25 Syntactic Silicone System........10-11
C25 Application Method...............12-13
Material Properties.........................14-15
Advanced Insulation has developed its ContraTherm® solutions specifically to meet the need for resilient insulation materials capable of tolerating the temperature and pressure extremes required for high temperature developments. The ContraTherm® systems are engineered to withstand the particular service requirements demanded by offshore oil and gas production and come into their own where high temperature, high pressure field developments are concerned.

### ContraTherm® Subsea Systems

#### C25 Syntactic Silicones

Silicone resins offer a highly flexible, high temperature insulation system that is fast becoming the recognised solution for dynamic application service. Advanced Insulation recommends the C25 Series for service on dynamic application such as production jumpers, tie in spools and steel risers.

<table>
<thead>
<tr>
<th>C25 Syntactic Silicone Foam</th>
<th>C25 Primer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate Coated with Corrosion Coating</td>
<td></td>
</tr>
</tbody>
</table>

#### C55 Syntactic Phenolics

Phenolic resins are widely used in high temperature applications and are the acknowledged choice for elevated service temperatures. Advanced Insulation recommends the C55 Series for service on less dynamic applications such as Xmas trees, manifolds, supported jumpers and pipeline end terminations.

<table>
<thead>
<tr>
<th>Epoxy Flow Coat</th>
<th>D2004 Phenolic Composite Laminate</th>
</tr>
</thead>
<tbody>
<tr>
<td>C55 Phenolic Insulation Foam</td>
<td>Tie Coat</td>
</tr>
<tr>
<td>Substrate Coated with Corrosion Coating</td>
<td></td>
</tr>
</tbody>
</table>

### Benefits to industry

- Excellent thermal insulation properties
- Excellent resistance to water ingress
- Excellent stability in water depths to 3000 msw
- Excellent resistance to compression loads
- Excellent resistance to impact loads
- Long term high temperature stability
- Long term structural stability
- Ease of application, modification and repair

The use of ContraTherm® on subsea pipelines and equipment assists flow assurance by maintaining flow rates, which will in turn optimise productivity and lower processing costs.

ContraTherm® can be applied to subsea equipment such as Xmas trees, manifolds, jumper spools, pipeline end terminations and flange connections.

---

**ContraTherm**

An Advanced Insulation Product

---

3
ContraTherm® C55 is a multi-layer syntactic phenolic composite system with properties that can be tailored to meet specific 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 thermal conductivity and robust mechanical structure of ContraTherm® C55 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 top coat 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 composite also provides a barrier to water ingress limiting water absorption in the insulation foam.

ContraTherm® 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. There are several ContraTherm® material grades individually developed for differing water depth requirements.

ContraTherm® Tie Coat provides a tacky interlayer which bonds the syntactic foam core material and gives good bond integrity to the substrate. Tie Coat may be applied directly to shot blasted steel coated with the standard high performance anti-corrosion coatings widely used by the subsea equipment manufacturers.

C55 ambient curing properties make the system ideal for direct application to equipment on construction or manufacturing sites globally. The hand applied application methodology combined with the minimum requirement for complex application equipment, and the absence of mould tooling, ensures C55 is a very flexible material to apply from a scheduling perspective; a benefit where complex equipment build programmes are involved.

The final layer of the GRP top skin is a resin flow coat to finish the laminating process. The standard colour for the flow coat is yellow however other standard RAL colours may be used to suit the client’s requirements.

The yellow flow coat ensures the insulation is visible to ROVs on subsea operations.

The C55 Subsea System is equally comfortable in ‘hot/wet’ or ‘hot/dry’ conditions and is therefore ideal for use in a retrofitted insulation system for flange protection covers or doghouses.

Advanced Insulation reports both new and aged thermal conductivities for the bare C55 foam. Advanced Insulation recommends that the aged values are used in all thermal calculations providing a more conservative coating thickness.
The C55 insulation foam thickness will be determined by calculation from the thermal conductivity or specific heat capacity to meet the required overall heat transfer coefficient or cool down criteria. C55 is applied in layers until the required thickness is achieved. There is no practical limitation to the thickness of insulation that may be applied. ContraTherm® C55 will perform as an integrated system fully bonded at all interfaces under the anticipated exposure conditions.

**Glass Microspheres**

The excellent thermal performance and high hydrostatic pressure capability of C55 insulation foam 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. Advanced Insulation has tested for and established the maximum water absorption of the C55 insulation foam which occurs when the bare foam is exposed to highly pressurised water.

ContraTherm® C55 ambient curing makes it ideal for direct application to equipment on construction or manufacturing sites globally.

The Tie Coat may be applied directly to shot blasted steel coated with the standard high performance anti-corrosion coatings widely used by subsea equipment manufacturers. There are several C55 material grades individually developed for different water depth requirements.
ContraTherm®
C55 Direct Application Method

ContraTherm® C55 is supplied either as a wet coating applied directly to the corrosion coated substrate in the field or as a pre-moulded engineered component. A combination of both methodologies may provide the best solution in certain applications.

The process of direct application involves mobilising materials, equipment and personnel to construction sites worldwide and applying the ContraTherm® C55 system directly to the equipment substrate. The ContraTherm® C55 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. This 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.

In its wet state, the core material 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 guarantees joints will become homogenous ensuring there are no weak points in the system. The process is relatively simple and makes any modification or adjustments to the insulation thickness and coverage during application quick and simple. The composite outer skin will be applied to the ContraTherm® core once the curing process is sufficiently advanced. The individual glass fibre layers are wrapped onto the core material and impregnated with resin between each individual layer.
The ContraTherm® C55 System does not require the fabrication of mould tooling nor does it require complex pumping equipment.

The ContraTherm® C55 System 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 the ContraTherm® C55 System an ideal material for application using local labour with suitable training and under the supervision of Advanced Insulation technicians.

The ContraTherm® C55 System is supplied in pre-measured and pre-packaged kits to ensure correct usage.

Where the ContraTherm® C55 System is directly applied, the insulation foam may be shaped to suit detailed interface requirements prior to curing. The post cured composition and texture of C55 insulation foam ContraTherm® is ideally suited for machining using standard woodworking type equipment. This means that the removal of the ContraTherm® C55 System is straightforward should it be required.
ContraTherm®

C55 Pre-moulded Engineered Components

ContraTherm® C55 can 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 be required.

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

C55 components are produced by compression moulding. The material properties allow intricate single piece mouldings to be manufactured. This is advantageous as large or complex mouldings need not be manufactured in smaller subassemblies 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 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 Advanced Insulation 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 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 are delivered in their final assembled condition in advance of final installation. This may involve the fixing into position of painted steel handling and closure frames and sealing arrangements to minimise the flow of water through the cover. Advanced Insulation supplies 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. Advanced Insulation engineers 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.
Contratherm® C25 is a specially formulated two part syntactic silicone system tailored to meet stringent subsea requirements. Syntactic silicone foams have been used in the offshore industry for 10 years and syntactic foams in general for over 30 years. The low thermal conductivity and flexible nature of Contratherm® C25 make it an ideal product for subsea thermal insulation on dynamic structures.

C25 insulation foam consists of an optimised fill of glass microspheres dispersed and supported within a silicone resin matrix which provides the necessary integrity and strength. The thickness of material is determined by the insulation performance requirements of the specific project.

C25 is applied by direct casting to shot blasted steel coated with the high performance anti-corrosion coatings widely used by the subsea equipment manufacturers. Contratherm® Primer is first applied to the substrate to provide an interlayer to the syntactic foam core material and to give good bond integrity to the substrate.

C25 products are applied at room temperature so there is no need to heat the substrate being insulated.

C25’s ambient curing properties make the system ideal for direct application to equipment on construction or manufacturing sites globally. The pump in situ application methodology, combined with non complex standardised equipment, ensures that C25 is a very flexible material to apply from a scheduling perspective; a benefit where complex equipment build programmes are involved.

The application strategy is to use multiple low capacity pumps to maximise flexibility, increase ease of handling and provide redundancy at the operating site. Multiple pumps provide the option of filling moulds in parallel.

C25 is applied by pumping the material into moulds fitted to the substrate to provide the required insulation thickness and profile. The silicone resin has a greater open time than other pumped materials which allows a slower and more considered pumping strategy. The rheology of the material requires a slower pump speed which allows the operator sufficient time to manage the pumping process.

C25 is a flexible insulation material that is capable of absorbing the stresses applied through structure movements in service. Stresses are caused by the movement of the pipe structures through thermal expansion at elevated operating temperatures, pipe deflections and natural movement. The material will absorb such stresses without cracking or buckling.

The standard colour for C25 is yellow, however, other standard RAL colours may be used to suit the client’s purpose. The yellow colour provides high visibility to the insulation to ensure it is visible to ROVs on subsea operations. C25 is equally comfortable in ‘hot/wet’ or ‘hot/dry’ conditions and is therefore ideal for use in a retrofitted insulation system where ease of subsequent removal is important.
The ContraTherm® C25 Subsea System’s ambient curing properties makes the system ideal for direct application to equipment on construction or manufacturing sites globally.

The primer may be applied directly to shot blasted steel coated with the standard high anti-corrosion coatings widely used by subsea equipment manufacturers.

The C25 insulation foam thickness will be determined by calculation from the thermal conductivity or specific heat capacity to meet the required overall heat transfer coefficient or cool down criteria.

The C25 system is applied by filling moulds to the required thickness in a single pour. 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.

During mould tool design Advanced Insulation will be able to manipulate client CAD models to optimise mould design.

The mould tools are designed to be robust and reusable yet simple to aid ease of installation and removal.

Glass Microspheres

The excellent thermal performance and high hydrostatic pressure capability of C25 is provided by the presence of specially developed glass microspheres supported in the silicone resin.

The microspheres are microscopic closed cells of borosilicate glass which exhibit very stable insulation properties over long term environmental exposure. The silicone binder does not absorb water and any voids between the microspheres and the resin represent an almost insignificant volume into which water can ingress. Advanced Insulation has tested for and established the maximum water absorption of the C25 insulation foam which occurs when the C25 is exposed to highly pressurised water.

Once cured ContraTherm® is sufficiently robust to allow transportation without the need for further protection beyond that typically required for the equipment itself.
ContraTherm®
C25 Direct Application Method

ContraTherm® C25 is supplied as a wet coating applied directly to the primed substrate in the field. Engineered components can be moulded to provide removable insulation solutions for certain applications.

The process of direct application involves mobilising materials, equipment and personnel to construction sites worldwide and applying the ContraTherm® C25 system directly to the equipment substrate. The ContraTherm® C25 system’s ambient 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 jumpers 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 requires the construction of mould tooling which is engineered to suit any areas that are more difficult to access. This is not an issue with jumpers and tie-in spools which are the key service application for C25.

The material does not experience shrinkage during curing enabling accurate thickness control. The application process guarantees joints become homogenous ensuring there are no weak points in the system.

The C25 product is a two part high viscosity liquid material applied by using a plural component pump. Application is by means of pumping the mixed material into moulds constructed around the structure being insulated. The material is poured into the cavity between the substrate and the mould tools guaranteeing the thickness and position of the insulation. Tools are generally reusable to provide a cost efficient system of application.
The mould tools dictate the dimension and profile of the insulation moulding. Each moulding is profiled to accept the adjacent moulding to ensure correct bonding.

Contratherm® primers are used at all interfaces to ensure good bonding between insulation mouldings and the substrate. The primers are pigmented to highlight coverage during the application process. The bond strength created by the primer is greater than the strength of the bulk material. C25 can be cast to any thickness subject to any practical limitation within the subsea structure’s dimensions.

C25 is applied in ambient conditions and does not require the substrate to be preheated. The material is ambient curing and does not create internal stresses or impose stresses on the substrate. This process ensures long term security of the insulation system as the risk of future separation of individual mouldings is negated.

C25 material is easily removeable with the correct tools and is easily repaired using the same application process. Whilst closed moulds are normally used, open moulds can be used, when required by the application.

The ContraTherm® C25 Subsea System’s ambient curing properties make it an ideal material for direct application at any stage in the build programme of subsea equipment, including finished assembled packages such as jumpers and manifolds.

Once cured, ContraTherm® C25 is sufficiently robust to allow transportation without the need for further protection beyond that typically required for the equipment itself.
ContraTherm®

Material & Technical Properties

ContraTherm® has been developed thanks to continuing investment in research and development within Advanced Insulation’s own laboratories and through qualification programmes often involving third party facilities. In developing the materials, a constant focus was maintained on the critical parameters required of high temperature, high pressure insulation materials. The material evaluation process can be split into two main categories, material definition and full scale performance testing.

Material Definition

Extensive laboratory scale testing is completed to determine material properties in new and aged conditions. Such testing enables material performance to be defined according to:

- Temperature Capability
- Hydrostatic Pressure Capability
- Thermal Performance
- Material Density
- Mechanical Performance
- Water Absorption Resistance

Full Scale Testing

Service capabilities of the materials are also determined by laboratory testing. However, it is essential to verify the materials performance at the full scale to demonstrate ‘fitness for purpose’. Advanced Insulation have tested their products predicted service performance through:

- Simulated Service Testing
- Thermal Cycling Testing
- Cool Down Testing
- Cathodic Disbondment Testing

Advanced Insulation has successfully tested its products to major oil company qualification programmes, further full scale testing can be undertaken to meet individual project requirements.

Chemical Resistance

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

Mechanical Stability

ContraTherm® provides excellent mechanical stability. The insulation properties of ContraTherm® will not significantly change with time which is important considering extended duration field design lives. Water absorption into the material initially affects mechanical and thermal properties, however once the system reaches equilibrium in service these properties will remain constant.

ContraTherm® 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.
### ContraTherm® Mechanical and Thermal Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>C25 Series Syntactic Silicone</th>
<th>C55 Series Syntactic Phenolic</th>
<th>D2004 Series Phenolic Outer Skin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density [kgs/m³]</td>
<td>780-820</td>
<td>600-850</td>
<td>1300-1350</td>
</tr>
<tr>
<td>Thermal Conductivity (Dry) [W/mK]</td>
<td>0.15-0.16</td>
<td>0.14-0.17</td>
<td>0.18-0.22</td>
</tr>
<tr>
<td>Thermal Conductivity (Aged) [W/mK]</td>
<td>0.16-0.18</td>
<td>0.19-0.22</td>
<td>0.22-0.24</td>
</tr>
<tr>
<td>Specific Heat Capacity [J/kgK]</td>
<td>1300-1700</td>
<td>1700-2200</td>
<td>-</td>
</tr>
<tr>
<td>Maximum Service Temperature [ºC]</td>
<td>150</td>
<td>185</td>
<td>200</td>
</tr>
<tr>
<td>Maximum Operating Depth [msw]</td>
<td>3000</td>
<td>3000</td>
<td>3000</td>
</tr>
<tr>
<td>Hardness</td>
<td>70 Shore A</td>
<td>50 Shore D</td>
<td>-</td>
</tr>
</tbody>
</table>

*Aged data is based upon long term exposure testing of un-faced foam having been exposed on all sides and represents the worst case scenario.

Please note this information is based on our present state of knowledge and is intended to provide general notes on our products and their properties. It should therefore not be construed as guaranteeing specific properties of the products described or their suitability for a particular application. The values are subject to changes without notice, please consult with us prior to the application.

For more detailed product datasheets please contact Advanced Insulation.
We offer full technical support service for all our products regardless of location or application. For further information please contact us to discuss your requirements and/or request product trial reports.

sales@aisplc.com
www.aisplc.com