CUMING

TECHNICAL BULLETIN 601

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# *C-THERM* SYNTACTIC FOAM THERMAL INSULATION

## INTRODUCTION

Cuming Corporation's ***C-THERM*** product line of subsea thermal insulation offers improved performance for deep-sea oil and gas production. Higher temperature, longer life, lower density, and better thermal efficiency than conventional insulating materials are among the advantages that can be realized. The following notes are a general guide to the products available. For more information, please see contact information on the back page for your nearest representative.

## SYNTACTIC FOAM

The basis of any ***C-THERM*** product is syntactic foam, an advanced composite material of glass or ceramic microspheres cast into a binder of rigid, semi-rigid, or flexible plastic resin. Larger fiberglass macrospheres may be added if appropriate. The chemical and mechanical properties of ***C-THERM*** materials can be formulated to suit almost any kind of operating conditions.

## APPLICATIONS

FLOWLINES: Using proprietary patented cast-on-pipe technology, rigid or flexible ***C-THERM*** insulation is applied to any subsea flowline.
SCR's: A variation of the cast-on-pipe process to apply ***C-THERM*** coatings of controlled flexibility and buoyancy to steel catenary risers.
VERTICAL RISERS: Similar methods are used to create optimized combinations of insulation and/or buoyancy for vertical riser systems.
HYBRID RISERS: Efficiently engineered insulation and buoyancy packages are made for both integral and non-integral pipe systems.
FIELD JOINTS: ***C-THERM*** syntactic foam is cast into sleeves, collars, and bulkhead covers for insulating joints in flowlines and SCR's.
JUMPERS: Custom-engineered solutions combine a variety of ***C-THERM*** materials options to insulate all kinds of jumpers and similar lines.
SUBSEA EQUIPMENT: The widest choice of pack-in-place, pour-in-place, or precast shapes for insulating trees, manifolds, and equipment.

***C-THERM*** Insulated Vertical Riser Joints

## THE CAST-ON-PIPE PROCESS

The patented (U.S. Patent 6,058,979) process by which Cuming Corporation applies ***C-THERM*** syntactic foam insulation to pipe is innovative and unique. The inner portion of the insulation material is tightly bonded to the anticorrosion coating of the pipe, preventing water intrusion, not only affording extra corrosion protection to the pipe, but also greatly reducing the danger of "hot/wet" degradation. And the efficient casting process eliminates the need for any post operation, such as bonding sleeves to the pipe. See Chart 1 on the next page for properties.

## SPECIALIZED FACILITIES

Cuming Corporation's new factory in New Iberia, Louisiana, is expressly designed for the cast-on-pipe manufacturing process. Located near the water on the Gulf of Mexico and adjacent to Bayou Pipe's FBE coating facility, the factory routinely coats double joints 80 feet long, from which joints 160 feet or longer are readily fabricated. In addition, our highly experienced factory crews make and install any of the wide variety of ***C-THERM*** insulation materials described herein.

## BUOYANT INSULATION

***C-THERM*** insulation materials are low in density, making them inherently efficient sources of buoyancy. This is often a valuable asset in verti-

CONTINUED INSIDE





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Boston, MA USA — Houston, TX USA
Macae RJ, Brazil — New Iberia, LA USA
Frankfurt, GERMANY

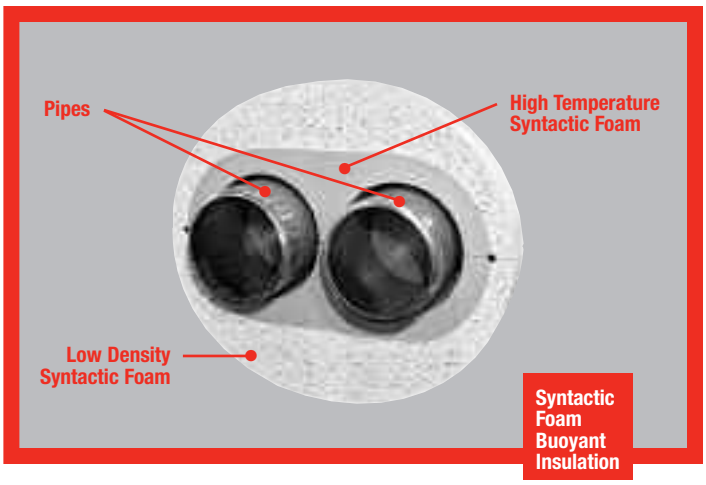
CHART 1

| *C-THERM* Cast-On-Pipe Flowline Insulation Materials | | | | |
|---|---|---|---|---|
| ***C-THERM*** Product Grade | Maximum Service Depth Rating, m (ft) | Maximum Temperature, C° (F°) | Thermal Conductivity, W/m °K (Btu/ft °F hr) | Syntactic Construction Notes |
| ***C-THERM*** R-Series | 1,200 (4,000) to 2,300 (7,500) | 80 (175) to 100 (212) | 0.08 (0.04) to 0.12 (0.07) | Rigid epoxy solid or composite |
| ***C-THERM*** S-Series | 1,200 (4,000) to 2,300 (7,500) | 80 (175) to 100 (212) | 0.09 (0.05) to 0.13 (0.08) | Semi-rigid solid or composite |
| ***C-THERM*** L-Series | 1,200 (4,000) to 2,300 (7,500) | 80 (175) to 100 (212) | 0.10 (0.06) to 0.14 (0.09) | Flexible solid or composite |

Notes: 1. R-Series, S-Series, and L-Series are suitable for S-Lay or J-Lay installation. L-Series is suitable for reeling installation.
2. Other depth and temperature ratings available. See Technical Bulletin 610 and the current product-specific Data Sheets for more information.

cal risers and hybrid riser systems, where both insulation and buoyancy are required. These materials can be applied by the integral cast-on-pipe process or in the form of non-integral modules for bolting or strapping to the pipe.

The physical and thermal properties of integral cast-on-pipe buoyant insulation are similar to those of S-Series materials in Chart 1, while the properties of non-integral modules are more similar to the R-Series. The photograph below illustrates one form of hybrid buoyant insulation. Chart 2




compares the density of typical ***C-THERM*** insulation materials (exposed to hot water) to the density of conventional ***C-FLOAT*** buoyancy materials (exposed to cold water only).

## HYDROTHERMAL TESTING

Syntactic foam has over thirty years of successful history as a buoyancy material. Its use as an insulation material, however, is more recent and less well established. Recognizing this, Cuming Corporation operates one of the most extensive testing and qualification programs in the industry, with hundreds of candidate materials under test. A number of heated pressure vessels are used to perform characterization and accelerated aging on syntactic foam samples ranging from small screening chips to full-size modules weighing up to 450 kg (1,000 lbs) or more. The typical "testing hierarchy" consists of the following steps: (1) initial screening to determine the hydro-thermal resistance of the polymer and its fillers; (2) long-term testing to verify performance over extended periods; and (3) type-specific testing for actual project qualification.

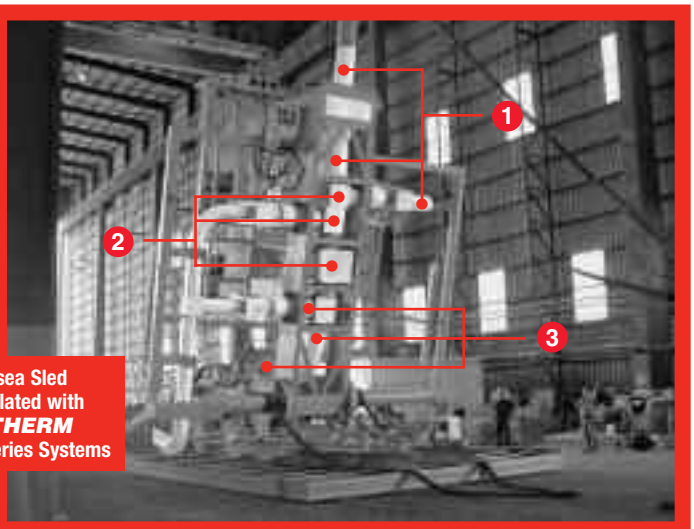
CHART 2

| Comparison of Densities<br>Nominal kg/m$^3$(lbs/ft$^3$) vs. Temperature Ratings | | |
|---|---|---|
| Max Depth m (ft) | ***C-FLOAT*** 4°C (40° F) | ***C-THERM*** 80° C (175° F) |
| 600 (2,000) | 385 (24.0) | 513 (32) |
| 900 (3,000) | 415 (26.0) | 545 (34) |
| 1,200 (4,000) | 450 (28.0) | 577 (36) |
| 1,500 (5,000) | 480 (30.0) | 609 (38) |
| 1,800 (6,000) | 513 (32.0) | 641 (40) |
| 2,300 (7,500) | 545 (34.0) | 689 (43) |
| 3,000 (10,000) | 577 (36.0) | 721 (45) |

Note: Relative Densities Are Approximate

## FIELD-APPLIED SYSTEMS

***C-THERM*** syntactic foam insulation materials are available in a full range of products designed for ease of installation on sleds, trees, manifolds, jumpers, and other subsea equipment. All F-Series materials are




Subsea Sled Insulated with ***C-THERM*** F-Series Systems

Numbers correspond to subheads below and at right

tested and qualified to the same demanding standards as every other ***C-THERM*** product. The photo above illustrates a typical field installation of these materials by factory-trained Cuming Corporation technicians.

① ***C-THERM*** FPC Precast blocks, panels, shapes, and sleeves of syntactic foam for bonding, bolting, or strapping directly to the equipment. Made from semi-rigid ***C-THERM*** syntactic foam, these custom shapes offer outstanding thermal insulation over a long, reliable life. Fastening systems, including special compliant adhesives, are provided, along with expert engineering advice and trained installers. See Technical Bulletin 625-1 for more information.

② ***C-THERM*** FPP "Pour-in-place" syntactic materials provide a quick and easy way to insulate even the most complex shapes. Low temperature curing means that work can be done outdoors without special equipment or preparations. Formulated from the same semi-rigid ingredients as ***C-THERM*** FPC, these materials are supplied in premeasured kits for mixing and pouring by factory trained installers. See Technical Bulletin 625-2 for details.

③ ***C-THERM*** FPG "Pack-in-place" syntactic foam insulation has become the standard of the offshore industry, with more installations than any other materials system. Supplied in two-part kits, ***C-THERM*** FPG is easily mixed together like modeling clay to cure into a tough, semi-rigid solid at ambient temperature. A variety of installation techniques, including plastic net laths and fiberglass overcoats, allow our technicians to insulate any kind of equipment. See Technical Bulletin 625-3.

CHART 3

***C-THERM*** **F-Series**
Field-Applied Insulation Systems

| Typical Properties (See TB's) | Rated for 1,200 m (4,000 ft) | Rated for 2,300 m (7,500 ft) |
|---|---|---|
| Nominal density, $kg/m^3$, ($lbs/ft^3$) | 500-600 (31-37) | 600-720 (37-45) |
| Conductivity W/m °K (Btu/ft °F hr) | 0.09-0.12 (0.05-0.07) | 0.12-0.14 (0.07-0.08) |
| Spec. heat c, J/g °K (Btu/lb °F) | 1.2 (0.3) | 1.2 (0.3) |
| Water absorp. after 168 hr | Beyond 168 hr, ***FPG*** absorp. rate slows to match others. | |
| ***FPC*** and ***FPP*** | <5.0% | <5.0% |
| ***FPG*** | <10.0% | <10.0% |

Note: Properties shown are for maximum service temperature of 100° C (212° F). See the Technical Bulletins and Data Sheets for other ratings.

Installing a ***C-THERM*** field joint off West Africa

## FIELD JOINTS

***C-THERM*** syntactic foam is frequently molded into collars and sleeves for insulating field joints, bulkheads, and flanges on flowlines, SCR's and riser pipes. Thermal properties are similar to those given in Chart 1. A number of proprietary techniques have been developed for attaching and sealing these units. The amount of insulation, as well as the corrosion protection afforded the pipe, is engineered into the joint system.

## MATERIALS SELECTION

Great strides have been made in the last few years in our understanding of the effects of "hot/wet" conditions on syntactic foam. Materials that perform in cold water or under low hydrostatic pressure may not do well when exposed to a more severe environment. All of the ingredients in a thermal insulation system – the polymeric binder and the glass or ceramic filler –

must work together if advertised properties are to be maintained over the design life.

***C-THERM*** insulation materials are custom formulated for specific applications. However, the following general guidelines apply:

- Rigid and semi-rigid products are based on epoxy resin chemistry.
- A choice of polyamide, amine, or anhydride hardeners is used with the epoxy, depending on conditions.
- Polyurethane elastomers are the binding materials of choice for flexible applications.
- A variety of glass or ceramic microspheres are used with the above, depending on conditions.

## INDEPENDENT TESTING

In addition to the rigorous in-house testing program described on Page 2, ***C-THERM*** insulation materials have been thoroughly evaluated by a number of customers as well as independent laboratories. Testing at Heriot-Watt University in Edinburgh, Southwest Research Institute in San Antonio, and Mohr Engineering in Houston have all confirmed the superior thermal and mechanical performance of ***C-THERM*** syntactic foam.

## SIMULATED SERVICE VESSEL TESTING

The most realistic method of testing subsea insulation materials is a Simulated Service Vessel (SSV), in which the insulation is cast onto a steel pipe that is heated by an internal flow of hot oil. The insulated pipe assembly is then placed in a vessel filled with chilled water and pressurized to simulate service deep in the ocean. The resulting conditions effectively reproduce the thermal and mechanical strains to be experienced in actual service. As part of its hydrothermal test laboratory, Cuming Corporation operates an SSV capable of testing full-size castings of ***C-THERM*** syntactic foam insulation under full temperature and pressure for very long periods of time. Many thousands of hours of test data have been accumulated. Not only is this information invaluable for developing new and improved materials, but our customers also find it useful in qualifying ***C-THERM*** products for specific applications, assuring them they are receiving insulation systems that will provide reliable service for many years to come.

CHART 4

**Standards and Specifications**

| Heriot-Watt University | Pressurized Thermal Conductivity Testing |
|---|---|
| ASTM D 792 | Density |
| ASTM C 518 | Thermal Conductivity |
| ASTM C 351 | Specific Heat |
| ASTM D 2240 | Hardness |
| ASTM D 695 | Compressive Strength |
| ASTM D 1623 | Tensile Strength |
| ASTM D 2736 | Hydrostatic Strength |
| ASTM D 570 | Water Absorption |

This custom-built simulated service vessel tests new material formulations for hydrostatic integrity.

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