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## FOAMGLAS® INSULATION SYSTEMS

Protecting Companies and  
Their People Worldwide

for Industrial Applications with Operating Temperatures  
of -268°C to +482°C (-450°F to +900°F)



**FOAMGLAS®**

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## FOAMGLAS® CELLULAR GLASS INSULATION IS PROVEN VALUE

### PRODUCT VALUES

FOAMGLAS® cellular glass insulation is the result of more than a half-century of proven performance and continual product improvement by Pittsburgh Corning Corporation, the developer of cellular glass insulation.

### Selection and Experience

FOAMGLAS® insulation is comprised of a family of seven material grades providing the precise properties and performance for your specific applications, from -450°F to +900°F (-286°C to +482°C). *Billions* of units have been installed throughout the world in thousands of industries and operations.

### Worldwide Availability

With plants in the U.S. and Europe, Pittsburgh Corning can uniquely provide consistency of supply, a millions-of-units inventory and ready availability.

### Accessory Products

In addition, Pittsburgh Corning offers a full line of complementary accessory products, each laboratory- and service-proven to provide *maximum* performance specifically with FOAMGLAS® cellular glass insulation.

### SERVICE VALUES

Equally critical to product performance is the added value of Pittsburgh Corning's support services to ensure that the product is smoothly and properly incorporated into the customer's requirements, project and facility.

### Technical Service

Pittsburgh Corning's Technical Service Staff provides product, application and materials testing—standardized and customized specifications—on-site customer assistance and installation guidance.

### Energy Analysis Service

To simplify your insulation specification process, Pittsburgh Corning offers and Energy/Economic Analysis Service, resulting in our exclusive Energy Analysis Report (EAR). Developed with customer-specific data subjected to computer analysis and other calculations, EARs assist systems designers in specifying the proper insulation thicknesses for above or below ground pipelines and for storage vessels, tanks and other equipment. Typical reports present heat flow rates, interface and surface temperatures, and insulation thicknesses required to prevent condensation.

### Energy Survey Service

Pittsburgh Corning offers this service free to all prospective clients to assist in planning for building renovations and to identify deteriorating insulation systems. This service helps to determine payback periods for reinsulated systems and will evaluate the performance of existing thermal insulation on piping and equipment. The survey is conducted on-site and can result in energy savings and condensation-ice control.

Specialized reports are available for:

- Underground pipelines
- Predicting outlet temperatures
- Estimating exit pressure and quality of steam for long steamlines
- Determining the time for water and sewage to freeze in pipelines
- Calculating heat flow and interface temperatures for tank base systems

Requests for EARs can be made through your local Pittsburgh Corning representative.

### Sales Support

A system of local sales representatives and distributors are available for consultation and problem resolution. Training videos, CD-ROM presentations and literature, are also available from your local sales personnel. Literature is also available electronically on our website at: [www.foamglas.com](http://www.foamglas.com).

### Industry Support

Pittsburgh Corning supports technical and trade and certifying organizations, including ASTM, CSI, CEN, FESI, UDI, CEPMC, ASHRAE, NACE, NIA, UL and FM. The result is an ever-growing series of application and regional certifications and approvals (see page 18) that provide you will complete assurance of materials compliance for a variety of installations. Pittsburgh Corning is ISO 9001:2000 certified with registered production processes regarding quality control.



## A UNIQUE COMBINATION OF PROPERTIES CREATES THE INSULATION OF CHOICE

### SUPERIOR PHYSICAL ATTRIBUTES

FOAMGLAS® insulation is a lightweight, rigid insulating material composed of millions of completely sealed glass cells, each an insulating space. This all-glass closed-cell structure provides an unmatched combination of physical properties ideal for piping and equipment above ground, as well as underground, indoors or outdoors, at operating temperatures from -450°F to +900°F (-268°C to +482°C):



FOAMGLAS® insulation—in 2" (50.8mm)-thick, 12" x 18" (304.8mm x 457.2mm) blocks—being applied to a petroleum storage tank at a West Coast refinery. Industrial Applications include pipelines as well as vessels of all types.

- Resistant to water in both liquid and vapor forms
- Noncorrosive
- Noncombustible/nonabsorbent of combustible liquids
- Resistant to most industrial reagents
- Dimensionally stable under a variety of temperature and humidity conditions
- Superior compressive strength
- Resistant to vermin, microbes and mold
- Fiber, CFC and HCFC free
- Fire resistance protects the insulated equipment, and helps minimize subsequent plant shutdown time
- Virtual elimination of the potential for auto-ignition from absorbed combustible liquids or fire from condensed low-temperature gases
- Proven durability for underground and exterior installations
- Manufacturing of FOAMGLAS® insulation puts no stress on the atmosphere's ozone layer ... while its long-term thermal efficiencies reduce energy demand and the effects of burning fossil fuels on the environment

- Heat transfer fluid systems
- Hydrocarbon and sulfur processing systems
- Underground steam and chilled water piping
- Chilled and hot water service lines
- Off-shore platforms
- Above ground steam lines
- Pulp/paper mills and water treatment plants
- Food processing/cold storage facilities and breweries
- Cyclic and dual temperature applications
- Heat traced pipes and equipment

For each of these applications and for all special conditions, FOAMGLAS® insulation is fabricated in a wide range of shapes, thicknesses and sized to meet virtually all industrial requirements. Pittsburgh Corning's many accessory products are designed to produce the maximum insulation system performance.

### MANY UNIQUE BENEFITS

FOAMGLAS® insulation's diversity of properties results in an equally unmatched combination of benefits, proven over decades of in-the-field performance:

- Constant, long-term energy efficiency provides low, predictable energy costs
- Enhanced process control allows improved, consistent product quality
- Minimal maintenance/repair/replacement of insulation or facility infrastructure reduces life cycle costs

### WIDE-RANGING, SERVICE-PROVEN APPLICATIONS

FOAMGLAS® insulation has over 60 years of applications that have stood the test of time with a record untouched by any other insulation product on the market:

- Cryogenic and low-temperature pipelines, vessels, tanks and equipment
- Medium- and high-temperature pipelines and equipment
- Hot oil/asphalt storage tanks

## MOISTURE RESISTANCE DELIVERS LONG-TERM PERFORMANCE

### CONSTANT THERMAL EFFICIENCY

Lost thermal efficiency due to moisture absorption is the single most common cause of insulation failure. In fact, just 4% by volume, can reduce thermal efficiency by 70%\*!

\* "Thermal Conductivity of Wet Insulations." Ludwig Adams, ASHRAE JOURNAL, October 1974.

For over 60 years, FOAMGLAS® insulation has proven itself to resist moisture and provide constant thermal resistance. *No other insulation manufacturer can make this claim.*



FOAMGLAS® insulation is ideal for low temperature applications—including chill water piping and equipment.

### WATER'S EFFECTS

Eventually, other insulation materials absorb moisture. So, eventually other insulations lose thermal efficiency. This is because liquid water has a thermal conductivity up to 20 times greater than most insulation materials.

And, the thermal conductivity of ice is 100 times greater—a major threat for cryogenic systems (see Figure 1).

**When moisture in any form invades insulation, thermal efficiency is destroyed and energy consumption increases.**

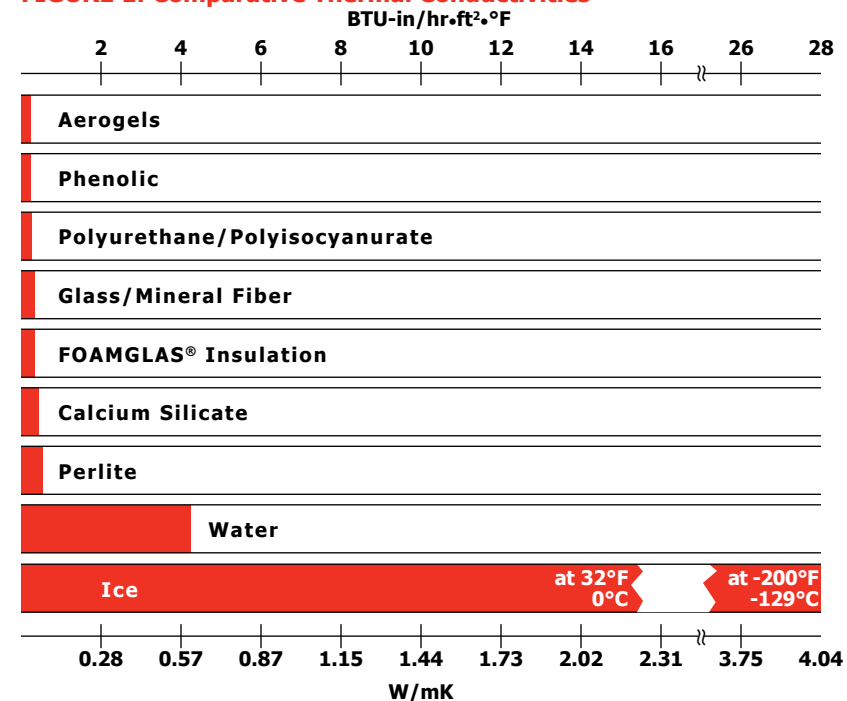
### OPERATIONS PROBLEMS

The problems that can result when moisture enters an insulation are multiple. Foremost, is the effect on operating cost. When moisture reduces an insulation's thermal efficiency, the system it protects is not functioning optimally and production costs increase—often very insidiously. When a system is not operating at its proper temperature, process control and product quality and quantity are compromised. Simultaneously, as invasive moisture causes production costs to go up and product quality to go down, the facility's infrastructure itself can fall prey to corrosion.

### LONG-TERM PROTECTION

Because FOAMGLAS® insulation is an all-glass, totally closed-cell material with minimal absorption, it eliminates moisture intrusion. Even after total immersion in water, the only measurable moisture found on FOAMGLAS® insulation is that which adheres to its surface cells (see Table 1).

FIGURE 1: Comparative Thermal Conductivities





Aging and moisture penetration can cause a chronic, increasing loss of thermal efficiency in other insulating materials. FOAMGLAS® insulation provides *constant* thermal efficiency for the *life of the system*. Constant insulating efficiency minimizes the need for insulation replacement, and long-term, life-cycle costs are among the lowest and most predictable.

**COLD & CRYOGENIC SERVICE**

Moisture can enter an insulation directly as absorbed water, but with cold applications an even more significant source of moisture penetration is diffusion of water *vapor* which can condense as a liquid or as ice. As the temperature gradient increases between the exterior insulation surface and the surface of the insulated equipment itself, so does the potential rate of water vapor penetration. Thus, it is even more critical that an insulation have a *low vapor transmission rate* than an initially low thermal conductivity. Any vapor retarders that are used with permeable insulations are subject to mechanical damage, temperature change and weather. And, because retarders are normally adhered directly to these insulations, movement can contribute to their damage.

More recently, some manufacturers of permeable insulation have given up trying to protect their products with vapor barriers. They have introduced perforated jacket systems with wicking materials that supposedly draw the moisture away from the pipe. Meanwhile these systems ignore the continuous vapor drive towards the cold line. In this type of system, the equipment will be continuously wet and subject to corrosion and mold growth.

Most low-temperature system insulations are closed-cell *organic foams* subject to water vapor permeability. With these organic foams, moisture can penetrate and be transmitted through the insulation via the water vapor gradient pressure previously mentioned. These wet insulations in low-temperature service have no opportunity to dry out, so moisture builds to permanent liquid saturation or ice accumulation.

However, the water vapor permeability of FOAMGLAS® insulation (0.00 perm-inch) is at least *100 to 10,000 times lower* than competitive insulation materials (see Table 1). As a result, water vapor intrusion into low-temperature systems is virtually eliminated and thermal efficiency



FOAMGLAS® insulation being installed as an "OVERFIT" system.

maintained. Thus, FOAMGLAS® insulation does not require a vapor barrier (although they can be used for added protection).

**HIGH-TEMPERATURE SERVICE**

For high-temperature conditions, absorptive fibrous or particulate insulations are often used. These include calcium silicate which can hold over 400% of its weight in water without dropping; up to 90% is not unusual. In many cases complete saturation can occur in less than three hours. Even the effects of silicone water-repellent treatments on mineral wools and perlite are very short-lived, with performance deteriorating at temperatures as low as 265°F (129°C) for the former, and 100°F (38°C) for the latter. And, once moisture gets into insulation it may never dry out, even on steam lines at 1000°F (538°C). The process heat involved can drive water back to a certain point, but some always remains in the insulation layers that are below 212°F (100°C), resulting in substantial heat loss and a compromise in process control. Non-absorbent FOAMGLAS® insulation protects against moisture penetration. Where this condition has occurred on an existing system, the FOAMGLAS® "OVERFIT" System *can* reverse the problem. FOAMGLAS® insulation and jacketing are installed directly over the existing wet insulation and metal



With many FOAMGLAS® insulation projects, an insulation sample is removed after many years of service for testing and replaced with new FOAMGLAS® insulation.

Even after 32 years of service, the properties measured for the FOAMGLAS® insulation on this tank compare favorably with the same properties at the time of insulation.

jacketing. System heat can now drive moisture out of the original insulation as vapor, through jacketing seams and the open joins of the FOAMGLAS® insulation overfit, and, finally, out of the system. At one refinery where overfit was employed, operating costs were reduced 56% and a potential \$10 million shutdown was averted.

If FOAMGLAS® insulation can perform like this on a high-temperature operation with *wet* insulation of some *other* material, imagine how it performs when installed initially. In one instance, after 30 years of *unjacketed* services (not recommended) on a refinery's heated (190°F/88°C) wax and oil tank, FOAMGLAS® insulation remained dry, with a thermal conductivity increase of 0.01Btu-in/hr•ft²•°F.

**HIGH-TEMPERATURE SYSTEMS**

FOAMGLAS® insulation can be fabricated for specific high-temperature piping and equipment requirements. Systems include various bonding agents, composite insulation systems, and the StrataFab® and Advantage® systems. See page 20 for selection chart.

**CORROSION UNDER INSULATION**

Significant metallic corrosion—with major economic and safety consequences—can develop in systems using absorptive insulations, particularly when these systems are at temperatures which allow water to exist in the liquid state. With carbon steel, ions leached from the insulation by intrusive moisture can produce acids that accelerate corrosion; and chlorides from insulation products can promote stress cracking in stainless steel.

The corrosion rate under wet insulation can be up to 20 times greater than the rate of corrosion by the ambient atmosphere. With "invisibility" compounding the situation, it has been described as the greatest corrosion problem facing the chemical industry. The cost for system replacement at just one plant can be millions of dollars, not including lost production and the potential of total shutdown.

Because under-insulation corrosion can progress undetected, hazardous leaks are possible. And, results can be catastrophic—to personnel, plant equipment and production.



Corroded flange under absorbent insulation.

There are three approaches to averting under-insulation corrosion:

- The use of suitable weather or vapor retarders ... but these are not reliable.
- The physical "encapsulation" of equipment via paints or mastics, including silicones, epoxy phenolics, coal tar epoxies and bitumens ... but these require critical surface preparation and a defect-free coating
- An insulation that minimizes water intrusion and does not retain water

Impermeable, inert FOAMGLAS® insulation provides the third approach and resists the development of corrosion in three ways:

- Protection against water intrusion and retention
- No acceleration of the corrosion due to water soluble chlorides or other corrosive agents
- Acting as a barrier to corrosion

**TABLE 1: Permeability (E 96 Wet Cup) and Moisture Absorption (C 240)**

Insulation Material	Permeability Perm-Inch <sup>1</sup>	Permeability Perm-Cm	Absorption % by Vol.
FOAMGLAS® Insulation	0.00	0.0	0.2 <sup>2</sup>
Polyurethane or Polyisocyanurate	1-3	1.67-5.01	1.6
Polystyrene	0.5-4	0.835-6.68	0.7
Phenolic	0.1-7	0.17-11.69	10
Fibrous Glass	40-110	66.8-183.7	50-90
Mineral Fiber <sup>3</sup>	40-99	66.8-165.3	zero-90 <sup>3</sup>
Calcium Silicate	24-38	40.08-63.46	90
Expanded Perlite <sup>3</sup>	32	53.44	2-90 <sup>3</sup>
Aerogels	N/A	N/A	N/A

<sup>1</sup> Perm-Inch is the accepted unit of water vapor permeability  
 $1 \text{ Perm-Inch} = \frac{1 \text{ Grain-Inch}}{\text{Ft}^2 \cdot \text{Hr} \cdot \text{Inch of Mercury}}$        $1 \text{ Perm-Inch} = \frac{1 \text{ Grain-Cm}}{\text{SqM} \cdot \text{Hr} \cdot \text{Cm Mercury}}$   
<sup>2</sup> The only moisture retained is that adhering to surface cells after immersion  
<sup>3</sup> Waterproofing agents may be destroyed when exposed to temperatures of 250°F (121°C) or higher

## NONCOMBUSTIBLE ... PERSONNEL AND EQUIPMENT PROTECTION

When reviewing an insulation material's fire endurance, three factors must be considered: fire resistance, toxicity and performance in the presence of combustible chemicals. It can be said that FOAMGLAS® cellular glass insulation has proven to be totally noncombustible, nontoxic and nonabsorptive of combustible fluids.

### FIRE RESISTANCE

Because FOAMGLAS® insulation is 100% glass, without binders or fillers, it simply cannot burn, even when in direct contact with intense flame. "Thermal insulation" is usually considered as a material limited to helping maintain operating system temperatures, while acknowledged as having a potentially active role in fire propagation. However, in the case of FOAMGLAS® insulation, it can actually serve to protect piping and equipment from fire damage, retard fire spread and help safeguard personnel.

### PLASTIC FOAMS

The fire performance of FOAMGLAS® insulation contrasts greatly with the manufacturers' warnings that accompany many other insulations:

- "[Polyisocyanurate] foam insulation products are combustible. They should be properly protected from exposure to fire during storage, transit and application ..."
- "Warning—Polyisocyanurate is an organic material which will burn when exposed to an ignition source of sufficient heat and intensity, and may contribute to flames spreading."
- "Warning—These [expanded polystyrene] products will burn and may pose a fire hazard. They will ignite with exposure to heat

sources of sufficient intensity, such as open flames and welders' torches. Once ignited, they can burn with intense heat and smoke."

Organic and foamed insulations are not only flammable, but often act to rapidly spread fire with molten plastic, while generating toxic fumes and chemicals and massive quantities of smoke.

### FIRE PERFORMANCE CONFUSION

Insulation designations such as "self-extinguishing" and "fire retarding" often are thought to mean "noncombustible." And, even "slow-burning" or "self-extinguishing" materials can produce deadly smoke and toxic fumes. In fact, flames are the least likely cause of death from fire.

One test, for surface burning characteristics (ASTM E 84, to be discussed), can give dramatically different results depending on the presence of fire retarding additives. With polyurethanes, for example, additives can reduce flame spread under test conditions, but have little retardant effect in an actual fire. Additionally, retardants can contribute their own toxic fumes, as well as attack metallic structures, reinforced concrete and electronics for months after a fire with their corrosive composition.

Other factors that can have a critical effect on actual fire performance versus test behavior are the substrate material on which an insulation is used and how fast maximum temperatures are reached in petrochemical as opposed to building fires. Compounding the confusion is an international lack of fire testing uniformity in this area.

### TESTING

FOAMGLAS® insulation has been subjected to scores of national and international tests. The following are four of the United States fire-resistance tests, covering both building and petrochemical fire performance.

*ASTM E 119—Standard Fire Tests of Building Construction Materials*  
This test examines the performance of materials under fire exposure conditions within a furnace. The basic test is run at an ambient temperature reaching 1700°F (925°C).

The test is continued until failure occurs, or until the average temperature of the protected steel reaches 1000°F (538°C). This maximum represents the threshold of structural failure for carbon steel. Above this temperature, piping/structural steel would have to be replaced.

In ASTM E 119 testing, FOAMGLAS® insulation has demonstrated exceptional fire protection, as shown in Figure 2.

*ASTM E 814/UL 1479—FOAMGLAS® insulation is approved for use in through-penetration firestop systems described in Vol. 2 of the U.L. Fire Resistance Directory.*

A firestop system is a specific construction consisting of a wall or floor assembly. A penetrating item such as chilled water pipes passes through an opening in the wall or floor assembly and the materials designed preserve the fire resistance rating of the assembly.

See page 18 for a list of approved systems. Call Pittsburgh Corning for a list of UL approved fabricators.

### ASTM E 136 Noncombustible

*ASTM E 136—Behavior of Materials in a Vertical Tube Furnace at 1382°F (750°C)*

This test also examines the combustion and heat generating characteristics of building materials within a furnace environment; limited flaming is allowable. The specimen, with thermocouples, is inserted into the furnace and the test continued until the specimen thermocouples reach the 1382°F (750°C) furnace temperature, or the specimen fails. A material passes the test if three of four specimens: (1) do not have thermocouple temperatures more than 54°F (12°C) above the furnace temperature; (2) show no flaming after the first 30 seconds; and (3) show no temperature rise or flaming, if their weight loss exceeds 50%.

This test, and similar international tests, are applied by United States Coast Guard; Factory Mutual Research; Japan Ship Machinery Quality Control; Lloyd's Register of Shipping; Campbell Shillinglaw/University of Hong Kong; Singapore Institute of Standards and Industrial Research; and The Technical Center for Fire Prevention, The Netherlands. In every case, FOAMGLAS® insulation has been classified "noncombustible."

### ASTM E 84

Flame Spread 0 Smoke Developed 0

*ASTM E 84—Surface Burning Characteristics of Building Materials*

This test observes the comparative surface burning characteristics of building materials—versus red oak and inorganic reinforced cement board. "Flame spread index" is a comparative, numerical measure relating to the progress of a flame zone. "Surface flame spread" is the advancement of flame away from an ignition source across a specimen's surface. And, "smoke developed index" is a comparative classification based on smoke obscuration.

Test results for FOAMGLAS® insulation show a smoke density of 0 and a flame spread of 0.

Material Rating  
FOAMGLAS® Insulation Layer Noncombustible 0

*UL1709 (Modified)—Fire Resistance Test for Petrochemical Facility Structural Elements*

Unlike most fire ratings developed for interior building fires, this test, specially designed for the unique conditions of a petrochemical plant conflagration, measures the hourly protection afforded steel during a rapid-temperature-rise fire that reaches 2000°F (1093°C) within five minutes. A material's performance is based on its ability to limit the temperatures measured on a steel member to an average value of 1000°F (538°C). This test is necessary because the burning rate and fuel energy potential at a petrochemical facility—as well as its normal corrosive atmosphere—are totally unlike those with fires involving typical building materials of construction.

Thermocouples monitor the furnace chamber temperature, while temperatures of the steel sample are measured by additional thermocouples within the sample. During the test, the average temperature of the sample must not exceed 1000°F (538°C) and no thermocouple can exceed 1200°F (649°C) within the control period. The furnace used allows the specimen uniform time/temperature exposure.

FIGURE 2: ASTM E 119 Performance Test

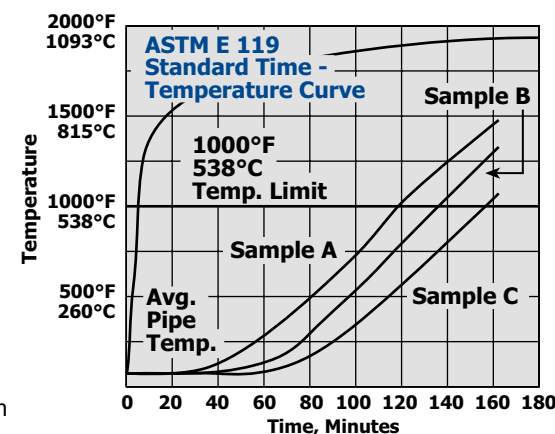


TABLE 2: Intertek Fire Test Chart

Sample I.D.	Date Tested	Steel Shape	Steel Length	Thickness of FOAMGLAS®	Corrected Fire Resistance
1	November 11, 2006	W10x49	8'	6"	3 hrs, 48 min
2	November 11, 2006	6"x6"x3/16" Structural Tube	2'	4"	1 hr, 27 min
3	June 13, 2007	W10x49	8'	4"	2 hrs, 23 min
4	June 13, 2007	10"Ø Schedule 40 Pipe	8'	5"	1 hr, 2 min
5	June 13, 2007	6"x6"x3/16" Structural Tube	2'	4" SALT SPRAY	1 hr, 31 min
6	June 13, 2007	6"x6"x3/16" Structural Tube	2'	4" COMBO WET/FREEZE/DRY	1 hr, 54 min

Notes:  
Sample #2—Control sample for subsequent environmental exposure tests.  
Sample #5, #6—Environmental exposure samples must perform within 75% of the small-scale control (Sample #2). Conclusion: Both passed.  
A separate data appendix includes results from three samples not used in this report, including a 6"x6"x3/16" structural tube with 6" FOAMGLAS®, a W10x49 with 4" FOAMGLAS®, and 10" Schedule 40 Pipe with 5" of FOAMGLAS®.  
The conclusions of this test report may be used as part of the requirements for Intertek product certification. Authority to Mark must be issued for a product to become certified.

### Specifications for Specimens

- 3.5" (90 mm) NPS pipe, 4" (102 mm) OD
- Double layers of FOAMGLAS® insulation, each with stainless steel bands, having tightly butted joints, Hydrocal® B-11 bore-coated inner layers, and outer layer joints staggered and sealed with PITTSEAL® 444N sealant
- Galvanized 0.012" (0.305 mm) steel jacketing secured with stainless steel bands on 12" (30.5 cm) centers

### Performance

Sample	Inner Layer	Outer Layer	Protection Time
A	2" (50 mm) Thick	2" (50 mm) Thick	120 min
B	3" (75 mm) Thick	2" (50 mm) Thick	138 min
C	3" (75 mm) Thick	3" (75 mm) Thick	158 min



Three FOAMGLAS® insulation systems have been submitted to this testing as jacketed double-layer systems on a pipe, a small column and a large column. The results are shown in Figure 3.

**COMBUSTIBLE FLUID ABSORPTION**

Factory Mutual (FM) Engineering and Research has a document known as "Loss Prevention Data Sheet: 7-99/12-19, Heat Transfer by Organic and Synthetic Fluids," rev. 4/92. The scope of the document provides recommendations for the location, design, operation, maintenance, inspection and fire protection of systems circulating heat transfer fluids (HTF). In the section addressing insulation of these systems the following is listed:

2.3.7.1 The insulation used to cover HTF piping and equipment should be of the type that is nonabsorbent.

Any type of insulation may be used where the pipe is all welded (i.e., without flanged fittings) and where there are no other sites prone to leakage such as valves or pumps. Commonly used insulating materials are grouped as follows:

**NONABSORBENT:** closed cell cellular glass, foamed glass, reflective aluminum foil or sheets.

**ABSORBENT:** calcium silicate, 85% magnesia, glass fiber batts, ceramic wool, mineral wool, silicate-bonded asbestos fibers.

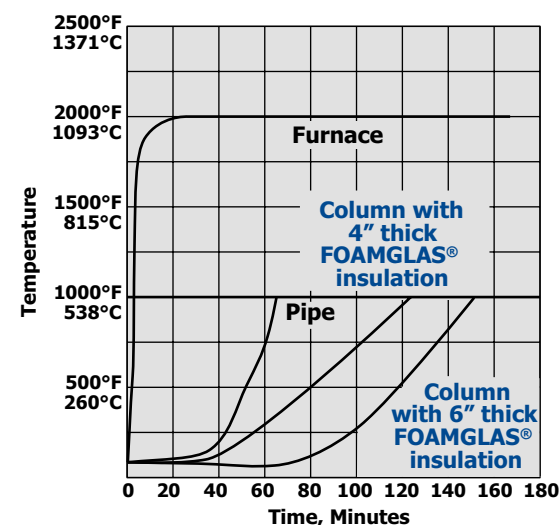
**WICKING OF ORGANICS**

There are several inorganic insulations that technically are noncombustible—fiberglass, calcium silicate, mineral wool and perlite. However, each of these can absorb, or "wick," combustible liquids, such as oils, heat transfer fluids, resins, solvents, silicones,

fatty acids, explosives, oxidizers and chemical intermediates. Consequently, the effect of these insulation materials is not only to fail to protect from fire the system they are insulating, but also to contribute to fire spread. And, while such insulations can ignite due to an external fire source, there are also certain conditions under which

the combustible fluids within them will auto-ignite. With applications prone to leaking organic fluids—valve packing glands, thermocouple connections, and equipment flanges, as well as flat surfaces that collect leakage, the elevated-temperature petrochemical environment is particularly ripe for this clandestine development.

**FIGURE 3: UL1709 (Modified) Performance Test**



**Specifications for Specimens**

- Pipe section test—10" (25.4 cm ø, sch 40 steel pipe column tests—W10 x 49 steel column
- Double layers of FOAMGLAS® insulation, each with stainless steel bands:
  - Pipe test—Bore coating of Hydrocal® B-11 applied to both layers
  - Column tests—Layers adhered with PC® 88 adhesive; column voids filled with insulation
- Stainless steel 0.016"-thick (0.406 mm) jacketing secured with 0.5" (12.7 mm) stainless steel bands

**Performance**

Sample	Inner Layer	Outer Layer	Protection Time
Pipe	3" (75 mm) Thick	2" (50 mm) Thick	64 min
Column	2" (50 mm) Thick	2" (50 mm) Thick	122 min
Column	3" (75 mm) Thick	3" (75 mm) Thick	153 min



FOAMGLAS® insulation (above) remains non-wicking and non-burning while mineral wool, calcium silicate and two brands of perlite sustain flames from wicking or oil.

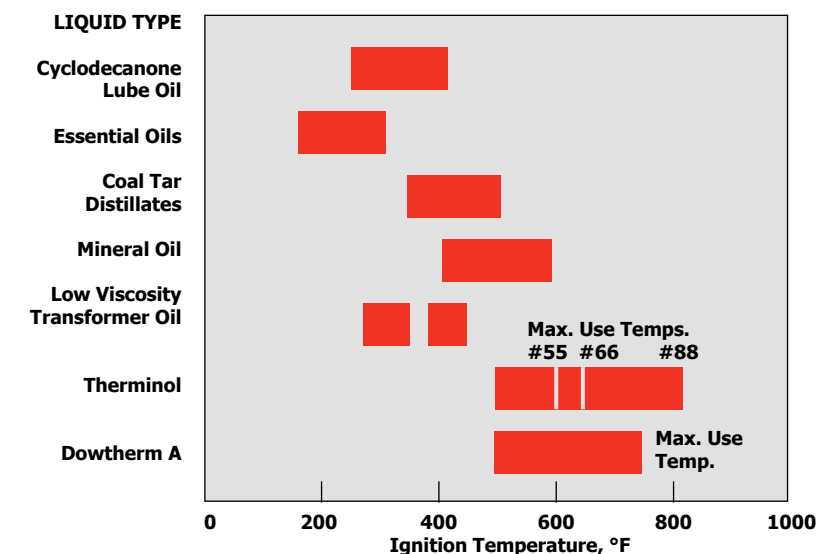
**AUTO-IGNITION**

Auto-ignition appears to result from slow oxidation between the leaked organic and air, a temperature buildup within the saturated insulation, and, ultimately, spontaneous combustion.

With heat transfer fluids, oxidation occurs on systems above 500°F (260°C). Then, with porous insulations, the combination of a large reaction surface, vapor volume space, poor heat dissipation and possible catalysis by the insulation itself all contribute to temperature buildup. Finally, when the insulation is exposed to a large volume of air during repairs, etc., ignition of the organic, already above its auto-ignition temperature (see Figure 4), can occur. Research has shown that this ignition temperature can be reduced almost 50% when fluids are absorbed by insulation.

Noncombustible, nonabsorptive FOAMGLAS® insulation is ideal for these applications. In fact, the leading manufacturers of heat transfer fluids are unanimous in recommending closed-cell insulation where organic leakage and contamination are likely. Impermeability to liquids and air eliminates the risk of self-heating due to leakage. And, even in low-temperature service the potential dangers of condensed hydrocarbon gases or liquid oxygen are minimized.

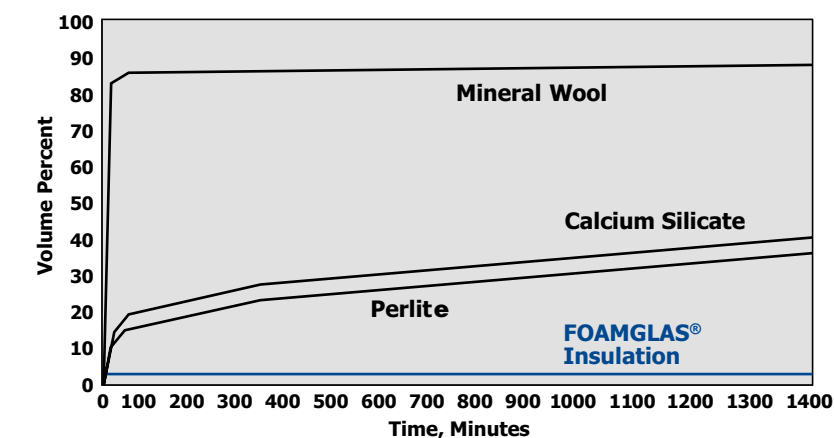
**FIGURE 4: Ignition Temperatures for Combustible Liquids**



This same spontaneous ignition phenomenon is exhibited by oils, which have auto-ignition temperatures much lower than heat transfer fluids. In fact, studies have shown spontaneous combustion with oil-soaked lagging at routine operating temperatures as low as 176°F (80°C).

Spontaneous ignition has been observed when liquid loadings occupied 6% to 12% by volume of the void spaces in insulation. However, tests have shown 10w30 oil absorption rates significantly higher than this for calcium silicate, perlite and mineral wool after only a few hours (see Figure 5). In fact, mineral wool absorbed almost 90%, by volume, within minutes. FOAMGLAS® insulation, however, does not absorb any oil, regardless of time elapsed.

**FIGURE 5: 10w30 Oil Absorption Rates for Various Materials**



## CHEMICALLY DURABLE ... CHEMICALLY RESISTANT

All-glass FOAMGLAS® insulation is unaffected by most chemicals and by most corrosive plant atmospheres which can quickly destroy other materials.

### CHEMICAL DURABILITY PROBLEMS

An insulation's chemical durability is often the most important criterion in insulation system selection. Chemical absorption can not only mechanically destroy an insulation and its thermal performance, but also increase fire risk and lead to structural corrosion of pipelines and equipment. This potential for chemical attack comes both externally—from the atmosphere and spillage, and internally—from the system being insulated, itself, by way of leaks at joints, valves or flanges.

### Organic Foam Insulations

Foamed plastics are significantly deteriorated by immersion in chemical reagents—even water—for just 30 days (see Table 2). Polyisocyanurate manufacturers' own literature states that the material should not be exposed to any chemicals or solvents which might soften or degrade the foam.

The literature from one manufacturer of phenolic foam states that their product is severely attacked by concentrated nitric acid and has only fair to poor resistance to phosphoric acids, concentrated hydrochloric acid, 10% sodium hydroxide, acetone, methylated spirits and methyl acetate.



All-glass FOAMGLAS® insulation is commonly used on chemical storage tanks because its high corrosion resistance extends equipment service life.

### Glass and Mineral Fibers

While these materials are essentially silicate glass, as is FOAMGLAS® insulation, their form is a *fiber*, not a closed cell. And, when submerged in water, glass wool loses its strength and elasticity while mineral fiber becomes brittle. Both actions subject the materials to a higher rate of chemical attack. Also, when the organic binders that often coat these fibers are destroyed by heat or chemicals, these insulations can absorb potentially hazardous chemicals, as well as water.

### Calcium Silicate/Perlite

With these highly absorptive materials, liquid and vapor absorption not only cause a significant loss in thermal efficiency—serious safety and fire hazards also can exist when acid or caustic spillage occurs.

Perlite often contains organic-based water repellents which are rapidly destroyed by temperatures over 392°F (200°C) and by petrochemicals; and its inorganic binders are frequently water-leachable. The result is an absorptive insulation.

### ONE-HUNDRED-PERCENT GLASS

FOAMGLAS® insulation is both all-glass and closed-cell—a critical combination for providing its unmatched chemical durability. Unlike the other insulating materials discussed, it has no fibers, binders or other components subject to chemical attack or degradation. The chemical resistance of glass has been universally recognized and applied for food and chemical products, laboratory containers and for industrial applications requiring exceptional durability.

**TABLE 3: Materials Which Showed Significant Changes in Volume and Weight When Immersed in Solvents**

Solvent	Polyisocyanurate	Polyolefin	Polystyrene	Phenolic	FOAMGLAS® Insulation
Concentrated Nitric Acid	X			Dissolved	
Concentrated Hydrochloric Acid	X			X	
Concentrated Sulfuric Acid	Dissolved			X	
Concentrated Phosphoric Acid					
40% Nitric Acid	X			Dissolved	
10% Hydrochloric Acid	X				
30% Sulfuric Acid	X				
5% Carbolic Acid	X			X	
5% Acetic Acid	X	X		X	
10% Citric Acid	X	X			
Orange Terpenes		X	Dissolved		
Citrus Peel Oil		X	Dissolved		
Orange Juice	X	X		X	
Concentrated Ammonium Hydroxide	X	X		X	
Concentrated Potassium Hydroxide				X	X
10% Ammonium Hydroxide	X			X	
10% Sodium Hydroxide	X			X	X
2% Sodium Carbonate	X			X	
Heptane		X	X		
Methanol	X		X	X	
Formaldehyde	X			X	
Dichloromethane	X	X	Dissolved	X	
Benzene	X	X	Dissolved		
Methyl Ethyl Ketone	X	X	Dissolved	X	
1-Butanol	X			X	
Toluene	X	X	Dissolved		
Acetone	X	X	Dissolved	X	
Ethyl Acetate	X	X	Dissolved	X	
Mineral Spirits		X	Dissolved		
Ethylene Glycol		X		X	
Kerosene		X	Dissolved		

## DIMENSIONAL STABILITY ENHANCES THERMAL PERFORMANCE

Proper insulation performance, and thus system integrity, is directly related to the dimensional stability of the insulating material. Poor dimensional stability can cause swelling, expansion, shrinkage and buckling of a system's insulation. These actions can eventually lead to thermal bridges between insulation and equipment, coating/waterproofing breaches, and, most critically, unpredictable insulation performance.

However, with FOAMGLAS® insulation, all of these potential problems are avoided because of its excellent stability under a variety of temperature and humidity conditions.

### FACTORS AFFECTING STABILITY Reversible Changes at Low Temperatures

The rate of reversible, dimensional change—the thermal contraction coefficient—exhibited when an insulation material is cooled is

most often related to its chemical composition. Organics, such as plastic foams, display coefficients five to ten times greater than those of the metals they insulate (see Figure 6). This will result in open joints which not only create a thermal short circuit path but may totally destroy joints that had been sealed against water intrusion. FOAMGLAS® insulation exhibits a predictable, minimal, reversible coefficient of thermal contraction.

Because this expansion is so close to that of the steel and concrete most often being insulated, virtually no relative movement occurs at the insulation joints during system temperature cycling.

At low temperatures, severe shrinkage cracking can also occur within the foam. In tests on a two-layer urethane system under cryogenic conditions, the joints opened enough to permit convection

and substantial heat gain (+174% on liquid nitrogen systems), while with polystyrene insulation, open joints reduced thermal efficiency about 10%.

### Reversible Changes at Moderate Temperatures

At elevated temperatures the problem is reversed; the high thermal expansion coefficient of organic foams (see Figure 7) can lead to warping and buckling, putting severe stress on weather barriers and vapor retarders. In contrast, FOAMGLAS® insulation remains stable since it is well matched in expansion coefficient to typical steel piping and equipment.

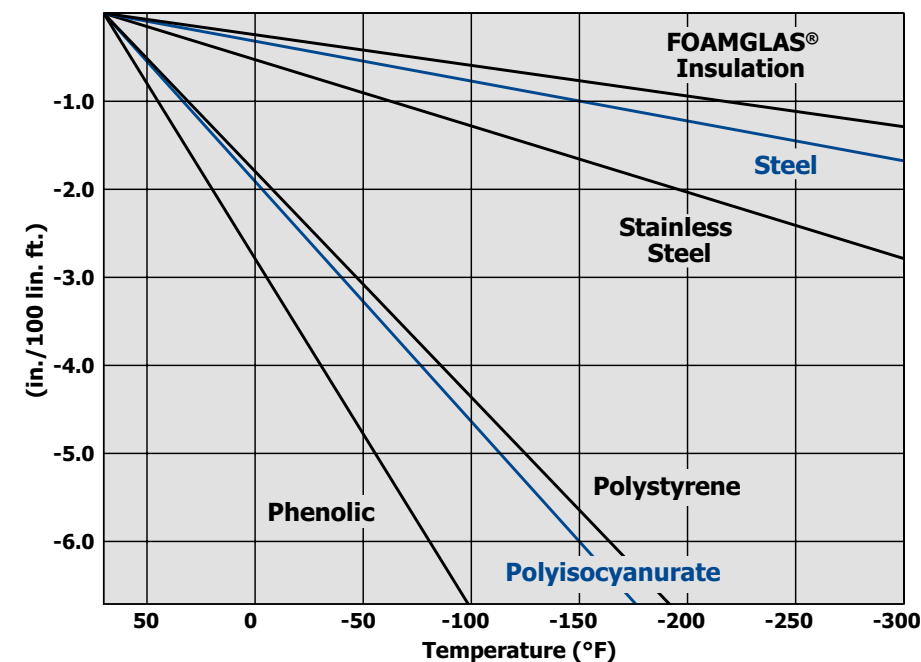
### Irreversible Changes at High Temperatures

At high temperatures, inorganic insulation must be used. And unfortunately, as temperatures rise and metal pipes and vessels expand, some insulations actually shrink (see Figure 7). This shrinkage leads to open joints and cracks which can cause thermal short circuits and serious damage to weather barriers. FOAMGLAS® insulation has a reversible coefficient of expansion similar to metals and will not shrink.

### Other Irreversible Changes

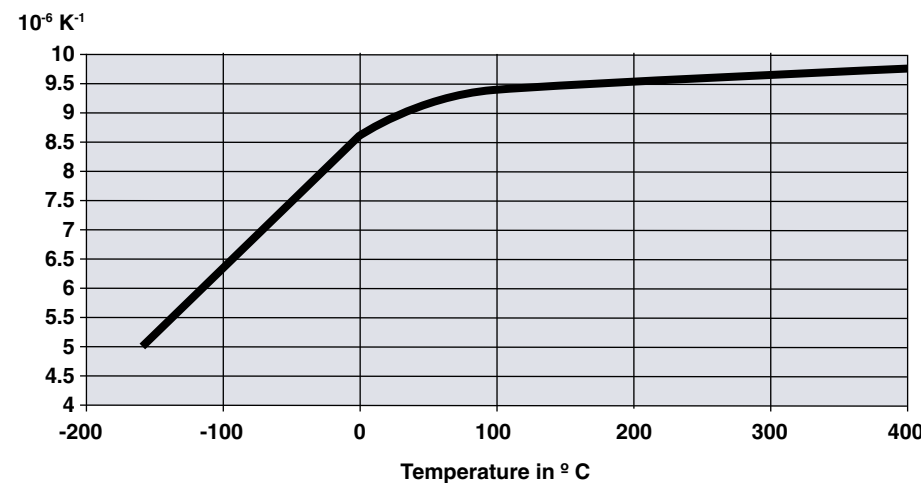
These permanent dimensional changes have many causes, including aging of the insulation material—i.e., the post-production shrinkage of plastic foams (particularly polyurethane), blistering with foamed-in-place PUR, and outgassing of foaming agents from expanded polystyrene causing shrinkage of up to 2%. On cold systems, low-density polyurethane's in-cell gases can condense, break down cell walls and lead to insulation collapse.

**FIGURE 6: Thermal Contraction of Insulations versus Steel (70°F to -300°F)**



**FIGURE 6A: Coefficient of Thermal Expansion**

The coefficient of thermal expansion of FOAMGLAS® cellular glass is given by the following graph. As can be seen, it slightly increases with the higher temperature and decreases more sharply a low temperature.





**Temperature and Humidity**

Moisture can enter some insulations during its storage, transportation or installation, then can be trapped by waterproofing or admitted by malfunctioning vapor barriers. Combined with temperature changes, a significant alteration of insulation dimensions can occur.

Polyurethane at 158°F (70°C) and 85% relative humidity shows an irreversible expansion of 3% (one manufacturer states that even *greater* changes are possible). On the other hand, under similar conditions phenolic foams *shrink* up to 2%. Polyisocyanurate is affected by humid aging. Its rapid, permanent warping puts severe stress on external vapor and weather barriers.

But with FOAMGLAS® insulation, service and testing have again proven that it remains dimensionally stable under extreme humidity. Testing at 68°F (20°C) and 95% relative humidity have shown no changes in the material.

**Temperature and Loading**

Load on an insulation at elevated temperatures is a potential source of dimensional change with possibly severe consequences. Therefore, foamed plastics manufacturers publish temperature-related load recommendations. The combination of FOAMGLAS® insulation's high-temperature resistance, rigidity and strength (discussed later), however, creates excellent dimensional stability under load at low, ambient or high temperatures.

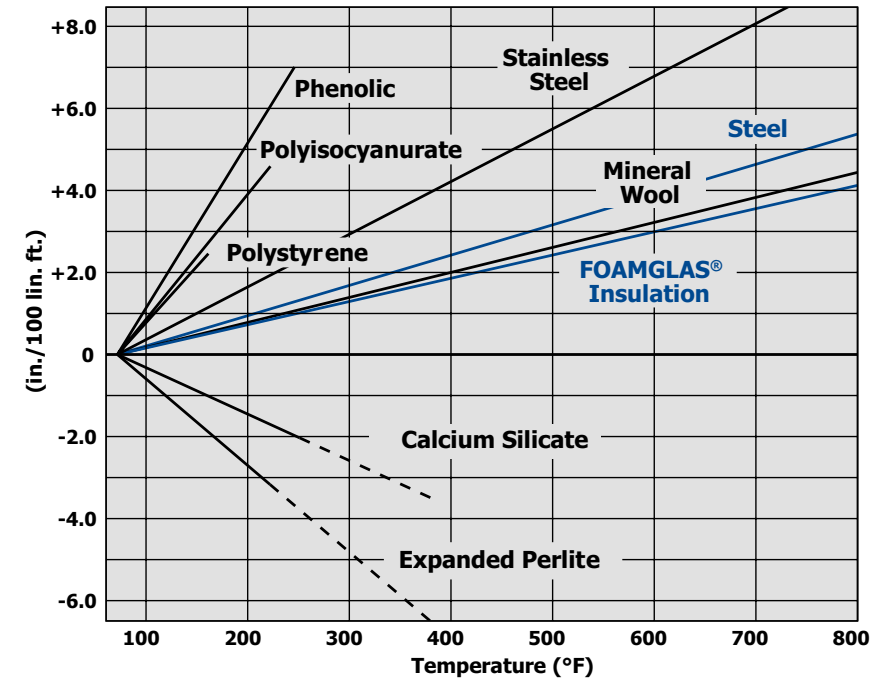
**High-Temperature Systems**

See page 20 for recommended systems.



When exposed to laboratory heat lamps, polyisocyanurate (top) and polystyrene (middle) both exhibit significant thermal distortion. FOAMGLAS® insulation (bottom) remains dimensionally stable.

**FIGURE 7: Thermal Expansion/Contraction of Insulations versus Steel (70°F to 800°F)**



# HIGH COMPRESSIVE STRENGTH WITHOUT DEFORMATION

Because commonly used insulations, such as fibrous materials, have limited compressive strength, the property is often not seriously considered when specifying thermal insulation. This is a critical mistake, for in many applications insulation *strength* is *vital* to system performance and should be a *prerequisite* when selecting materials.

FOAMGLAS® insulation provides a compressive strength of 90 psi (620 kPa) when capped according to ASTM C 240. When capped, it provides high compressive strength without deforming or consolidating (see Table 3). And FOAMGLAS® insulation combines rigidity with its outstanding compressive and flexural strengths. In addition, its relative light weight of 7.5 lb/ft³ (120 kg/m³) gives an ideal strength-to-weight ratio; lighter materials have a fraction of FOAMGLAS® insulation's strength. This combination of properties—virtually unaffected by temperatures over a wide service range—allows simplified design for load-bearing insulation systems.

### Compressive Strength versus Deformation

While compressive strength technically measures the stress at which a material fails under load, deformation monitors a material's structural distortion *with or without* actual failure. So, with compressible insulations, such as foamed plastics, fibrous glass and calcium silicate, "failure" is recorded as the point when an insulation's deformation reaches a percentage of its thickness—usually between 5% and 25%—for various densities.

With FOAMGLAS® insulation, however, the data is totally nonsubjective,

**TABLE 4: Compressive Strengths of Various Materials**

Insulation Material	Compressive Strength		Density	
	psi	kPa	lb/ft³	Kg/m³
FOAMGLAS® Insulation	90	600	7.5	120
Polyisocyanurate	30	207	2.0	32
Polystyrene	45	310	2.0	32
Phenolic	22@10% def.	152	2.5	40
Fiberglass	2.3@10% def.	16	6.0	96
Mineral Fiber	10@10% def.	69	5–15	80–240
Calcium Silicate	100@5% def.	689	11–15	176–240
Perlite	80@5% def.	620	5–13	80–208

making its specification a relatively uncomplicated, direct calculation. Deformation is insignificant and independent of insulation thickness.

### Time and Temperature Effects

Adding to compressive strength ambiguities are the effects of time and temperature. Studies have shown that for phenolics and urethanes compressive strength at 10% deformation is reduced by greater than 50% with a temperature increase from 68°F to 266°F (20°C to 130°C). In other tests of polyurethane foam, when under a moderate 3 psi (0.2 kg/cm²) load at 266°F (130°C), thickness deformation of up to 10% developed after just 75

days. That deformation puts urethane at its maximum compression tolerance, according to some test methods, in less than three months.

With FOAMGLAS® insulation, time and temperature have a negligible effect on creep and compressive strength *throughout* the insulation's wide service temperature range.

### Safety Factors

Because deformation and resulting strength reduction can seriously affect performance of some compressible insulations, higher engineering safety factors are generally required with cellular plastics and fibrous materials.

**TABLE 5: Physical Properties of FOAMGLAS® HLB Cellular Glass Insulation**

The following is a summary of the acceptance values for lot average compressive strength as defined in the Quality Assurance Specifications.

Grade of FOAMGLAS® HLB Insulation	DENSITY AND COMPRESSIVE STRENGTH							
	Nominal Lot Avg. Density		Compressive Strength (Tested According to ASTM C 165/C 240)					
	kg/m³	pcf	Average			Lower Spec. Limit		
			N/mm²	psi	kg/cm²	N/mm²	psi	kg/cm²
HLB 800	120	7.5	0.80	116	8.12	0.55	80	5.6
HLB 1000	130	8.1	1.00	145	10.15	0.69	100	7.0
HLB 1200	140	8.7	1.20	174	12.18	0.83	120	8.4
HLB 1600	160	10	1.60	232	16.24	1.10	160	11.2

Note: 0.8 N/mm² = 800 kPa



FOAMGLAS® insulation has been installed in over 75% of the world's LNG tanks.

FOAMGLAS® insulation provides constant thermal efficiency for LNG transfer and storage facilities. Because of its compressive strength, it withstands extreme loads without deterioration and can be used on long vertical pipe runs without special supports.

### Grades of FOAMGLAS® Insulation

FOAMGLAS® insulation, with a compressive strength of 90 psi (6.3 kg/cm²) and itself stronger than almost every other insulation material, is just one of seven grades available, ranging up to FOAMGLAS® HLB 1600 (High-Load Bearing) insulation with a compressive strength of 232 psi (16.3 kg/cm²) (see Table 4). The full family of FOAMGLAS® insulation is available worldwide. Where high loading is anticipated, consideration should be given to adequate surface preparation to avoid undue overstresses.

### Problems and Applications Tanks

For low- and cryogenic-temperature tank bottom applications, the use of insulation lacking proper compressive strength can allow settlement. In turn, this can result in lost thermal efficiency, ground heaving and elevation of foundation temperatures that may cause major failures, including bottom rupture.

Because of its compressive strength, FOAMGLAS® insulation has been the dominant choice for base applications on LPG, LNG, LOX, ammonia, ethylene and liquid nitrogen tanks. In fact, it has been installed on over 80% of the world's above-ground cryogenic storage tanks.

With high-temperature tank bases, an insulation's poor compressive strength can also lead to settlement. The resulting thermal performance loss can destabilize the processing environment causing reduced viscosity control and possible solidification of the contents. Again, FOAMGLAS® insulation is ideal for these hot base applications.

### Underground Systems and Pipe Support and Hanger Applications

See page 31.

# VERMIN RESISTANT

An insulation's resistance to vermin—rats, mice, insects and fungi—is often given little consideration during material specification. But this "out of sight, out of mind" potential problem can lead to serious trouble for underground piping and storage vessels, agricultural/ food processing buildings and exterior industrial applications. Gnawing, boring, nesting and microbial infestation can seriously affect thermal performance and mechanical strength to the point of complete destruction of the insulating system. Organic and open-structured insulations, by their physical form encourage nesting and tunneling. However, over 50 years of testing and field applications have proven FOAMGLAS® insulation's superior, total vermin resistance.

### Three-Fold Problem

As insulation is attacked by vermin and partially or totally destroyed, thermal efficiency suffers or is rendered totally lost. Secondly, there are the resulting, potentially enormous economic losses, including increased energy consumption, repair cost of the equipment or installations damaged by gnawing, and even infrastructure loss and the compromise of products produced or stored at the facility. And, finally, there is the possibility of transmission of infectious diseases to humans and domestic animals through contamination of food products, or via airborne microorganisms, with chilled or hot water and HVAC systems.

### The "Vermin Barrier"

With FOAMGLAS® insulation in place, not only are the potential vermin problems found with other materials eliminated, but the presence of cellular glass can even provide a physical barrier blocking the entrance of mice, rats, etc. To view the total resistance of FOAMGLAS® insulation to rodents another way: its vermin endurance is so great that it can be categorized with concrete, sheet metal and glass—which is, of course, what FOAMGLAS® insulation is—as a building material that discourages gnawing.



# PROPERTIES AND CERTIFICATIONS OF FOAMGLAS® INSULATION

## Partial Certifications\* and Approvals List

FOAMGLAS® insulation can be certified to conform to the requirements of:

- ASTM C 552 "Specification for Cellular Glass Thermal Insulation"
- Canadian Standard CAN/CGSB51.38M
- Military Specification MIL-I-24244C, "Insulation Materials, Thermal, with Special Corrosion and Chloride Requirement"
- Nuclear Regulatory Guide 1.36, ASTM C 795, C 692, C 871
- Flame Spread 5, Smoke Developed 0 (UL 723, ASTM E 84), UL R2844; also classified by UL of Canada
- ISO 9001:2000
- Through-Penetration Firestop Systems UL 1479 (www.ua.com)  
**UL Through-Penetration Firestop Approved Systems**  
For a listing of UL Through-Penetration Firestop Approved Systems please search the UL Database at <http://www.ul.com>. Once on this page click on CERTIFICATIONS on the left hand side. Under General Search click on UL FILE NUMBER and type in R15207 and then SEARCH.
- Board of Steamship Inspection (Canada) Certificate of Approval No. 100/F1-98
- General Services Administration, PBS (PCD): 15250, Public Building Service Guide Specification, "Thermal Insulation (Mechanical)"
- New York City Dept. of Bldgs., MEA #138-81-M FOAMGLAS® insulation for piping, equipment, walls and ceilings
- New York State Uniform Fire Prevention and Building Code Dept. of State (DOS) 07200-890201-2013
- City of Los Angeles General Approval RR22534
- U.S. Coast Guard
- Rosstroy
- SINTEF
- NORSEK
- Det Norske Veritas
- See-Berufsgenossenschaft
- Allgemeine Bauaufsichtliche Zulassung (ABZ, DIBtT)
- DCC
- Russian Maritime
- Allgemeine Bauaufsichtliche Prüfzeugnisse (ABP, MPA)

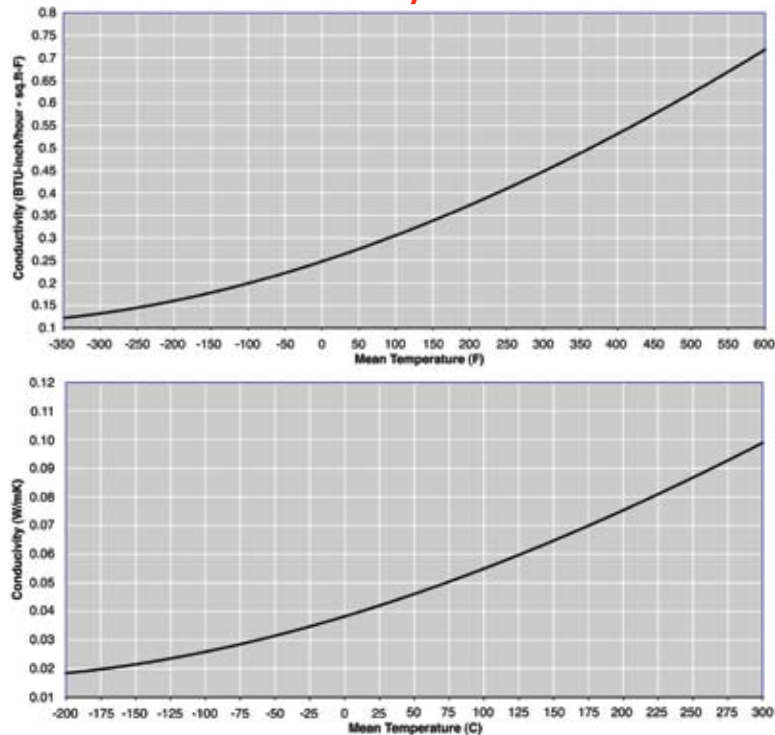
FOAMGLAS® insulation is identified by Federal Supply Code for Manufacturers (FSCM 08869)

**\*Written request for certificate of compliance must accompany order**

**TABLE 6: Physical and Thermal Properties of FOAMGLAS® ONE™ Insulation**

PHYSICAL AND THERMAL PROPERTIES OF FOAMGLAS® ONE™ INSULATION				
PHYSICAL PROPERTIES	ASTM			EN ISO
	SI	ENGLISH	Method	Method
Absorption of Moisture (Water % by Volume)	0.2%	0.2%	C 240	EN 1609 EN 12087
Only moisture retained is that adhering to surface cells after immersion				
Water-Vapor Permeability	0.00 perm-cm	0.00 perm-in	E96 Wet Cup Procedure B	EN 12086 EN ISO 10456
Acid Resistance	Impervious to common acids and their fumes except hydrofluoric acid			
Capillarity	None			
Combustibility & Reaction to Fire	Noncombustible - will not burn Flame Spread 0 Smoke Development 0			E 136 E84 EN ISO 1182 (Class A1)
Composition	Soda-lime silicate glass - inorganic with no fibers or binders			
Compressive Strength, Block	620 kPa 90 psi	C 165 C 240 C 552	EN 826 Method A	
Density	120 kg/m <sup>3</sup>	7.5 lb/ft <sup>3</sup>	C 303 EN 1602	
Dimensional Stability	Excellent—does not shrink, swell or warp			EN 1604 (DS 70/90)
Flexural Strength, Block	480 kPa 70 psi	C 203 C 240	EN 12089 (BS450)	
Hygroscopicity	No increase in weight at 90% relative humidity			
Linear Coefficient of Thermal Expansion	9.0 x 10 <sup>-7</sup> /K 25°C to 300°C	5.0 x 10 <sup>-7</sup> /°F 75°F to 575°F	E 228	EN 13471
Maximum Service Temperature	482° C 900° F			
Modulus of Elasticity, Approx.	900 MPa	1.3 x 10 <sup>5</sup> psi	C 623	EN 826 Method A1
Thermal Conductivity	0.040 @ 10°C 0.042 @ 24°C	Btu-in/hr-ft <sup>2</sup> -°F 0.28 @ 50°F 0.29 @ 75°F	C 177 C 518	EN 12667 EN 12939 (λ <sub>0,10/20</sub> ) ≤ 0.041 W/mK @ 10° C
Specific Heat	0.84 kJ/kg.K 0.18 Btu/lb.-°F			
Thermal Diffusivity	4.2 x 10 <sup>-7</sup> m <sup>2</sup> /sec 0.016 ft <sup>2</sup> /hr			

**FIGURE 8: Thermal Conductivity of FOAMGLAS® Insulation**



## Pipe Insulation

When requested by the purchaser, FOAMGLAS® pipe and tubing insulation can be fabricated worldwide in accordance with ASTM Standard C 552 and C 585. Specifying FOAMGLAS® pipe and tubing insulation in accordance with these standards will ensure proper fit to pipe or tubing and nesting in multiple layer applications. Minimum single layer thickness is 1.5" (38 mm).

In Accordance with ASTM C 585

For your convenience, the following table lists the suggested single layer thickness of FOAMGLAS® insulation, to a maximum of 4" (100 mm). The use of this table permits nesting or construction of multiple layer assemblies in order to obtain greater thicknesses.



FOAMGLAS® cellular glass insulation is manufactured in 12" x 18" (305 mm x 457 mm) blocks, 1-1/2" (38 mm) through 5" (127 mm) thick, in 1/2" (13 mm) increments and in 18" x 24" (600 mm x 450 mm) blocks 2" (51 mm) through 6" (150 mm) thick in 1/2" (13 mm) increments. For the nearest source of FOAMGLAS® insulation, contact your Pittsburgh Corning representative.

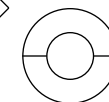


FOAMGLAS® insulation is fabricated into coverings for virtually all standard pipes, valves, fittings, and curved segments, and beveled head and lag segments. Contact your Pittsburgh Corning representative for the nearest fabricating distributor. FOAMGLAS® insulation shapes can be easily modified on-site with ordinary hand tools to insulate valves, tees, flanges, etc.

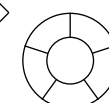
**TABLE 7: Pipe Insulation Dimensional Standards (English)**

NOMINAL PIPE SIZES (inches)		NOMINAL 1.5"		NOMINAL 2"		NOMINAL 2.5"		NOMINAL 3"		NOMINAL 3.5"		NOMINAL 4"	
Nominal O.D.	Actual O.D.	FOAMGLAS® Thickness	O.D. of Covering	FOAMGLAS® Thickness	O.D. of Covering	FOAMGLAS® Thickness	O.D. of Covering	FOAMGLAS® Thickness	O.D. of Covering	FOAMGLAS® Thickness	O.D. of Covering	FOAMGLAS® Thickness	O.D. of Covering
1/4	0.540	1.47	3.50	1.97	4.50	2.50	5.56	3.03	6.62	3.53	7.62	4.03	8.62
3/8	0.675	1.66	4.00	2.16	5.00	2.44	5.56	2.97	6.62	3.47	7.62	3.97	8.62
1/2	0.840	1.57	4.00	2.07	5.00	2.89	6.62	3.39	7.62	3.89	8.62	4.38	9.62
3/4	1.050	1.47	4.00	1.97	5.00	2.79	6.62	3.29	7.62	3.78	8.62	4.28	9.62
1	1.315	1.58	4.50	2.12	5.56	2.67	6.62	3.15	7.62	3.65	8.62	4.15	9.62
1-1/4	1.660	1.67	5.00	1.94	5.56	2.49	6.62	2.97	7.62	3.47	8.62	3.97	9.62
1-1/2	1.900	1.54	5.00	2.36	6.62	2.86	7.62	3.36	8.62	3.86	9.62	4.43	10.75
2	2.375	1.58	5.56	2.11	6.62	2.61	7.62	3.11	8.62	3.61	9.62	4.17	10.75
2-1/2	2.875	1.87	6.62	2.37	7.62	2.87	8.62	3.37	9.62	3.94	10.75	4.44	11.75
3	3.500	1.56	6.62	2.05	7.62	2.55	8.62	3.05	9.62	3.61	10.75	4.11	11.75
3-1/2	4.000	1.80	7.62	2.30	8.62	2.80	9.62	3.36	10.75	3.86	11.75	4.36	12.75
4	4.500	1.55	7.62	2.05	8.62	2.56	9.62	3.11	10.75	3.61	11.75	4.11	12.75
4-1/2	5.000	1.78	8.62	2.28	9.62	2.84	10.75	3.34	11.75	3.84	12.75	4.49	14.00
5	5.563	1.49	8.62	1.99	9.62	2.56	10.75	3.06	11.75	3.56	12.75	4.18	14.00
6	6.625	1.47	9.62	2.03	10.75	2.53	11.75	3.03	12.75	3.66	14.00	4.16	15.00
7	7.625	1.53	10.75	2.03	11.75	2.53	12.75	3.16	14.00	3.66	15.00	4.16	16.00
8	8.625	1.53	11.75	2.03	12.75	2.66	14.00	3.16	15.00	3.66	16.00	4.16	17.00
9	9.625	1.53	12.75	2.16	14.00	2.66	15.00	3.06	16.00	3.66	17.00	4.16	18.00
10	10.750	1.58	14.00	2.08	15.00	2.58	16.00	3.08	17.00	3.58	18.00	4.08	19.00
11	11.750	1.58	15.00	2.08	16.00	2.58	17.00	3.08	18.00	3.58	19.00	4.08	20.00
12	12.750	1.58	16.00	2.08	17.00	2.58	18.00	3.08	19.00	3.50	20.00	4.08	21.00
14	14.000	1.50	17.00	2.00	18.00	2.50	19.00	3.00	20.00	3.50	21.00	4.00	22.00
15	15.000	1.50	18.00	2.00	19.00	2.50	20.00	3.00	21.00	3.50	22.00	4.00	23.00
16	16.000	1.50	19.00	2.00	20.00	2.50	21.00	3.00	22.00	3.50	23.00	4.00	24.00
17	17.000	1.50	20.00	2.00	21.00	2.50	22.00	3.00	23.00	3.50	24.00	4.00	25.00
18	18.000	1.50	21.00	2.00	22.00	2.50	23.00	3.00	24.00	3.50	25.00	4.00	26.00
19	19.000	1.50	22.00	2.00	23.00	2.50	24.00	3.00	25.00	3.50	26.00	4.00	27.00
20	20.000	1.50	23.00	2.00	24.00	2.50	25.00	3.00	26.00	3.50	27.00	4.00	28.00
21	21.000	1.50	24.00	2.00	25.00	2.50	26.00	3.00	27.00	3.50	28.00	4.00	29.00
22	22.000	1.50	25.00	2.00	26.00	2.50	27.00	3.00	28.00	3.50	29.00	4.00	30.00
23	23.000	1.50	26.00	2.00	27.00	2.50	28.00	3.00	29.00	3.50	30.00	4.00	31.00
24	24.000	1.50	27.00	2.00	28.00	2.50	29.00	3.00	30.00	3.50	31.00	4.00	32.00

Sizes in this area are furnished in sectional form.



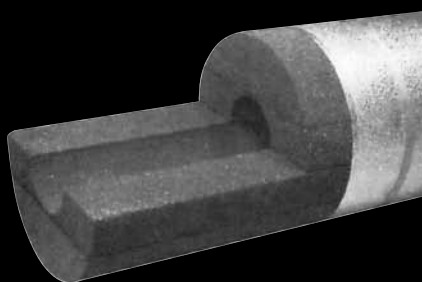
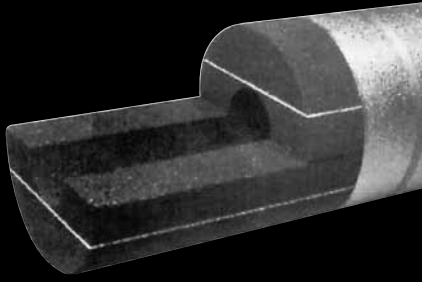
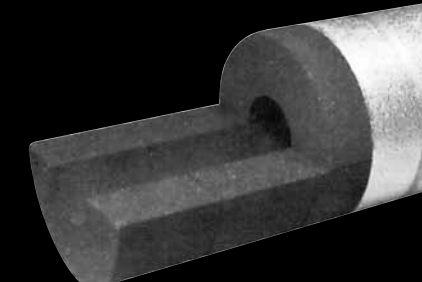
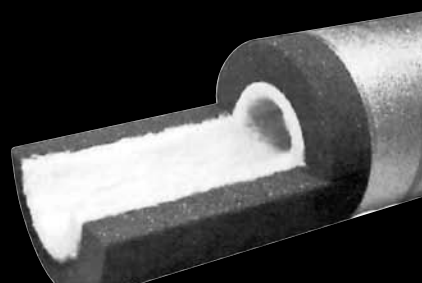
Sizes in this area are furnished in segmental form. (Number of segments vary with pipe O.D.)



**TABLE 8: Pipe Insulation Dimensional Standards (Metric)**

NOMINAL PIPE SIZES		NOMINAL 1.5"		NOMINAL 2"		NOMINAL 2.5"		NOMINAL 3"		NOMINAL 3.5"		NOMINAL 4"	
Nominal	O.D. inch	O.D. mm	DN	O.D. of Covering inch	O.D. of Covering mm	O.D. of Covering inch	O.D. of Covering mm	O.D. of Covering inch	O.D. of Covering mm	O.D. of Covering inch	O.D. of Covering mm	O.D. of Covering inch	O.D. of Covering mm
1/4	0.540	14	8	3.50	89	4.50	114	5.56	141	6.62	168	7.62	194
3/8	0.675	17	10	4.00	102	5.00	127	5.56	141	6.62	168	7.62	194
1/2	0.840	21	15	4.00	102	5.00	127	6.62	168	7.62	194	8.62	219
3/4	1.050	27	20	4.00	102	5.00	127	6.62	168	7.62	194	8.62	219
1	1.315	33	25	4.50	114	5.56	141	6.62	168	7.62	194	8.62	219
1-1/4	1.660	42	32	5.00	127	5.56	141	6.62	168	7.62	194	8.62	219
1-1/2	1.900	48	40	5.00	127	6.62	168	7.62	194	8.62	219	9.62	244
2	2.375	60	50	5.56	141	6.62	168	7.62	194	8.62	219	9.62	244
2-1/2	2.875	73	65	6.62	168	7.62	194	8.62	219	9.62	244	10.75	273
3	3.500	89	80	6.62	168	7.62	194	8.62	219	9.62	244	10.75	273
3-1/2	4.000	102	90	7.62	194	8.62	219	9.62	244	10.75	273	11.75	298
4	4.500	114	100	7.62	194	8.62	219	9.62	244	10.75	273	11.75	298
4-1/2	5.000	127	115	8.62	219	9.62	244	10.75	273	11.75	298	12.75	324
5	5.563	141	125	8.62	219	9.62	244	10.75	273	11.75	298	12.75	324
6	6.625	168	150	9.62	244	10.75	273	11.75	298	12.75	324	14.00	356
7	7.625	194	200	10.75	273	11.75	298	12.75	324	14.00	356	15.00	406
8	8.625	219	200	11.75	298	12.75	324	14.00	356	15.00	381	16.00	432
9	9.625	244	250	12.75	324	14.00	356	15.00	381	16.00	406	17.00	457
10	10.750	273	250	14.00	356	15.00	381	16.00	406	17.00	432	18.00	483
11	11.750	298	300	15.00	381	16.00	406	17.00	432	18.00	457	19.00	508
12	12.750	324	300	16.00	406	17.00	432	18.00	457	19.00	483	20.00	533
14	14.000	356	350	17.00	432	18.00	457	19.00	483	20.00	508	21.00	559
15	15.000	381	400	18.00	457	19.00	483	20.00	508	21.00	533	22.00	584
16	16.000	406	400	19.00	483	20.00	508	21.00	533	22.00	559	23.00	610
17	17.000	432	450	20.00	508	21.00	533	22.00	559	23.00	584	24.00	635
18	18.000	457	450	21.00	533	22.00	559	23.00	584	24.00	610	25.00	660
19	19.000	483	500	22.00	559	23.00	584	24.00	610	25.00	635	26.00	686
20	20.000	508	500	23.00	584	24.00	610	25.00	635	26.00	660	27.00	711
21	21.000	533	550	24.00	610	25.00	635	26.00	660	27.00	686	28.00	737
22	22.000	559	550	25.00	635	26.00	660	27.00	686	28.00	711	29.00	762
23	23.000	584	600	26.00	660	27.00	686	28.00	711	29.00			

## FABRICATED FOAMGLAS® INSULATION SYSTEMS

System	Benefits	Recommended Temperature Range	Limits
<b>Bitumen Bonded</b> Single or multiple layers of FOAMGLAS® insulation fabricated with hot asphalt (ASTM D 312, Type III) in all joints. 	<ul style="list-style-type: none"> <li>Standard, readily available fabrication technique for cold to moderately warm applications.</li> </ul>	-290°F (-179°C) to 250°F (121°C)	<ul style="list-style-type: none"> <li>Do not use at or below temperatures where liquid oxygen (LOX) will form (-297°F/-183°C).</li> </ul>
		251°F (122°C) to 400°F (204°C)	<ul style="list-style-type: none"> <li>When above ground, recommended only in well ventilated areas.</li> </ul>
<b>Hydrocal® B-11* Bonded</b> Single or multiple layers of FOAMGLAS® insulation fabricated with a special inorganic adhesive.  <small>*A product of U.S. Gypsum Co.</small> 	<ul style="list-style-type: none"> <li>Fabrication technique allows usage over broadest temperature range.</li> </ul>	-450°F (-268°C) to Ambient	<ul style="list-style-type: none"> <li>Joint zone is permeable to water vapor below ambient. Use a double layer system, seal joints of outer layer with PITTSEAL® 444N, cover with a vapor retarder finish.</li> </ul>
		Ambient to 900°F (482°C)	<ul style="list-style-type: none"> <li>Use a double layer system at temperatures above 400°F (204°C).</li> </ul>
<b>StrataFab® System</b> A patented method of fabricating FOAMGLAS® insulation by bonding blocks together with a high-temperature-resistant, flexible adhesive to create a uniform, multi-layered stack from which are cut the desired insulation shapes. 	<ul style="list-style-type: none"> <li>Minimal breakage during shipment and installation.</li> <li>Can be installed directly on hot surfaces.</li> <li>Provides excellent control of stress relief cracking.</li> <li>Wide range of thickness eliminates need for double layering.</li> </ul>	-100°F (-73°C) to Ambient	<ul style="list-style-type: none"> <li>Joint zone is permeable to water vapor below ambient. Use a double layer system, seal joints of outer layer with PITTSEAL® 444N, cover with a vapor retarder finish.</li> </ul>
		Ambient to 900°F (482°C)	<ul style="list-style-type: none"> <li>When used in a tunnel, vault, or other confined air space, ventilation is recommended. Bonding adhesive may smoke in contact with hot surfaces above 125°F (52°C). See MSDS for safe handling and use.</li> </ul>
<b>Composite System</b> Insulation consisting of inner layer(s) of high-density fibrous glass blanket or mineral wool and outer layer(s) of FOAMGLAS® insulation. 	<ul style="list-style-type: none"> <li>Fabrication technique allows usage on systems:                             <ul style="list-style-type: none"> <li>undergoing continuous thermal cycling.</li> <li>undergoing excessive vibration.</li> <li>operating above 900°F (482°C).</li> </ul> </li> </ul>	401°F (205°C) to 1200°F (649°C)	<ul style="list-style-type: none"> <li>Not for service on systems containing combustible liquids.</li> </ul>



FOAMGLAS® insulation was installed as part of a composite insulation system. It incorporates a one-inch layer of fibrous glass felt material directly around the pipe, covered with FOAMGLAS® insulation.



StrataFab® sections were installed in succession and butted against one another with PITTWRAP® butt stripes at the interfaces, and heat sealed.





### INSULATION THICKNESSES FOR PROCESS PIPING TO LIMIT HEAT GAIN TO 9 BTU/HR•FT<sup>2</sup> (28.4 W/SQM)

**TABLE 11: English (°F)**

**OUTDOOR DESIGN CONDITIONS:** 80°F Ambient • 80.0% Relative Humidity • 73.3°F Dew Point • 7.5 mph Wind Velocity • 0.40 Emittance

FOAMGLAS® INSULATION THICKNESS, INCHES																						
NPS	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	11.0	12.0	
0.50	-5	-70	-140	-290	-415																	
0.75	10	-45	-110	-235	-335																	
1.00	0	-50	-110	-185	-265	-370																
1.50	10	-30	-110	-175	-245	-335																
2.00	15	-25	-70	-125	-185	-255	-350															
2.50	15	-40	-85	-135	-195	-270	-355															
3.00	20	-10	-50	-90	-140	-200	-265	-345														
4.00	25	-5	-40	-75	-125	-175	-230	-310	-390													
5.00	30	0	-30	-65	-105	-150	-210	-270	-340	-420												
6.00	30	5	-25	-55	-95	-145	-190	-240	-300	-370												
8.00		10	-20	-55	-85	-125	-165	-210	-260	-315	-380											
10.00		10	-15	-45	-70	-105	-140	-180	-225	-275	-330	-390										
12.00		10	-10	-35	-65	-95	-130	-165	-205	-250	-300	-360	-430									
14.00		15	-5	-30	-55	-85	-115	-150	-185	-230	-275	-335	-395									
16.00		20	0	-25	-50	-75	-105	-140	-175	-220	-265	-315	-375	-445								
18.00		20	0	-20	-45	-75	-105	-135	-170	-210	-255	-300	-360	-420								
20.00		20	0	-20	-45	-70	-100	-130	-165	-205	-245	-290	-345	-405								
24.00		20	0	-20	-40	-65	-95	-125	-155	-190	-230	-275	-325	-380	-440							
28.00		25	5	-15	-40	-65	-90	-120	-150	-185	-220	-265	-310	-360	-415							
30.00		25	5	-15	-40	-65	-90	-120	-150	-180	-220	-260	-300	-350	-405							
36.00		25	5	-15	-40	-60	-85	-115	-145	-175	-210	-245	-290	-335	-385	-445						
42.00		25	5	-15	-35	-60	-85	-110	-140	-170	-200	-240	-280	-320	-370	-425						
48.00		25	5	-15	-35	-60	-80	-110	-135	-165	-195	-230	-270	-310	-360	-410						
60.00		25	5	-15	-35	-55	-80	-105	-130	-160	-190	-225	-260	-300	-340	-390	-440					
72.00		25	5	-15	-35	-55	-80	-100	-130	-155	-185	-215	-250	-290	-330	-375	-425					
96.00		25	5	-10	-30	-55	-75	-100	-125	-150	-180	-210	-245	-280	-315	-360	-405	-440				
120.00		25	5	-10	-30	-50	-75	-100	-125	-150	-175	-205	-235	-270	-310	-350	-390	-425				
168.00		25	5	-10	-30	-50	-75	-95	-120	-145	-170	-200	-230	-265	-300	-335	-380	-425				
FLAT		25	10	-10	-30	-50	-70	-90	-115	-135	-160	-185	-215	-245	-275	-310	-345	-380	-425			

MINIMUM HEAT GAIN=8.5 BTU/HR SQFT • MAXIMUM HEAT GAIN=12.4 BTU/HR SQFT

**TABLE 11: Metric (°C)**

**OUTDOOR DESIGN CONDITIONS:** 26.7°C Ambient • 80.0% Relative Humidity • 22.9°C Dew Point • 12.1 kmph Wind Velocity • 0.40 Emittance

FOAMGLAS® INSULATION THICKNESS, MM																							
NPS	25.4	38.1	50.8	63.5	76.2	88.9	101.6	114.3	127.0	139.7	152.4	165.1	177.8	190.5	203.2	215.9	228.6	241.3	254.0	279.4	304.8		
0.50	-32	-76	-126	-240																			
0.75	-21	-60	-102	-196																			
1.00	-28	-61	-104	-158	-222																		
1.50	-20	-47	-105	-149	-205																		
2.00	-17	-44	-77	-113	-157	-210																	
2.50	-15	-55	-86	-121	-164	-223																	
3.00	-11	-35	-60	-89	-123	-169	-219																
4.00	-10	-30	-53	-79	-113	-148	-190	-256															
5.00	-7	-26	-46	-73	-100	-131	-178	-222															
6.00	-5	-22	-44	-66	-91	-126	-160	-199	-246														
8.00		-21	-39	-64	-86	-112	-141	-174	-212	-257													
10.00		-21	-37	-56	-76	-99	-124	-152	-185	-223													
12.00		-19	-35	-52	-71	-92	-115	-141	-170	-204	-245												
14.00		-14	-29	-46	-64	-83	-105	-129	-156	-188	-226												
16.00		-13	-28	-43	-60	-79	-99	-123	-150	-180	-215												
18.00		-12	-26	-41	-58	-76	-97	-119	-145	-174	-207	-246											
20.00		-12	-25	-40	-57	-75	-94	-117	-141	-169	-201	-237											
24.00		-11	-24	-39	-55	-72	-91	-112	-135	-161	-191	-224	-263										
28.00		-11	-24	-38	-54	-70	-89	-109	-131	-156	-183	-215	-251										
30.00		-11	-24	-38	-53	-70	-88	-107	-129	-153	-180	-211	-246										
36.00		-10	-23	-37	-52	-68	-85	-104	-125	-148	-174	-202	-234										
42.00		-10	-23	-36	-51	-67	-84	-102	-122	-144	-169	-196	-226	-261									
48.00		-10	-23	-36	-50	-66	-82	-100	-120	-141	-165	-191	-220	-253									
60.00		-10	-22	-35	-49	-64	-81	-98	-117	-137	-160	-184	-212	-243									
72.00		-10	-22	-35	-49	-64	-79	-96	-115	-135	-156	-180	-206	-235									
96.00		-9	-22	-34	-48	-62	-78	-94	-112	-131	-152	-174	-199	-226	-257								
120.00		-9	-21	-34	-47	-62	-77	-93	-110	-129	-149	-171	-195	-221	-250								
168.00		-9	-21	-34	-47	-61	-76	-92	-108	-126	-146	-167	-190	-215	-243								
FLAT		-9	-21	-33	-46	-59	-73	-88	-104	-121	-138	-157	-178	-200	-224	-250							

MINIMUM HEAT GAIN=27.1 KCAL/HR SQM • MAXIMUM HEAT GAIN=40.1 KCAL/HR SQM

**TABLE 12: English (°F)**

**SEVERE DESIGN CONDITIONS:** 90.0°F Ambient • -9.0 ± 0.1 BTU/hr-ft<sup>2</sup> Heat Flow Limit • 7.5 mph Wind Velocity • 0.40 Emittance

FOAMGLAS® INSULATION THICKNESS, INCHES																							
NPS	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	11.0	12.0		
0.50	29	-18	-71	-181	-271	-384																	
0.75	40	-2	-48	-144	-220	-314	-433																
1.00	31	-5	-53	-110	-174	-253	-349																
1.50	38	6	-58	-107	-166	-235	-331	-437															
2.00	40	8	-29	-71	-119	-176	-253	-336	-438														
2.50	41	-5	-41	-83	-131	-195	-263	-344															
3.00	45	17	-13	-48	-89	-142	-197	-261	-359														
4.00	45	20	-7	-39	-81	-123	-172	-243	-312	-393													
5.00	47	24	-1	-35	-69	-107	-163	-215	-274	-344	-427												
6.00	49	27	0	-28	-60	-105	-147	-194	-248	-310	-382												
8.00		26	3	-29	-59	-93	-130	-171	-218	-272	-334	-405											
10.00		25	2	-22	-49	-80	-113	-151	-193	-240	-294	-355	-426										
12.00		26	4	-19	-45	-74	-106	-141	-180	-224	-273	-329	-392										
14.00		32	11	-11	-36	-64	-94	-127	-164	-205	-250	-302	-360	-427									
16.00		32	12	-10	-34	-61	-90	-121	-156	-195	-238	-286	-340	-402									
18.00		33	12	-8	-32	-58	-86	-116	-150	-187	-228	-273	-325	-382	-448								
20.00		33	13	-7	-31	-56	-83	-113	-145	-181	-220	-263	-312	-367	-428								
24.00		33	14	-6	-28	-52	-78	-107	-137	-171	-207	-248	-293	-343	-399								
28.00		34	15	-5	-26	-50	-75	-102	-132	-													



## RECOMMENDED INSULATION THICKNESSES FOR PERSONNEL PROTECTION SURFACE TEMPERATURE ≤ 140°F (60°C)

**TABLE 13: English (inches)**

Hot Pipe Worst Case 80.0°F Ambient for Surface Temperature ≤140.0°F: 0.40 Surface Emittance • 0.0 mph Average Wind Velocity

DEG F	NOMINAL PIPE DIAMETER, INCHES															
	0.5	1.0	1.5	2.0	3.0	4.0	6.0	8.0	10.0	12.0	14.0	18.0	24.0	30.0	36.0	FLAT
200.0	1.5*	1.5*	1.5*	1.5*	1.5*	1.5*	1.5*	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
300.0	1.5*	1.5*	1.5*	1.5*	1.5*	1.5*	1.5*	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
400.0	1.5*	1.5*	1.5*	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0
500.0	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5	2.5	2.5	3.0	3.0	3.0	3.0	3.0	3.0
600.0	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	3.5	3.5	4.0	4.0	4.0	4.0	4.5
700.0	2.5	2.5	2.5	3.0	3.5	3.5	4.0	4.0	4.5	4.5	5.0	5.0	5.0	5.0	5.0	5.5
800.0	2.5	3.0	3.0	3.5	4.0	4.5	4.5	5.0	5.5	5.5	6.0	6.0	6.0	6.5	6.5	7.5
900.0	3.0	4.0	4.0	4.5	5.0	5.0	6.0	6.0	6.5	7.0	7.0	7.5	7.5	8.0	8.0	9.5

MAXIMUM HEAT FLOW = 71.6 BTU/HR SQ FT

**TABLE 13: Metric (mm)**

Hot Pipe Worst Case 26.7°C Ambient for Surface Temperature ≤60.0°C: 0.40 Surface Emittance • 0.0 kmph Average Wind Velocity

DEG C	NOMINAL PIPE DIAMETER, INCHES															
	0.5	1.0	1.5	2.0	3.0	4.0	6.0	8.0	10.0	12.0	14.0	18.0	24.0	30.0	36.0	FLAT
93.3	38.5*	38.5*	38.5*	38.5*	38.5*	38.5*	38.5*	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5
148.9	38.5*	38.5*	38.5*	38.5*	38.5*	38.5*	38.5*	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5
204.4	38.5*	38.5*	38.5*	38.5	38.5	38.5	38.5	38.5	38.5	38.5	51.0	51.0	51.0	51.0	51.0	51.0
260.0	38.5	38.5	38.5	51.0	51.0	51.0	63.5	63.5	63.5	63.5	63.5	76.5	76.5	76.5	76.5	76.5
315.6	51.0	51.0	51.0	63.5	63.5	63.5	76.5	76.5	76.5	89.0	89.0	89.0	89.0	102.0	102.0	114.5
371.1	63.5	63.5	63.5	76.5	76.5	76.5	89.0	89.0	89.0	102.0	102.0	114.5	114.5	127.0	127.0	140.0
426.7	63.5	76.5	76.5	89.0	102.0	114.5	114.5	127.0	140.0	140.0	152.5	152.5	152.5	165.5	165.5	190.5
482.2	76.5	102.0	102.0	114.5	127.0	127.0	152.5	152.5	165.5	178.0	178.0	190.5	190.5	203.5	203.5	241.5

MAXIMUM HEAT FLOW = 194.1 KCAL/HR SQ M

**TABLE 13A: English (inches)**

Hot Pipe Worst Case 80.0°F Ambient for Surface Temperature ≤140.0°F: 0.90 Surface Emittance • 0.0 mph Average Wind Velocity

DEG F	NOMINAL PIPE DIAMETER, INCHES															
	0.5	1.0	1.5	2.0	3.0	4.0	6.0	8.0	10.0	12.0	14.0	18.0	24.0	30.0	36.0	FLAT
200.0	1.5*	1.5*	1.5*	1.5*	1.5*	1.5*	1.5*	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
300.0	1.5*	1.5*	1.5*	1.5*	1.5*	1.5*	1.5*	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
400.0	1.5*	1.5*	1.5*	1.5*	1.5*	1.5*	1.5*	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
500.0	1.5*	1.5*	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0
600.0	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5
700.0	1.5	2.0	2.0	2.0	2.5	2.5	2.5	2.5	3.0	3.0	3.0	3.0	3.5	3.5	3.5	3.5
800.0	2.0	2.5	2.0	2.5	3.0	3.0	3.5	3.5	3.5	3.5	4.0	4.0	4.0	4.0	4.5	4.5
900.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.0	4.5	5.0	5.0	5.0	5.5	5.5	5.5	6.0

MAXIMUM HEAT FLOW = 107.4 BTU/HR SQ FT

**TABLE 13A: Metric (mm)**

Hot Pipe Worst Case 26.7°C Ambient for Surface Temperature ≤60.0°C: 0.90 Surface Emittance • 0.0 kmph Average Wind Velocity

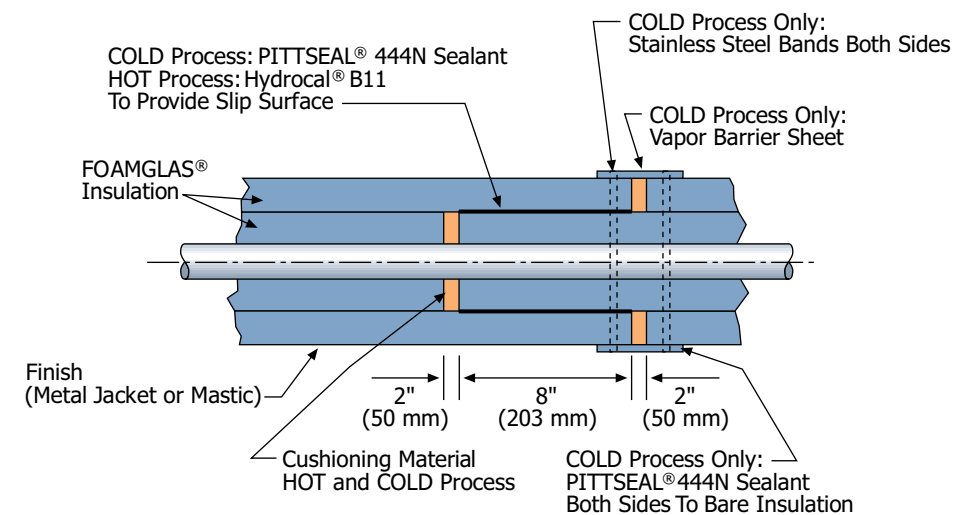
DEG C	NOMINAL PIPE DIAMETER, INCHES															
	0.5	1.0	1.5	2.0	3.0	4.0	6.0	8.0	10.0	12.0	14.0	18.0	24.0	30.0	36.0	FLAT
93.3	38.5*	38.5*	38.5*	38.5*	38.5*	38.5*	38.5*	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5
148.9	38.5*	38.5*	38.5*	38.5*	38.5*	38.5*	38.5*	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5
204.4	38.5*	38.5*	38.5*	38.5*	38.5*	38.5*	38.5*	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5
260.0	38.5*	38.5*	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	51.0	51.0	51.0	51.0	51.0	51.0
315.6	38.5	38.5	38.5	38.5	51.0	51.0	51.0	51.0	51.0	51.0	63.5	63.5	63.5	63.5	63.5	63.5
371.1	38.5	51.0	51.0	51.0	63.5	63.5	63.5	63.5	76.5	76.5	76.5	76.5	89.0	89.0	89.0	89.0
426.7	51.0	63.5	51.0	63.5	76.5	76.5	89.0	89.0	89.0	89.0	102.0	102.0	102.0	102.0	114.5	114.5
482.2	63.5	63.5	76.5	76.5	89.0	89.0	102.0	102.0	114.5	114.5	127.0	127.0	140.0	140.0	152.5	152.5

MAXIMUM HEAT FLOW = 291.3 KCAL/HR SQ M

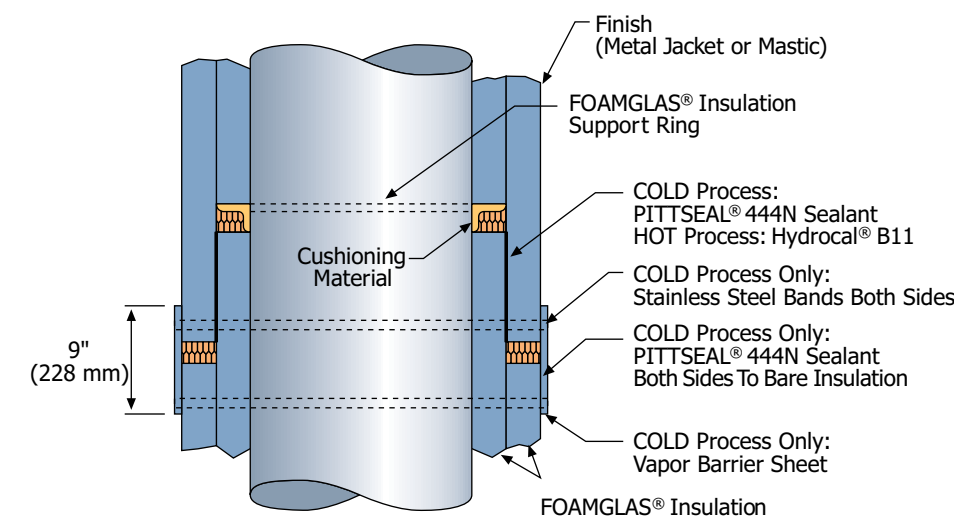
\* Thickness based on mechanical requirements and not necessarily personnel protection.

## TYPICAL ABOVE GROUND INSTALLATION DETAILS

**FIGURE 9: Two-Layer Expansion Contraction Joint**

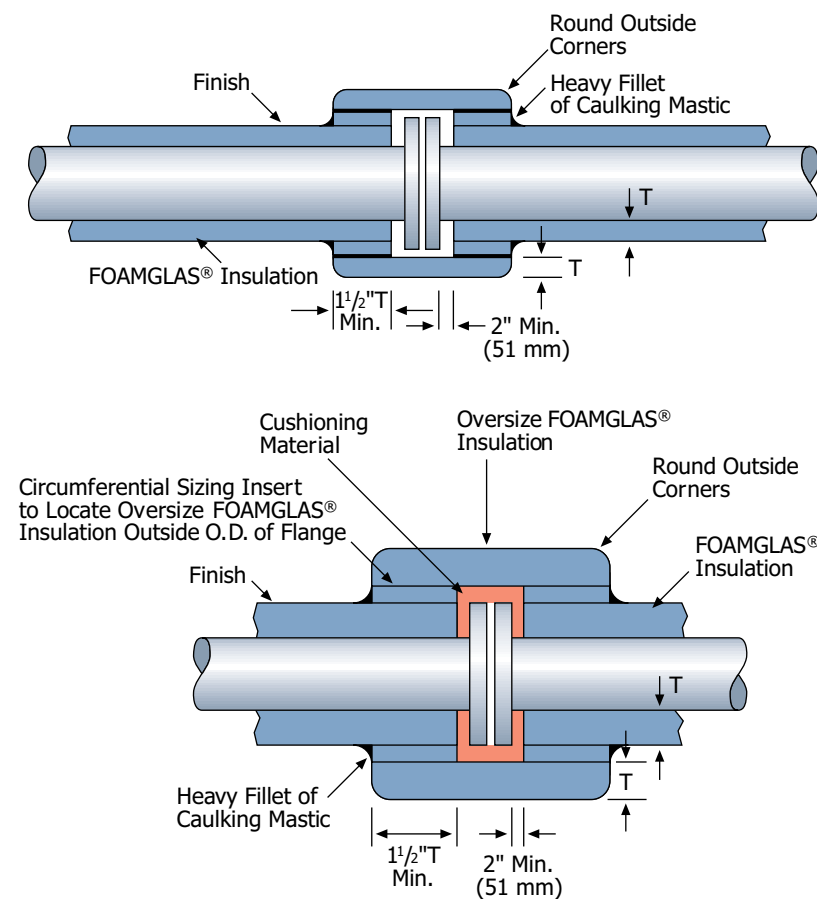


**FIGURE 10: Vertical Contraction Joint**

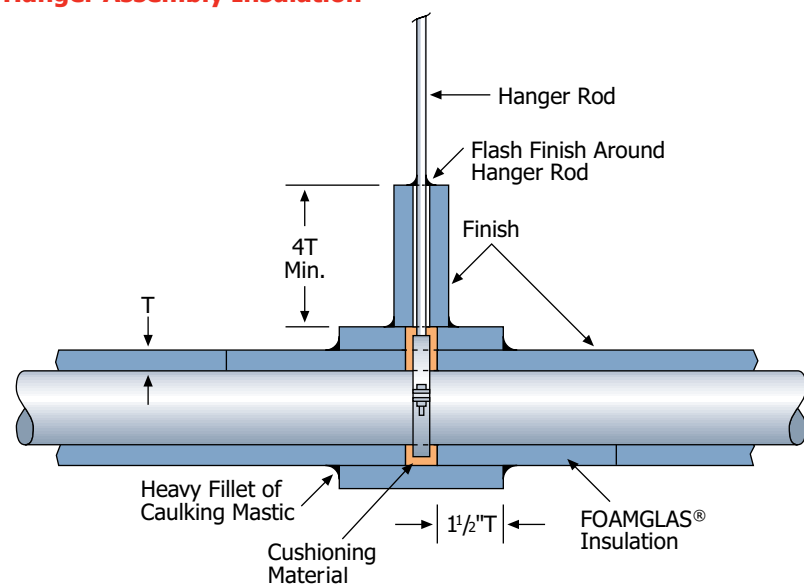


Contact your Pittsburgh Corning representative for assistance on other typical details.

**FIGURE 11: Insulation on Line Flanges**



**FIGURE 12: Pipe Hanger Assembly Insulation**



Cushioning material typically TYPE E Glass Fiber Pelt.  
Contact your Pittsburgh Corning representative for assistance on other typical details.

## UNDERGROUND SYSTEMS AND PIPE SUPPORTS/HANGERS

### Underground Systems

For direct burial of insulated pipes and vessels, FOAMGLAS® insulation is uniquely qualified for such remote, inaccessible applications. In this type of an installation without protective tunnels, high compressive strength in an insulation material is mandatory. When properly designed and installed with FOAMGLAS® insulation incorporating a protective jacketing, neither overburden loads nor above ground traffic are critical design issues. The long-term thermal efficiencies, impermeability, corrosion resistance and extended service life of FOAMGLAS® insulation make it an ideal choice for cost-effective field installed systems.

For design information, refer to Pittsburgh Corning Corporation's FOAMGLAS® *Insulation Systems for Underground Direct Burial Applications (FI-213)*.

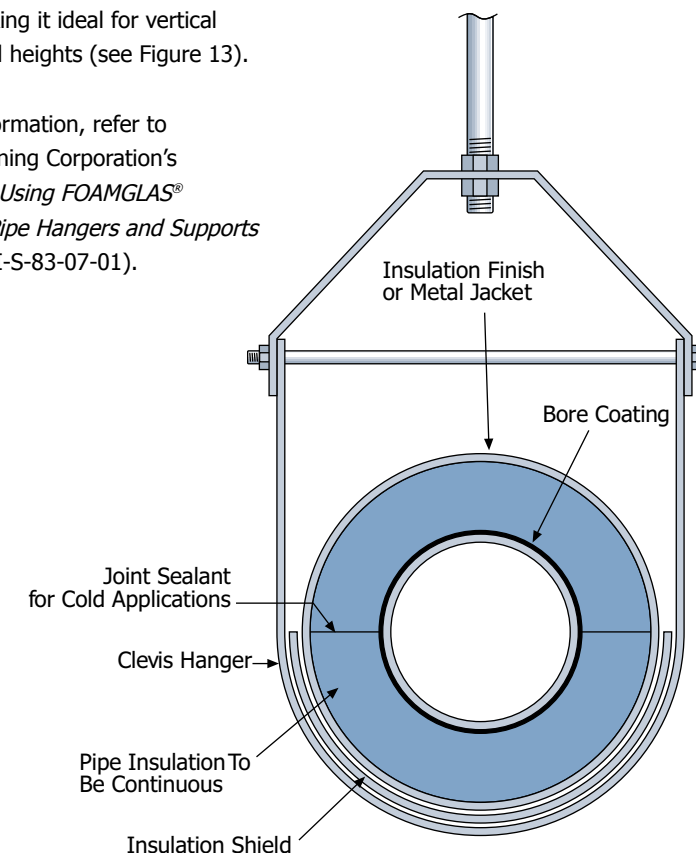
### Pipe Supports and Hangers

An insulation that has the ability to be used as a support component eliminates or significantly reduces the potential problems of direct thermal paths in the system. Resistance to settlement or failure of insulated pipe supports also means that pipes remain in their proper alignment, without stresses at nozzles, flanges or fittings.

FOAMGLAS® insulation also supports its own weight without sagging or slumping, making it ideal for vertical pipe runs of all heights (see Figure 13).

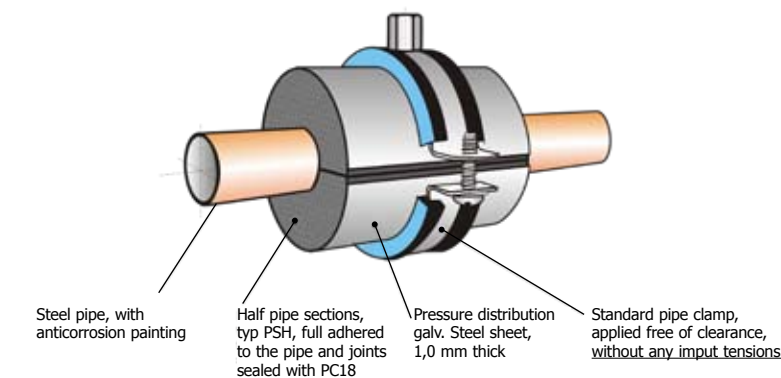
For design information, refer to Pittsburgh Corning Corporation's *Guidelines for Using FOAMGLAS® Insulation at Pipe Hangers and Supports (Specification I-S-83-07-01)*.

**FIGURE 13: Insulated Pipe Hanger (Clevis Type Only)**



**FIGURE 13B: Insulated Pipe Hanger**

**FOAMGLAS® For Chilled Water Pipes, Pipe Hanger**



Contact your Pittsburgh Corning representative for assistance on other typical details.



## GENERAL SPECIFICATIONS

This specification is offered as a guide for the purpose described herein and should be employed at the discretion of the user. **These specifications are written specifically for FOAMGLAS® cellular glass insulation. No warranty of procedures, either expressed or implied, is intended.** Before using this specification, contact Pittsburgh Corning to ensure that current details and revisions are incorporated. Pittsburgh Corning will review plans and specifications of users at no charge to assist in ensuring that proper procedures and materials are used. **However, the ultimate design and installation are the responsibility of the engineer or architect.**

### General Notes

1. These specifications are general in nature. For specific applications, contact your Pittsburgh Corning representative as listed on the back cover. The final application procedure is the responsibility of the project designer and/or owner. **No warranty of any nature, either expressed or implied, is made as to application or installation.**
2. Prior to application of insulation, surfaces to be insulated must be dry and clean. The use of primers or corrosion-resistant coatings is at the discretion of the owner or the design engineer. All testing, such as hydrostatic, X-ray, etc., should be completed prior to the application of the insulation.

3. The proper insulation thickness should be determined through calculations based on operating, environmental, and any other special conditions. Contact your Pittsburgh Corning representative if calculations are desired.

4. Multiple layers may be required:
  - When the total insulation thickness required is greater than the maximum single-layer thickness available.
  - To provide an outer layer that falls entirely within the applicable temperature range of a sealant, if one is used.
  - To eliminate through joints on piping or equipment operating at extreme temperatures.

5. The use of a bore-coating on the inner surface of the insulation in contact with the pipe may be required if the piping undergoes frequent temperature cycles or if pronounced vibration is present. Contact your Pittsburgh Corning representative for bore-coating recommendations.

6. Ambient temperature is to be defined by the design engineer based on job-site conditions.

7. **Precautions.** There are three situations which require precautions. Contact Pittsburgh Corning for proper procedures to overcome these situations.

Direct exposure to:

- Hydrofluoric acid or strong caustics
- Water during freeze-thaw cycling
- Prolonged exposure to condensing steam or boiling water.

### Temperatures below -290°F (-179°C)

Because of the highly specialized nature of applying insulation in this temperature range, it is recommended that you contact your Pittsburgh Corning representative for materials and procedures. Of prime concern is that components of such a system be compatible with liquid oxygen.

### -290°F to -60°F (-179°C to -51°C)

FOAMGLAS® insulation shall be applied in multiple layers with all joints staggered between layers. The number and thickness of layers shall be calculated so that the innermost layer is entirely above -60°F (-51°C). The outermost layer shall have all joints sealed with joint sealant.

Inner layers of piping insulation may be secured with fiber-reinforced tape. The outermost layer of insulation shall be secured with metal bands of appropriate width and thickness, two bands per insulation section.

The finish over the insulation may be either vapor retarder or weather-barrier reinforced mastic, and/or metal jacketing.

The exterior surface of the insulation under metal jacket shall be coated with PITTCOTE® 300 coating to fill the surface cells.

FOAMGLAS® insulation is impermeable to water or water vapor under most conditions, and providing that all joints between insulation sections are properly sealed, no vapor retarder is required. The designer may desire the use of a vapor retarder as a redundant measure.

### -60°F (-51°C) to Ambient

FOAMGLAS® insulation may be applied in a single layer where thickness permits. The use of joint sealant is recommended on all systems that operate below ambient temperature for any length of time, and is required on systems that operate at or below 36°F. In cases where the below ambient system is operating at a temperature higher than 36°F, and the outdoor relative humidity is not routinely expected to exceed 50%, the use of a joint sealant is at the discretion of the design engineer.

For securement and finish recommendations, see the above procedures given for -290°F to -60°F (-179°C to -51°C).

The exterior surface of the insulation under metal jacket shall be coated with PITTCOTE® 300 coating to fill the surface cells.

Tanks, spheres, and vessels operating in this temperature range may also be insulated by adhering FOAMGLAS® insulation to curved or flat surfaces using PC® 88 adhesive. This adhesive may also be used as the joint sealant. Contact your Pittsburgh Corning representative for specifications of materials and procedures for this method.

### Ambient to 400°F (204°C)

FOAMGLAS® insulation shall be applied in a single layer. No joint sealant is required. Staggering of joints is at the discretion of the owner or the design engineer. Pipe insulation may be secured using fiber-reinforced tape if a metal jacket will be used, or with metal bands if a reinforced weather-barrier mastic will be used.

Insulation on vessels shall be secured using metal bands. For operating temperatures up to 160°F (71°C), PC® 88 adhesive may be used to secure the insulation. Contact your Pittsburgh Corning representative for details concerning the use of PC® 88 adhesive.

The finish over FOAMGLAS® insulation on either piping or vessels may be a reinforced weather-barrier mastic or a metal jacket.

### Above 400°F (204°C)

Pittsburgh Corning offers several different procedures for applying FOAMGLAS® insulation to piping and vessels operating above 400°F (204°C). The preferred system is the StrataFab® System. Contact your Pittsburgh Corning representative for recommendations on various alternatives.

### StrataFab® System -100°F to 900°F (-73°C to 482°C)

The StrataFab® System shall be applied as a single layer for the temperature range of -60°F to 900°F (-51°C to 482°C). The use of joint sealant is recommended on all systems that operate below ambient temperature for any length of time, and is required on systems that operate at or below 36°F. In cases where the below ambient system is operating at a temperature higher than 36°F, and the outdoor relative humidity is not routinely expected to exceed 50%, the use of a joint sealant is at the discretion of the design engineer. For the temperature range of ambient to 900°F (482°C) no sealant is necessary.

StrataFab® System pipe insulation may be applied using fiber-reinforced tape or metal bands. StrataFab® System insulation for vessels tanks and equipment may be applied with metal bands, weld pins or PC® 88 adhesive, as appropriate for the application. Contact your Pittsburgh Corning Corporation Representative for more information about these systems.

The finish used over the FOAMGLAS® Insulation StrataFab® System may be a weather barrier mastic or metal jacket.

On below-ambient systems, the exterior surface of the insulation under metal jacket shall be coated with PITTCOTE® 300 coating to fill the surface cells.

\* For applications from -100°F to -60°F (-73°C to -51°C) refer to the application procedures for FOAMGLAS® insulation in the temperature range of -290°F to -60°F (-179°C to -51°C).

## ACCESSORY MATERIALS

Pittsburgh Corning Corporation offers a line of accessory materials exclusively designed for FOAMGLAS® cellular glass insulation for use in major types of industrial applications.

Pittsburgh Corning Corporation is continually evaluating accessory materials. While these materials are tested and selected especially for use with FOAMGLAS® insulation, the information given here is for general guidance. For the latest recommendations and specific data sheets on the individual accessories, consult your distributor or Pittsburgh Corning Corporation.

**Pittsburgh Corning makes no warranties whatsoever, and specifically disclaims warranties of merchantability and fitness for a particular use for these accessory products.**

Product	Description	Source+	
		USA	EUR
HYDROCAL® B-11	A reactive gypsum product which, when mixed with water, forms an inorganic, noncombustible adhesive or coating for fabricating or bore coating FOAMGLAS® insulation.	X	
PC® 11	A single component, cold bituminous adhesive ready to use. It is especially suitable for adhering FOAMGLAS® to metal substrates. PC® 11 cures to form a flexible, non-aging adhesive with very good adhesion to different materials.		X
PC® 136 Adhesive	A reactive cementitious product that is mixed with water to form an inorganic, noncombustible adhesive or coating for fabricating, bore coating or forming HT reinforced FOAMGLAS® insulation shapes. It is normally used at ambient above temperatures to 900°F (482°C) where stress-crack corrosion is a concern with stainless steel	X	
PC® 150	An open mesh, alkali-resistant glass fabric for reinforcing mastic finishes over FOAMGLAS® insulation. The large mesh openings (approx. 3mm) allow heavy mastics or mineral coatings to easily penetrate and bond to the insulation and fabric surfaces. The thickness of the fabric ensures proper application thickness of the coating. Its tensile resistance is greater than that of PC® Fabric 79, with lower deformation. It is especially suitable for use with PC® 74 A2.		X
PC® 18	A single component, cold bituminous adhesive ready to use. PC® 18 is used to seal the longitudinal and circumferential insulation joints of FOAMGLAS® insulation on chilled water lines. Cures to form a flexible, non-aging adhesive with very good adhesion to different materials.		X
PC® 500	A single-component, bituminous adhesive with low solvent content and a high content of extenders. PC® 500 retains long-term flexibility, does not freeze and is thixotropic. Adheres FOAMGLAS® to continuous-support substrates. Service temperature from -30°C to 80°C (-22°F to 176°F).		X
PC® 56 Adhesive	A two-component, solvent-free adhesive. Component one is based on bitumen emulsion with synthetic additives. Component two is cement. Service temperature range -15°C to 45°C (5° F to 113° F).		X
PC® 74A2	A dry, manufactured mineral coating used with glass fabric as a non-combustible coating and as an adhesive for FOAMGLAS® insulation. Contains a mixture of special sands, cement and hydrated lime.		X
PC® 80M Mortar	A two-component inorganic mortar based on specially formulated glass powder and fillers for component one and modified silica dispersion for component two. PC® 80M MORTAR is used to adhere FOAMGLAS® cellular glass to itself within a large temperature range when temperatures are very low, very high, or cycle rapidly, using the laminated technique that consists of embedding a specific reinforcement in the adhesive layer. Service temperature from -196°C to +380°		X
PC® 85	A mineral-based, totally inorganic powder that has been especially formulated for filling the open surface cells of FOAMGLAS® cellular glass when used for the insulation of liquid oxygen, liquid nitrogen and hot tank bases. When used with appropriate interleaving membranes the desired load distribution can be achieved with slightly reduced compressive strength versus reference values under EN 826 or ASTM C240-91 testing conditions.		X
PC® 86T	A single component bitumen emulsion product with fillers. Offers good resistance to high temperatures. PC® 86T is suitable for use on FOAMGLAS® cellular glass as a bedding compound in specific load bearing applications. Service temperature from -10°C to +90°C		X
PC® 88 Adhesive	A multi-purpose, two component adhesive for adhering FOAMGLAS® insulation to itself or to other porous or nonporous substrates. Air curing is not required. It has excellent wetting characteristics and cures to form a flexible bond that absorbs mechanical and thermal shock. Service temperature range: low to moderate.	X	X
PC® Fabric 79	An open mesh polyester fabric for reinforcing mastics such as PITTCOTE® 404 or PITTCOTE® 300 coating over FOAMGLAS® insulation. Service temperature range: low to moderate.	X	X
PC® High Temp Anti Abrasive	A one-component, dry mix of modified calcium sulphate with inert mineral fillers. PC® High Temp Anti-Abrasive is applied to FOAMGLAS® insulation as a reinforcement for high temperature applications, and when needed for dual temperature applications. When dry it forms a protective hard surface, filling the surface cells of the insulation and providing protection from abrasion up to 350° C (662°F).		X
PC® Primer Sealer 3A	A thin-bodied bitumen and volatile solvent blend, particularly suited for use as a tack coat for nonporous substrates such as steel or aluminum prior to the application of FOAMGLAS® insulation with hot bitumen. Can also be used on dense concrete.		X
PC® RTV 450 Silicone Adhesive	A one-part, acetoxy cure, silicone adhesive/sealant formulated for use at high temperatures. It cures to an elastomeric solid at room temperature. Service temperature range: -50°F to 400°F (-45°C to 204°).	X	
PITTCOTE® 300 Coating	Vapor and weather barrier single component asphalt coating especially formulated for use with FOAMGLAS® insulation. Service temperature range: low to moderate.	X	X
PITTCOTE® 404 Coating	A highly flexible acrylic latex coating used with FOAMGLAS® insulation where a superior weather barrier coating is required. Used with polyester fabric reinforcement. Service temperature: low to moderate.	X	X
PITTSEAL® 444 Sealant	Non-setting, single component butyl sealant used for sealing joints in FOAMGLAS® insulation systems, and to seal protrusions and metal jacket laps. Service temperature range: low to moderate.		X
PITTSEAL® 444N Sealant	Non-setting, single component butyl sealant used for sealing joints in FOAMGLAS® insulation systems, and to seal protrusions and metal jacket laps. Stainless steel compatible. Service temperature range: low to moderate.	X	
PITTWRAF CW30 Jacketing	A 30mil (0.8mm) thick self-sealing, modified bituminous membrane for protecting above ground FOAMGLAS® insulation systems on chilled water and hot service pipelines. Manual pressure seals the jacketing without the use of a torch or heater. Metal jacketing must be used over the PITTWRAF® CW30 jacketing for UV protection. PITTWRAF® CW30 jacketing cannot be factory applied on the insulation. <sup>1</sup>	X	
PITTWRAF® CW Plus Jacketing	A 50mil (1.3mm) thick self-sealing, modified bituminous membrane for protecting underground FOAMGLAS® insulation systems on chilled water and hot service <sup>1</sup> pipelines. Manual pressure seals the jacketing without the use of a torch or heater. PITTWRAF® CW Plus jacketing may also be factory applied on the insulation. PITTWRAF® CW Plus jacketing consists of a polymer modified bituminous compound reinforced with a glass fabric and a 1mil (0.03mm) aluminum top film and release paper backing.	X	
PITTWRAF® IW50 Jacketing	A 50mil (1.33mm) thick self-sealing, non-metallic sheet for protecting above ground FOAMGLAS® insulation systems on chilled water and hot service pipelines. Manual pressure seals the jacketing without the use of a torch or heater. Metal jacketing must be used over the PITTWRAF® IW50 jacketing for UV protection. PITTWRAF® IW50 jacketing consists of a polymer modified bituminous compound reinforced with a glass fabric, a 1mil polyester film and release paper backing.	X	
PITTWRAF® Jacketing	A 125mil (3.2mm) thick heat-sealable, multi-ply laminate for protecting underground FOAMGLAS® systems with outer surface temperatures below 190°F (87.7°C). PITTWRAF® jacketing consists of three layers of a polymer-modified, bituminous compound separated by glass reinforcement and aluminum foil. An outer layer of polyester film is laminated to the bituminous compound. Release paper prevents sticking in the roll before use. PITTWRAF® jacketing may also be factory applied on the insulation.	X	
PITTWRAF® SS Jacketing	A 70mil (1.8mm) thick self-sealing, modified bituminous membrane for protecting underground FOAMGLAS® insulation systems with outer surface temperatures below 170°F (76.7°C). Manual pressure seals the jacketing without the use of a torch or heater. PITTWRAF® SS jacketing may also be factory applied on insulation.	X	X
Terostat-PC FR	A sprayable and gunable, single component sealant, coating and adhesive. Terostat® - FR is a silane modified polymer base (MS® Polymer) that cures on reaction with moisture. Contains no solvents, isocyanates, silicones or PVC. Terostat® - FR has good weathering, chemical and UV resistance.		X

+ PC Accessories are available for shipment for projects worldwide. The sources are either at PCC plant locations or Pittsburgh Corning Europe locations. Pricing for all PC Accessories is available from your customer support representative.

<sup>1</sup>NOTE: Do not use in underground tunnels or trenches where jacketing will be exposed to air temperatures in excess of 140°F (60°C)