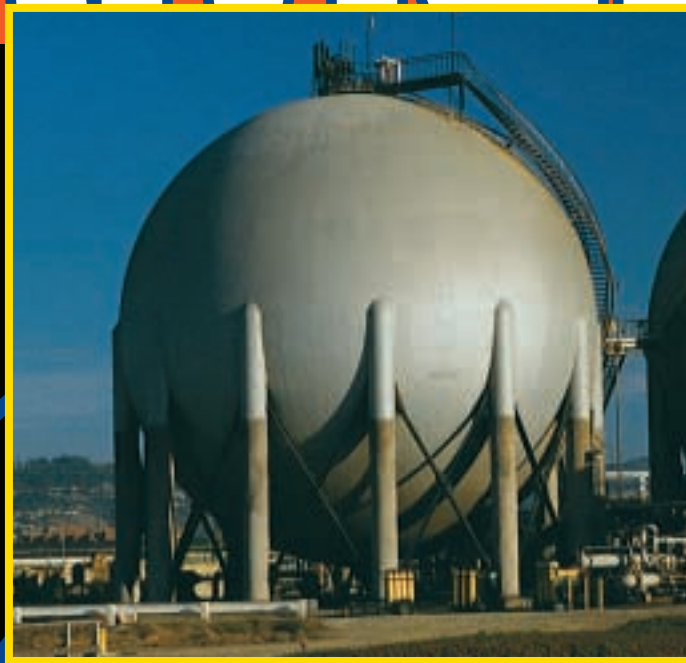


PITTSBURGH CORNING
FOAMGLAS®
INSULATION

www.foamglasinsulation.com

FOAMGLAS®



**INSULATION SYSTEMS FOR INDUSTRIAL APPLICATIONS WITH
OPERATING TEMPERATURES OF -450° F TO +900° F (-268° C TO +482° C)**

TABLE OF CONTENTS

PAGE

Section 1: Introduction3

**Section 2: Properties/Benefits/
Applications.....4**



Section 3: Moisture Resistance5



Section 4: Noncombustibility8



Section 5: Chemical Durability12



Section 6: Dimensional Stability14



Section 7: Compressive Strength.....16



Section 8: Vermin Resistance17

Section 9: Properties and Certifications18

Section 10: Selection Guide20

Section 11: Temperature Limits.....22

**Section 12: Insulation Thicknesses
for Process Piping26**

**Section 13: Insulation Thicknesses
for Personnel Protection.....28**

**Section 14: Above Ground and
Underground Installation29**

Section 15: General Specifications32

Section 16: Accessory Materials34

FOAMGLAS® CELLULAR GLASS INSULATION IS PROVEN VALUE

PRODUCT VALUES

FOAMGLAS® cellular glass insulation is the result of 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 (-268°C to +482°C). Billions of square feet and lineal feet have been installed throughout the world in thousands of industries and operations.

Worldwide Availability

With plants in the U.S. and Europe, Pittsburgh Corning Corporation and Pittsburgh Corning Europe can uniquely provide consistency of supply, a millions-of-board-feet 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 an 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.

Specialized reports are available for:

- Underground pipelines
- Predicting outlet temperatures

- Estimating exit pressure and quality of steam for long steam pipes
- 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, or the Energy Analysis Department at our Pittsburgh headquarters by calling 1-800-359-8433.

Sales Support

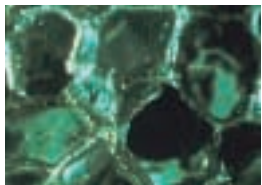
A system of local sales representatives and distributors are available for consultation and problem resolution. Training and instructional films, videos, and slide presentations are also available from your local sales personnel.

Industry Support

Pittsburgh Corning supports technical and trade organizations, including ASTM, CSI, IDEA, 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 with complete assurance of materials compliance for a variety of installations. Pittsburgh Corning is also an ISO 9002 company with registered production processes regarding quality control.



FOAMGLAS® insulation's cellular glass structure ensures constant thermal efficiency.



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):

- 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 and microbes
- Fiber, CFC and HCFC free.

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
- 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.

WIDE-RANGING, SERVICE-PROVEN APPLICATIONS

FOAMGLAS® insulation has over 50 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

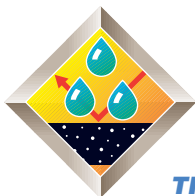
- Hot oil/asphalt storage tanks
- Heat transfer fluid systems
- Hydrocarbon and sulfur processing systems
- Underground steam and chilled water piping
- Chilled and hot water service lines
- Off-shore platforms
- Above ground steam lines
- Pulp/paper mills and water treatment plants
- Food processing/cold 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 sizes to meet virtually all industrial requirements. Pittsburgh Corning's many accessory products are designed to produce the maximum insulation system performance.



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

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% moisture, by volume, can reduce thermal efficiency by 70%*!

For over 50 years, FOAMGLAS® insulation has *proven* itself to resist moisture and provide constant thermal resistance. *No other insulation manufacturer can make this claim.*

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



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

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.

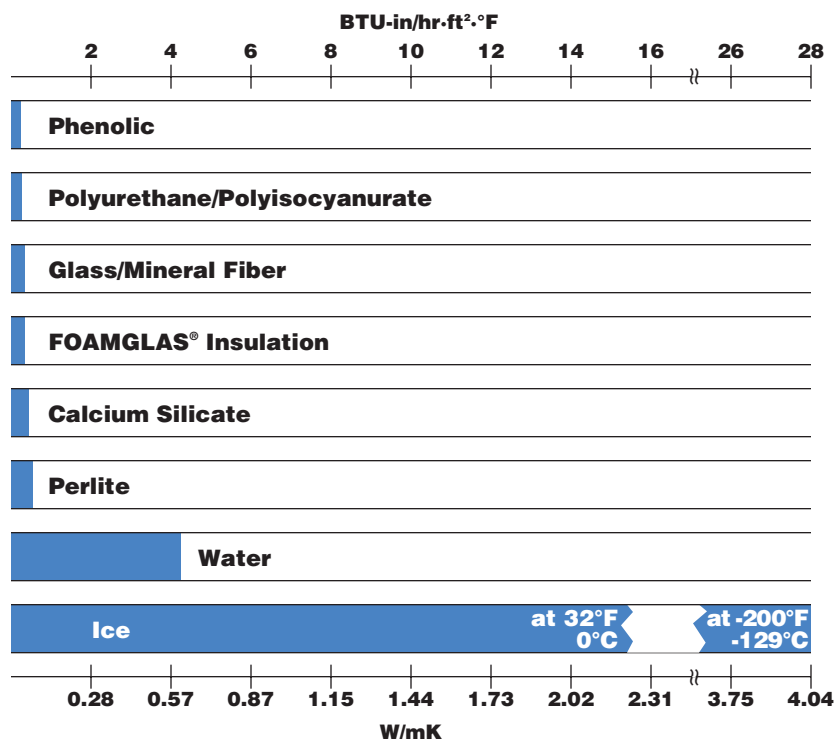
Operations Problems

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



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

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.

Low-Temperature 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

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 maintained. Thus, FOAMGLAS®

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 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 jacketing. System heat can now drive moisture out of the original insulation as vapor, through jacketing seams and the open joints 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

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

Insulation Material	Permeability Perm-Inch ¹	Permeability Perm-Cm	Absorption % by Vol.
FOAMGLAS® Insulation	0.00	0.0	0.2 ²
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 ³	40–99	66.8–165.3	nil–90 ³
Calcium Silicate	24–38	40.08–63.46	90
Expanded Perlite ³	32	53.44	2–90 ³

¹ Perm-Inch is the accepted unit of water vapor permeability

1 Perm-Inch = $\frac{1 \text{ Grain-Inch}}{\text{F}^2\text{-Hr-Inch of Mercury}}$ 1 Perm-Cm = $\frac{1 \text{ Grain-Cm}}{\text{SqM-Hr-Cm Mercury}}$

² The only moisture retained is that adhering to surface cells after immersion

³ Waterproofing agents may be destroyed when exposed to temperatures of 250°F (121°C) or higher

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.

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 dripping; up to 90% is not unusual. In many cases complete saturation can occur in less than three hours.



FOAMGLAS® insulation being installed as an “OVERFIT” system.

other material, imagine how it performs when installed initially. Case histories are legion. In one instance, after 20 years of *unjacketed* service (not recommended) on a refinery's heated (190°F/88°C) wax and oil tank, FOAMGLAS® insulation remained dry, with a thermal conductivity of 0.39 Btu-in/hr-ft²·°F—versus an initial value of 0.38 (0.056 W/mK versus 0.055).



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 installation.

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.

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.



Corroded flange under absorbent insulation.



NONCOMBUSTIBLE ... PERSONAL 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 non-absorptive 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).

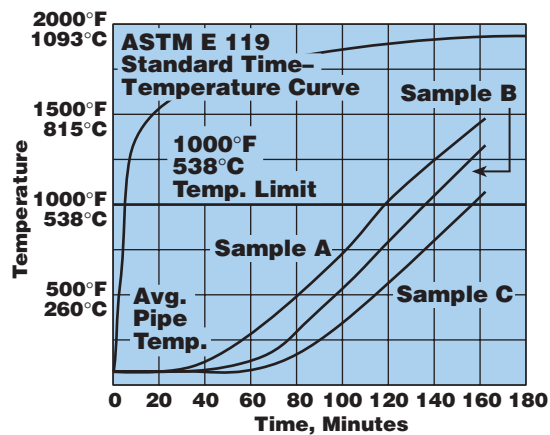
The test is continued until failure occurs, or until the average temperature of the protected steel reaches 1000°F (538°C). This maximum represents the threshold of structural failure for carbon steel. Above this temperature, piping/structural steel would have to be replaced.

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.

FIGURE 2: ASTM E 119 Performance Test**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

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.

Performance

Material	Rating
FOAMGLAS® Insulation Layer	Noncombustible

UL 1709 (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.

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:

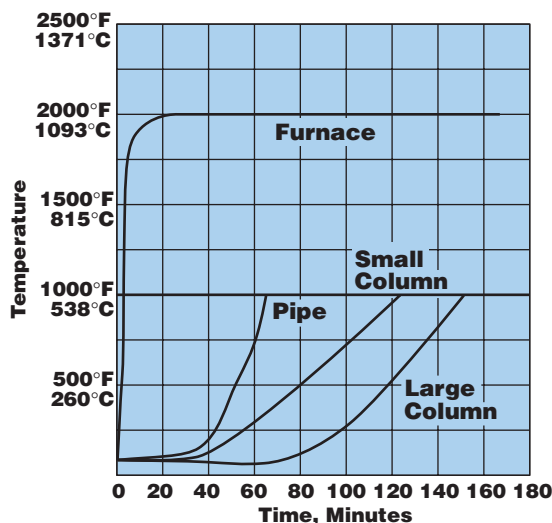
2.3.7.1 The insulation used to cover HTF piping and equipment should be of the type that is nonabsorbent.

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

FIGURE 3: UL1709 (Modified) Performance Test



Specifications for Specimens

- Pipe section test—10" (25.4 cm) \varnothing , sch 40 steel pipe
Small/large 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
Small Column	2" (50 mm) Thick	2" (50 mm) Thick	122 min
Large Column	3" (75 mm) Thick	3" (75 mm) Thick	153 min

wool, mineral wool, silicate-bonded asbestos fibers.

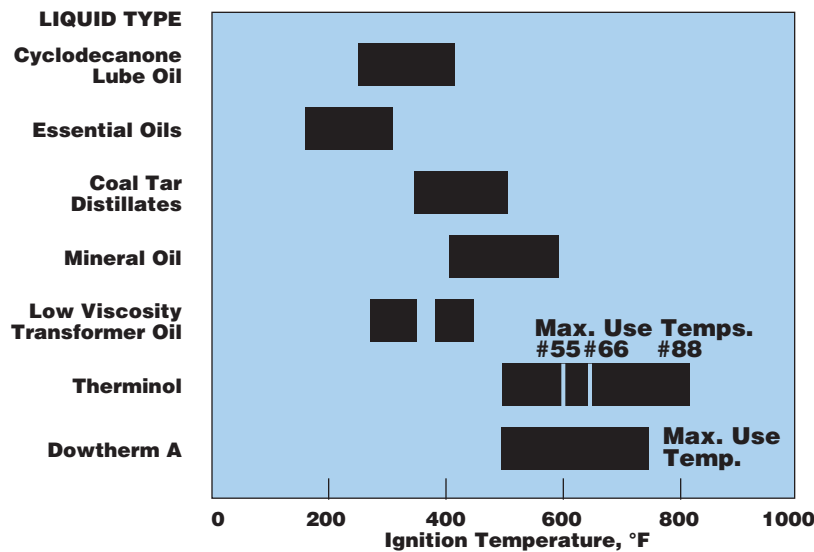
Wicking of Organics

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



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

FIGURE 4: Ignition Temperatures for Combustible Liquids

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.

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.

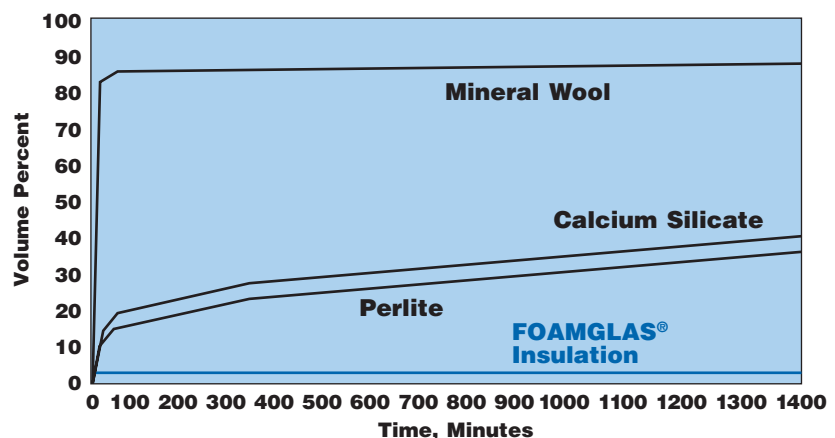
Noncombustible, *nonabsorptive* FOAMGLAS® insulation is ideal for these applications. In fact, the leading manufacturers of heat transfer fluids are unanimous in recommending closed-cell insulation where organic leakage and contamination are likely. Impermeability to liquids and air eliminates the risk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

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.

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.



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

TABLE 2: Materials Which Showed Significant Changes in Volume and Weight

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 ure-

thane 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.

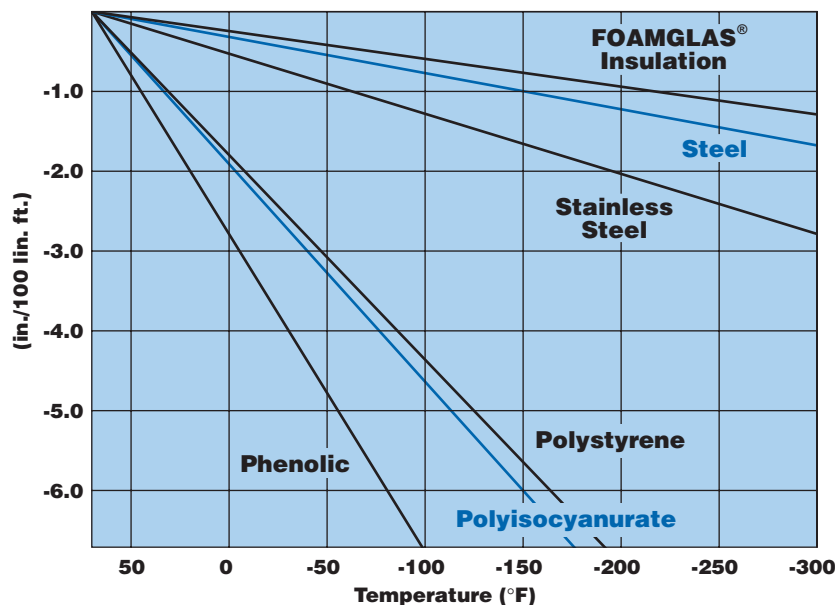
Irreversible Changes at High Temperatures

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 out-gassing of foaming agents from expanded polystyrene causing

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





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

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.

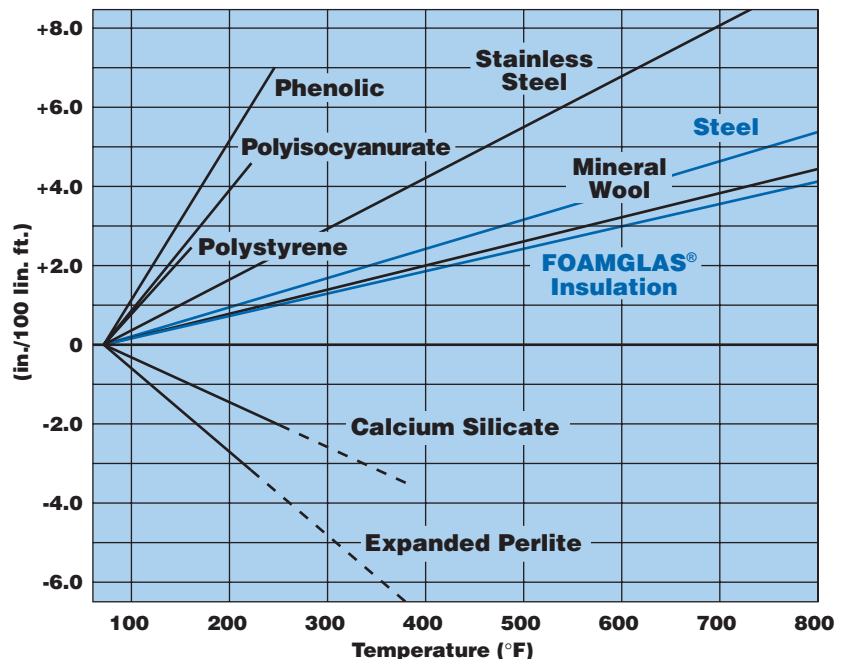
shrinkage of up to 2%. On cold systems, low-density polyurethane's in-cell gases can condense, break down cell walls and lead to insulation collapse.

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

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, 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.

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 over-stresses.

PROBLEMS AND APPLICATIONS

Tanks

For low- and cryogenic-temperature tank bottom applications, the use of insulation lacking proper compressive

TABLE 3: Compressive Strengths of Various Materials

Insulation Material	Compressive Strength		Density	
	psi	kPa	lb/ft ³	Kg/m ³
FOAMGLAS® Insulation	90+/- -10%	620	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	90@5% def.	620	5–13	80–208

TABLE 4: 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.

DENSITY AND COMPRESSIVE STRENGTH								
Grade of FOAMGLAS® HLB Insulation	Nominal Lot Avg. Density		Compressive Strength (Tested According to ASTM C 165/C 240)					
			Average			Lower Spec. Limit		
	kg/m³	pcf	N/mm²	psi	kg/cm²	N/mm²	psi	kg/cm²
HLB 800	135	8.43	0.80	116	8.16	0.55	79.8	5.61
HLB 1000	140	8.74	1.00	145	10.2	0.69	100.1	7.04
HLB 1200	145	9.05	1.20	174	12.2	0.82	118.9	8.36
HLB 1400	150	9.36	1.40	203	14.3	0.96	139.2	9.79
HLB 1600	165	10.3	1.60	232	16.3	1.10	159.5	11.22

Note: 0.8 N/mm² = 800 kPa

sive 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.



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.



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

CERTIFICATIONS* AND APPROVALS

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

- ASTM C 552-00 "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 0, Smoke Developed 0 (UL 723, ASTM E 84), R2844; also classified by UL of Canada, CR1957
- ISO 9002
- Through-Penetration Firestop Systems UL 1479 System Nos. CAJ5060, CAJ5069, CAJ5103, CAJ5120 and System Nos. WJ5011, WJ5015, WJ5038, WL5038, WL5045, WL5046, WL5051, WL5083
- 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

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

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

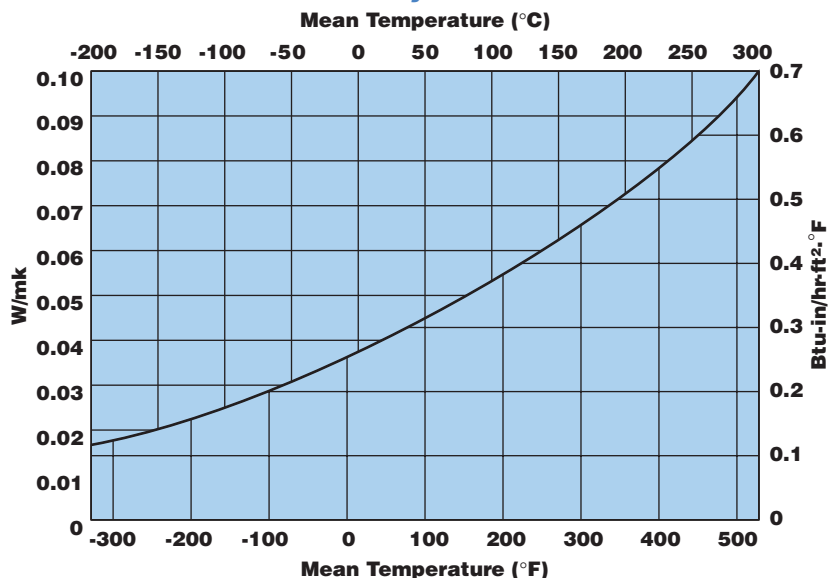
TABLE 5: Physical and Thermal Properties of FOAMGLAS® Insulation

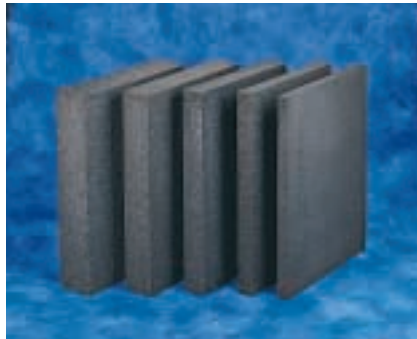
PHYSICAL PROPERTIES	USA	METRIC	SI	ASTM TEST
Absorption of Moisture (% By Volume)	0.2%			C 240
	Only moisture retained is that adhering to surface cells after immersion.			
Water-Vapor Permeability	0.00 perm-in	0.00 perm-cm		E 96†
Acid Resistance	Impervious to common acids and their fumes except hydrofluoric acid.			
Capillarity	None	None	None	
Combustibility	Noncombustible, will not burn.			E 136
Composition	Pure glass, totally inorganic, contains no binder.			
Compressive Strength Average, for Standard Material** (+/-10%)	90 psi	6.3 kg/cm ²	620 kPa	C 165, C 240, C 552-00
	Strength for flat surfaces capped with hot asphalt; different capping will give different values. For curved surfaces and pipe supports, contact PCC.			
Density, Average	7.5 lb/ft ³	120 kg/m ³	120 kg/m ³	C 303
Dimensional Stability	Excellent—does not shrink, swell or warp.			
Flexural Strength, Block Average	70 psi	4.9 kg/cm ²	480 kPa	C 203, C 240
Hygroscopicity	No increase in weight at 90% relative humidity.			
Linear Coefficient of Thermal Expansion (25° to 300°C)	5.0 x 10 ⁻⁶ /°F	9.0 x 10 ⁻⁶ /°C	9.0 x 10 ⁻⁶ /°K	E 228
Maximum Service Temperature	+900°F	+482°C	755°K	
Modulus of Elasticity, Approx.	1.3 x 10 ⁵ psi	9,300 kg/cm ²	900 MPa	C 623
Shear Strength	No reliable recognized test method for determination of the shear strength for cellular glass exists at this time. Where shear strength is a design criterion, PCC should be contacted for recommendations.			
Thermal Conductivity	Btu-in/hr-ft ² -°F 0.29 @ 75°F 0.28 @ 50°F	kcal/m-h-°C 0.033 @ 0°C 0.034 @ 10°C	W/mK 0.039 @ 0°C 0.040 @ 10°C	C 177, C 518
Specific Heat	0.20 Btu/lb-°F	0.20 kcal/kg-°C	0.84 kJ/kg-°K	
Thermal Diffusivity	0.016 ft ² /hr	0.0042 cm ² /sec	4.2 x 10 ⁻⁷ m ² /sec	

Note: Properties given at 75°F unless otherwise specified. Properties may vary with temperature. These values are average or typical values recommended for design purposes, and are not intended as specification or limit values.

† E 96 Wet Cup Method/Procedure B

FIGURE 8: Thermal Conductivity of FOAMGLAS® Insulation





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" (457 mm x 610 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.

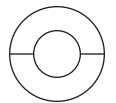
Pipe Coverings. When requested by the purchaser, FOAMGLAS® pipe and tubing insulation can be fabricated worldwide in accordance with ASTM Standard C 552-00 and C 585. Specifying FOAMGLAS® pipe and tubing insulation in accordance with these standards will ensure proper fit to pipe or tubing and nesting 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.

TABLE 6: 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	2.62	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.)

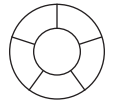
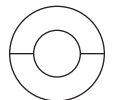


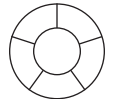
TABLE 7: Pipe Insulation Dimensional Standards (Metric)

NOMINAL PIPE SIZES				NOMINAL 1.5"		NOMINAL 2"		NOMINAL 2.5"		NOMINAL 3"		NOMINAL 3.5"		NOMINAL 4"	
				O.D. of Covering		O.D. of Covering		O.D. of Covering		O.D. of Covering		O.D. of Covering		O.D. of Covering	
Nominal	O.D. inch	O.D. mm	DN	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm
1/4	0.540	14	8	3.50	89	4.50	114	5.56	141	6.62	168	7.62	194	8.62	219
3/8	0.675	17	10	4.00	102	5.00	127	5.56	141	6.62	168	7.62	194	8.62	219
1/2	0.840	21	15	4.00	102	5.00	127	6.62	168	7.62	194	8.62	219	9.62	244
3/4	1.050	27	20	4.00	102	5.00	127	6.62	168	7.62	194	8.62	219	9.62	244
1	1.315	33	25	4.50	114	5.56	141	6.62	168	7.62	194	8.62	219	9.62	244
1-1/4	1.660	42	32	5.00	127	5.56	141	6.62	168	7.62	194	8.62	219	9.62	244
1-1/2	1.900	48	40	5.00	127	6.62	168	7.62	194	8.62	219	9.62	244	10.75	273
2	2.375	60	50	5.56	141	6.62	168	7.62	194	8.62	219	9.62	244	10.75	273
2-1/2	2.875	73	65	6.62	168	7.62	194	8.62	219	9.62	244	10.75	273	11.75	298
3	3.500	89	80	6.62	168	7.62	194	8.62	219	9.62	244	10.75	273	11.75	298
3-1/2	4.000	102	90	7.62	194	8.62	219	9.62	244	10.75	273	11.75	298	12.75	324
4	4.500	114	100	7.62	194	8.62	219	9.62	244	10.75	273	11.75	298	12.75	324
4-1/2	5.000	127	115	8.62	219	9.62	244	10.75	273	11.75	298	12.75	324	14.00	356
5	5.563	141	125	8.62	219	9.62	244	10.75	273	11.75	298	12.75	324	14.00	356
6	6.625	168	150	9.62	244	10.75	273	11.75	298	12.75	324	14.00	356	15.00	381
7	7.625	194		10.75	273	11.75	298	12.75	324	14.00	356	15.00	381	16.00	406
8	8.625	219	200	11.75	298	12.75	324	14.00	356	15.00	381	16.00	406	17.00	432
9	9.625	244		12.75	324	14.00	356	15.00	381	16.00	406	17.00	432	18.00	457
10	10.750	273	250	14.00	356	15.00	381	16.00	406	17.00	432	18.00	457	19.00	483
11	11.750	298		15.00	381	16.00	406	17.00	432	18.00	457	19.00	483	20.00	508
12	12.750	324	300	16.00	406	17.00	432	18.00	457	19.00	483	20.00	508	21.00	533
14	14.000	356	350	17.00	432	18.00	457	19.00	483	20.00	508	21.00	533	22.00	559
15	15.000	381		18.00	457	19.00	483	20.00	508	21.00	533	22.00	559	23.00	584
16	16.000	406	400	19.00	483	20.00	508	21.00	533	22.00	559	23.00	584	24.00	610
17	17.000	432		20.00	508	21.00	533	22.00	559	23.00	584	24.00	610	25.00	635
18	18.000	457	450	21.00	533	22.00	559	23.00	584	24.00	610	25.00	635	26.00	660
19	19.000	483		22.00	559	23.00	584	24.00	610	25.00	635	26.00	660	27.00	686
20	20.000	508	500	23.00	584	24.00	610	25.00	635	26.00	660	27.00	686	28.00	711
21	21.000	533		24.00	610	25.00	635	26.00	660	27.00	686	28.00	711	29.00	737
22	22.000	559		25.00	635	26.00	660	27.00	686	28.00	711	29.00	737	30.00	762
23	23.000	584		26.00	660	27.00	686	28.00	711	29.00	737	30.00	762	31.00	787
24	24.000	610	600	27.00	686	28.00	711	29.00	737	30.00	762	31.00	787	32.00	813

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.)



FABRICATED FOAMGLAS® INSULATION SYSTEMS

SYSTEM	BENEFITS	RECOMMENDED TEMPERATURE RANGE
Asphalt Bonded 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"> Standard, readily available fabrication technique for cold to moderately warm applications. 	-290°F (-179°C) to 250°F (121°C) 251°F (122°C) to 400°F (204°C)
HYDROCAL® B-11* Bonded Single or multiple layers of FOAMGLAS® insulation fabricated with a special inorganic adhesive.	<ul style="list-style-type: none"> Fabrication technique allows usage over broadest temperature range. 	-450°F (-268°C) to Ambient Ambient to 900°F (482°C)
StrataFab® System 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"> Minimal breakage during shipment and installation. Can be installed directly on hot surfaces. Provides excellent control of stress relief cracking. Wide range of thickness eliminates need for double layering. 	-100°F (-73°C) to Ambient Ambient to 900°F (482°C)
Composite System 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"> Fabrication technique allows usage on systems: <ul style="list-style-type: none"> undergoing continuous thermal cycling. undergoing excessive vibration. operating above 900°F (482°C). 	401°F (205°C) to 1200°F (649°C)
Advantage® System A method of fabricating FOAMGLAS® insulation by bonding segments or lags of insulation to a flexible facing with special adhesives.	<ul style="list-style-type: none"> Provides excellent control of stress relief cracking Can be supplied with jacketing pre-applied. Shipped flat for less damage, lower shipping costs. Supplied in 2' sections; other sizes available upon request. 	Ambient to 900°F (482°C)

* A product of U.S. Gypsum Co.

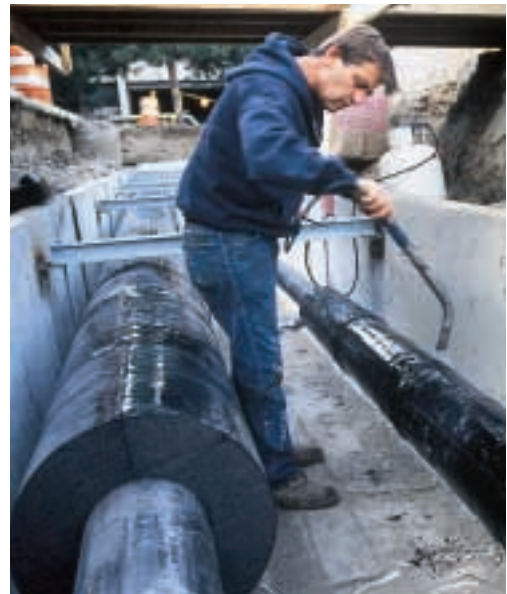
LIMITS

- | | |
|--|--|
| <ul style="list-style-type: none"> Do not use at or below temperatures where liquid oxygen (LOX) will form (-297°F/-183°C). | <ul style="list-style-type: none"> Bonding adhesive softens and may smoke in contact with hot surfaces above 125°F (52°C). Where stainless steel stress corrosion potential exists, contact your PCC representative. |
| <ul style="list-style-type: none"> When above ground, recommended only in well ventilated areas. | |
| <ul style="list-style-type: none"> 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. | <ul style="list-style-type: none"> Where stainless steel stress corrosion potential exists, contact your PCC representative. |
| <ul style="list-style-type: none"> Use a double layer system at temperatures above 400°F (204°C). | |
| <ul style="list-style-type: none"> 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. | |
| <ul style="list-style-type: none"> 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. | |
| <ul style="list-style-type: none"> Not for service on systems containing combustible liquids. | |

- Organic facing adhesive may smoke in contact with hot surfaces.



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.

RECOMMENDED LOWER PIPE TEMPERATURE LIMITS TO PREVENT CONDENSATION

TABLE 8: English (°F)

For normal indoor design conditions: 80.0°F Ambient • 70.0% Relative Humidity • 69.3°F Dew Point • 0.0 mph Wind Velocity • 0.90 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	-30	-125	-235																		
0.75	-10	-90	-185	-405																	
1.00	-25	-95	-190	-320																	
1.50	-10	-70	-200	-305																	
2.00	-10	-65	-140	-220	-330																
2.50	-5	-90	-160	-245	-355																
3.00	0	-50	-105	-170	-255	-375															
4.00	0	-40	-90	-150	-235	-330	-445														
5.00	5	-30	-80	-140	-210	-290	-420														
6.00	10	-25	-75	-125	-190	-280	-375														
8.00		-25	-65	-125	-185	-250	-330														
10.00		-25	-65	-110	-160	-220	-290	-375													
12.00		-25	-60	-105	-150	-205	-270	-345	-440												
14.00		-15	-50	-90	-135	-185	-245	-315	-395												
16.00		-10	-45	-85	-130	-175	-235	-300	-380												
18.00		-10	-45	-80	-125	-170	-225	-290	-365												
20.00		-10	-45	-80	-120	-165	-220	-280	-350	-435											
24.00		-10	-40	-75	-115	-160	-210	-270	-335	-415											
28.00		-10	-40	-75	-115	-155	-205	-260	-320	-395											
30.00		-10	-40	-75	-110	-155	-200	-255	-315	-390											
36.00		-5	-40	-70	-110	-150	-195	-245	-305	-375											
42.00		-5	-35	-70	-105	-145	-190	-240	-295	-360	-435										
48.00		-5	-35	-70	-105	-145	-190	-235	-290	-350											
60.00		-5	-35	-70	-105	-140	-185	-230	-280	-340	-410										
72.00		-5	-35	-65	-100	-140	-180	-225	-275	-330	-395										
96.00		-5	-35	-65	-100	-135	-175	-220	-270	-320	-385										
120.00		-5	-35	-65	-100	-135	-175	-215	-265	-315	-375	-445									
168.00		-5	-35	-65	-95	-130	-170	-210	-260	-310	-365	-430									
FLAT		-5	-30	-60	-95	-125	-165	-205	-245	-290	-345	-400									

MINIMUM HEAT GAIN=11.7 BTU/HR SQFT • MAXIMUM HEAT GAIN=15.3 BTU/HR SQFT

TABLE 8: Metric (°C)

For normal indoor design conditions: 26.7°C Ambient • 70.0% Relative Humidity • 20.7°C Dew Point • 0.0 kmph Wind Velocity • 0.90 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	-37	-88	-149																		
0.75	-25	-69	-121	-245																	
1.00	-34	-72	-125	-195																	
1.50	-25	-58	-129	-189																	
2.00	-23	-55	-95	-142	-202																
2.50	-21	-69	-108	-155	-216																
3.00	-18	-45	-76	-114	-161	-228															
4.00	-17	-41	-69	-103	-149	-201															
5.00	-14	-36	-62	-97	-134	-179	-251														
6.00	-12	-33	-60	-89	-123	-175	-227														
8.00		-33	-55	-89	-120	-157	-202														
10.00		-33	-55	-80	-108	-141	-179	-226													
12.00		-32	-52	-76	-103	-133	-169	-211	-262												
14.00		-26	-46	-68	-93	-122	-154	-193	-239												
16.00		-25	-45	-66	-90	-117	-148	-185	-229												
18.00		-25	-43	-64	-87	-114	-144	-179	-221												
20.00		-24	-42	-63	-86	-111	-141	-175	-214	-261											
24.00		-23	-41	-61	-83	-108	-136	-168	-204	-248											
28.00		-23	-41	-60	-81	-105	-132	-163	-198	-238											
30.00		-23	-40	-60	-81	-104	-131	-161	-195	-235											
36.00		-23	-40	-58	-79	-102	-127	-156	-188	-226											
42.00		-22	-39	-58	-78	-100	-125	-152	-184	-219	-261										
48.00		-22	-39	-57	-77	-99	-123	-150	-180	-214											
60.00		-22	-38	-56	-76	-97	-120	-146	-175	-208	-245										
72.00		-22	-38	-56	-75	-96	-118	-144	-172	-203	-239										
96.00		-21	-38	-55	-74	-94	-116	-141	-167	-198	-232										
120.00		-21	-37	-55	-73	-93	-115	-139	-165	-194	-227	-265									
168.00		-21	-37	-54	-72	-92	-113	-136	-162	-190	-222	-258									
FLAT		-21	-36	-53	-70	-89	-109	-131	-155	-181	-210	-241									

MINIMUM HEAT GAIN=33.4 KCAL/HR SQM • MAXIMUM HEAT GAIN=41.6 KCAL/HR SQM

The tables on these pages provide the minimum operating temperatures for pipe diameter/insulation thickness combinations below which condensation can be expected to occur for the ambient conditions given.

- Compare different pairs of tables to determine the effect when one ambient condition changes.
- Compare 8 and 9 for the effect of a change of relative humidity indoors.
- Compare 10 and 11 for the effect of a change in surface

emittance outdoors.

- Compare 9 and 10 for the effect of a change in wind velocity.

For design conditions not covered in these tables, contact your Pittsburgh Corning representative.

TABLE 9: English (°F)

For severe indoor design conditions: 80.0°F Ambient • 80.0% Relative Humidity • 73.3°F Dew Point • 0.0 mph Wind Velocity • 0.90 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	15	-35	-85	-195	-285	-395	-440														
0.75	25	-15	-65	-160	-235	-325	-355														
1.00	15	-20	-65	-125	-185	-260	-330	-430													
1.50	25	-5	-70	-120	-175	-240	-330	-430													
2.00	30	-5	-40	-80	-130	-185	-255	-335	-430												
2.50	30	-15	-50	-95	-140	-200	-265	-340													
3.00	35	5	-25	-60	95	-150	-200	-260	-350	-440											
4.00	35	10	-15	-50	-90	-130	-175	-240	-305	-375											
5.00	35	15	-10	-45	-75	-110	-165	-210	-265	-330	-405										
6.00	40	20	-10	-35	-65	-110	-145	-190	-240	-295	-360	-435									
8.00		20	-5	-35	-65	-95	-130	-170	-210	-260	-315	-375									
10.00		15	-5	-25	-55	-80	-115	-145	-185	-225	-275	-330	-390								
12.00		20	0	-25	-50	-75	-105	-135	-170	-210	-255	-305	-360	-425							
14.00		25	5	-15	-40	-65	-95	-125	-155	-195	-235	-280	-335	-390							
16.00		25	5	-15	-35	-60	-90	-115	-150	-185	-225	-265	-315	-370	-435						
18.00		25	5	-10	-35	-60	-85	-115	-145	-175	-215	-255	-300	-355	-410						
20.00		25	10	-10	-35	-55	-80	-110	-140	-170	-205	-245	-290	-340	-395						
24.00		25	10	-10	-30	-55	-75	-105	-130	-165	-195	-235	-275	-320	-370	-425					
28.00		25	10	-10	-30	-50	-75	-100	-125	-155	-190	-225	-260	-300	-350	-400					
30.00		30	10	-10	-30	-50	-75	-100	-125	-155	-185	-220	-255	-295	-340	-390					
36.00		30	10	-5	-25	-50	-70	-95	-120	-145	-175	-210	-245	-280	-325	-370	-420				
42.00		30	10	-5	-25	-45	-70	-90	-115	-145	-170	-200	-235	-270	-310	-355	-405				
48.00		30	10	-5	-25	-45	-65	-90	-115	-140	-165	-195	-230	-265	-300	-345	-390	-440			
60.00		30	10	-5	-25	-45	-65	-85	-110	-135	-160	-190	-220	-250	-290	-325	-370	-415			
72.00		30	10	-5	-25	-40	-60	-85	-105	-130	-155	-185	-215	-245	-280	-315	-355	-400			
96.00		30	15	-5	-20	-40	-60	-80	-105	-125	-150	-180	-205	-235	-265	-300	-340	-380	-425		
120.00		30	15	-5	-20	-40	-60	-80	-100	-125	-150	-175	-200	-230	-260	-295	-330	-370	-410		
168.00		30	15	-5	-20	-40	-60	-80	-100	-120	-145	-170	-195	-225	-250	-285	-320	-355	-395		
FLAT		30	15	0	-20	-35	-55	-75	-95	-115	-135	-160	-180	-205	-235	-260	-290	-320	-355	-425	

MINIMUM HEAT GAIN=7.6 BTU/HR SQFT • MAXIMUM HEAT GAIN=9.4 BTU/HR SQFT

TABLE 9: Metric (°C)

For severe indoor design conditions: 26.7°C Ambient • 80.0% Relative Humidity • 22.9°C Dew Point • 0.0 kmph Wind Velocity • 0.90 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	-10	-37	-67	-128	-176	-237	-262														
0.75	-4	-28	-54	-107	-148	-198	-216														
1.00	-9	-29	-56	-87	-122	-164	-216														
1.50	-4	-22	-58	-85	-116	-153	-203	-259													
2.00	-3	-20	-41	-64	-90	-121	-161	-204	-257												
2.50	-2	-28	-48	-70	-96	-130	-165	-207													
3.00	0	-15	-32	-51	-73	-101	-129	-163	-213	-262											
4.00	0	-13	-28	-45	-68	-90	-115	-152	-187	-228											
5.00	1	-10	-24	-42	-61	-81	-110	-136	-167	-202	-243										
6.00	3	-8	-23	-38	-55	-79	-100	-125	-152	-183	-219	-262									
8.00		-8	-21	-38	-54	-71	-90	-112	-136	-162	-193	-228									
10.00		-9	-21	-34	-48	-64	-81	-100	-121	-145	-171	-201	-236								
12.00		-8	-19	-32	-45	-60	-77	-94	-114	-136	-160	-188	-220	-256							
14.00		-5	-16	-28	-41	-55	-70	-87	-106	-126	-149	-175	-204	-237	-259						
16.00		-4	-15	-27	-39	-53	-67	-84	-102	-121	-143	-167	-194	-224							
18.00		-4	-14	-26	-38	-51	-66	-81	-98	-117	-138	-161	-186	-215	-247						
20.00		-3	-14	-25	-37	-50	-64	-79	-96	-114	-134	-156	-180	-207	-237						
24.00		-3	-13	-24	-36	-48	-62	-76	-92	-109	-128	-148	-170	-195	-223	-254					
28.00		-3	-13	-23	-35	-47	-60	-74	-89	-105	-123	-142	-163	-187	-213	-241					
30.00		-3	-13	-23	-34	-46	-59	-73	-88	-104	-121	-140	-161	-183	-208	-236					
36.00		-3	-12	-23	-34	-45	-58	-71	-85	-100	-117	-135	-154	-175	-198	-224	-253				
42.00		-2	-12	-22	-33	-44	-56	-69	-83	-98	-114	-131	-149	-169	-191	-216	-242				
48.00		-2	-12	-22	-32	-44	-56	-68	-82	-96	-111	-128	-146	-165	-186	-209	-235	-263			
60.00		-2	-12	-21	-32	-43	-54	-66	-79	-93	-108	-124	-141	-159	-179	-200	-224	-249			
72.00		-2	-11	-21	-31	-42	-53	-65	-78	-91	-106	-121	-137	-155	-174	-194	-216	-241			
96.00		-2	-11	-21	-31	-41	-52	-64	-76	-89	-103	-117	-133	-149	-167	-186	-207	-230	-254		
120.00		-2	-11	-20	-30	-41	-52	-63	-75	-88	-101	-115	-130	-146	-163	-182	-201	-223	-246		
168.00		-2	-11	-20	-30	-40	-51	-62	-74	-86	-99	-113	-127	-143	-159	-176	-195	-215	-237		
FLAT		-2	-10	-20	-29	-39	-49	-60	-71	-82	-94	-107	-120	-133	-148	-163	-180	-197	-215	-256	

MINIMUM HEAT GAIN=20.5 KCAL/HR SQM • MAXIMUM HEAT GAIN=25.4 KCAL/HR SQM

TABLE 10: English (°F)

For outdoor design conditions: 80.0°F Ambient • 80.0% Relative Humidity • 73.3°F Dew Point • 7.5 mph Wind Velocity • 0.90 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	-30	-125	-235	-400																	
0.75	-10	-90	-180	-310																	
1.00	-25	-95	-190	-310																	
1.50	-10	-70	-190	-295	-430																
2.00	-5	-60	-130	-215	-315	-445															
2.50	0	-85	-150	-235	-335																
3.00	5	-45	-95	-160	-240	-350															
4.00	5	-35	-85	-140	-220	-305	-410														
5.00	10	-25	-70	-130	-190	-265	-380														
6.00	15	-20	-65	-115	-170	-255	-340	-440													
8.00		-20	-55	-110	-165	-225	-295	-380													
10.00		-20	-55	-95	-140	-195	-255	-325	-415												
12.00		-15	-50	-90	-130	-180	-235	-300	-380												
14.00		-5	-40	-75	-115	-160	-215	-270	-340	-430											
16.00		-5	-35	-70	-110	-150	-200	-260	-325	-405											
18.00		0	-30	-65	-105	-145	-195	-250	-315	-390											
20.00		0	-30	-65	-100	-145	-190	-245	-305	-375											
24.00		0	-30	-60	-95	-135	-180	-230	-290	-355	-435										
28.00		0	-25	-60	-95	-135	-175	-225	-280	-340	-415										
30.00		0	-25	-60	-95	-130	-175	-220	-275	-335	-405										
36.00		0	-25	-55	-90	-125	-170	-215	-265	-320	-390										
42.00		0	-25	-55	-90	-125	-165	-210	-255	-310	-375										
48.00		0	-25	-55	-85	-120	-160	-205	-250	-305	-365	-435									
60.00		5	-25	-55	-85	-120	-155	-200	-245	-295	-350	-415									
72.00		5	-25	-50	-85	-115	-155	-195	-240	-285	-345	-405									
96.00		5	-20	-50	-80	-115	-150	-190	-230	-280	-330	-390									
120.00		5	-20	-50	-80	-115	-150	-185	-230	-275	-325	-380	-445								
168.00		5	-20	-50	-80	-110	-145	-185	-225	-265	-315	-370	-430								
FLAT		5	-20	-45	-75	-105	-140	-175	-210	-255	-295	-345	-400								

MINIMUM HEAT GAIN=11.6 BTU/HR SQFT • MAXIMUM HEAT GAIN=16.0 BTU/HR SQFT

TABLE 10: Metric (°C)

For outdoor design conditions: 26.7°C Ambient • 80.0% Relative Humidity • 22.9°C Dew Point • 12.1 kmph Wind Velocity • 0.90 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	-47	-109	-184																		
0.75	-33	-85	-148																		
1.00	-42	-88	-151	-239																	
1.50	-32	-70	-154	-227																	
2.00	-29	-66	-112	-168	-241																
2.50	-26	-81	-126	-182	-256																
3.00	-22	-53	-89	-132	-187																
4.00	-20	-47	-79	-118	-171	-231															
5.00	-17	-41	-70	-109	-151	-203															
6.00	-14	-37	-67	-99	-137	-196	-256														
8.00		-36	-61	-97	-132	-173	-223														
10.00		-36	-59	-86	-117	-153	-195	-247													
12.00		-34	-56	-81	-110	-143	-182	-228													
14.00		-28	-49	-72	-99	-130	-165	-207	-257												
16.00		-26	-47	-69	-95	-124	-157	-197	-245												
18.00		-25	-45	-67	-91	-120	-152	-191	-236												
20.00		-24	-43	-65	-89	-117	-149	-186	-229												
24.00		-23	-42	-63	-87	-113	-143	-178	-219												
28.00		-23	-42	-62	-85	-111	-139	-172	-211	-256											
30.00		-23	-41	-62	-84	-109	-138	-170	-208	-252											
36.00		-23	-41	-61	-82	-107	-134	-165	-201	-242											
42.00		-22	-40	-60	-81	-105	-131	-161	-195	-235											
48.00		-22	-40	-59	-80	-103	-129	-158	-192	-230											
60.00		-22	-39	-58	-79	-101	-126	-154	-186		-264										
72.00		-22	-39	-58	-78	-100	-125	-152	-182	-217	-257										
96.00		-21	-38	-57	-77	-98	-122	-148	-178	-211	-249										
120.00		-21	-38	-56	-76	-97	-121	-146	-175	-207	-244										
168.00		-21	-38	-56	-75	-96	-119	-144	-172	-203	-238										
FLAT		-21	-37	-54	-73	-93	-115	-138	-164	-193	-224	-260									

MINIMUM HEAT GAIN=35.7 KCAL/HR SQM • MAXIMUM HEAT GAIN=49.8 KCAL/HR SQM

TABLE 11: English (°F)

For outdoor design conditions: 80.0°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	-95	-120	-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)

For 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

INSULATION THICKNESSES FOR PROCESS PIPING

TO LIMIT HEAT GAIN TO 9 BTU/HR-FT² (28.4 W/SQM)

TABLE 12: English (°F)

For the following normal design conditions: 80.0°F Ambient • -9.0 ± 0.1 Btu/hrft² 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	18	-31	-85	-199	-292	-410															
0.75	29	-14	-62	-161	-239	-337															
1.00	20	-17	-66	-125	-192	-273	-374														
1.50	27	-5	-71	-122	-182	-254	-354														
2.00	29	-3	-42	-85	-135	-194	-273	-360													
2.50	30	-18	-55	-97	-147	-213	-283	-368													
3.00	34	5	-25	-62	-103	-158	-215	-282	-384												
4.00	34	9	-19	-52	-95	-139	-189	-263	-334	-419											
5.00	36	13	-13	-48	-83	-122	-180	-233	-295	-368											
6.00	38	16	-12	-41	-74	-120	-163	-212	-268	-332	-408										
8.00		15	-8	-42	-73	-107	-145	-188	-237	-293	-358	-432									
10.00		14	-8	-34	-62	-94	-129	-167	-211	-260	-316	-380									
12.00		15	-7	-31	-58	-88	-121	-157	-197	-243	-294	-352	-418								
14.00		20	0	-24	-49	-78	-109	-143	-181	-223	-270	-324	-385								
16.00		21	0	-22	-47	-74	-104	-137	-173	-213	-257	-307	-364	-429							
18.00		21	1	-21	-45	-71	-100	-132	-166	-205	-247	-294	-348	-408							
20.00		22	1	-20	-43	-69	-97	-128	-161	-198	-239	-284	-335	-392							
24.00		22	2	-18	-41	-66	-92	-122	-153	-188	-226	-268	-315	-367	-426						
28.00		23	3	-17	-39	-63	-89	-117	-147	-180	-217	-256	-300	-349	-404						
30.00		23	3	-16	-38	-62	-88	-115	-145	-177	-213	-252	-294	-342	-395						
36.00		23	4	-15	-37	-60	-84	-111	-140	-170	-204	-241	-281	-325	-374	-428					
42.00		24	5	-14	-35	-58	-82	-108	-135	-165	-198	-233	-271	-313	-359	-410					
48.00		24	5	-14	-34	-57	-80	-105	-132	-161	-193	-227	-263	-304	-348	-396					
60.00		24	6	-13	-33	-55	-78	-102	-128	-156	-186	-218	-253	-291	-332	-377	-427				
72.00		24	6	-12	-32	-53	-76	-100	-125	-152	-181	-212	-246	-282	-321	-364	-411				
96.00		25	7	-11	-31	-52	-74	-97	-121	-147	-175	-205	-237	-271	-308	-348	-392	-440			
120.00		25	7	-11	-30	-51	-72	-95	-119	-145	-172	-201	-231	-264	-300	-339	-380	-426			
168.00		25	7	-10	-30	-50	-71	-93	-117	-141	-168	-195	-225	-257	-291	-327	-367	-410			
FLAT		25	8	-9	-28	-47	-67	-88	-110	-133	-157	-183	-210	-238	-268	-300	-334	-371	-409		

TABLE 12: Metric (°C)

For the following normal design conditions: 26.7°C Ambient • -9.0 ± 0.1 Btu/hrft² Heat Flow Limit • 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	-7	-35	-65	-128	-180	-245															
0.75	-1	-25	-52	-107	-151	-205															
1.00	-6	-27	-54	-87	-124	-169	-225														
1.50	2	-20	-57	-85	-119	-159	-214														
2.00	-1	-19	-41	-65	-92	-125	-169	-218													
2.50	0	-27	-48	-72	-99	-136	-175	-222													
3.00	1	-14	-32	-52	-75	-105	-137	-174	-231												
4.00	1	-12	-28	-47	-70	-95	-123	-164	-203	-250											
5.00	2	-10	-25	-44	-64	-86	-117	-147	-182	-222											
6.00	3	-8	-24	-40	-58	-84	-108	-135	-166	-202	-244										
8.00		-9	-22	-41	-58	-77	-98	-122	-149	-180	-216	-258									
10.00		-9	-22	-37	-52	-70	-89	-110	-135	-162	-193	-229									
12.00		-9	-21	-35	-50	-66	-85	-105	-127	-152	-181	-213	-250								
14.00		-6	-18	-31	-45	-61	-78	-97	-118	-141	-168	-198	-231								
16.00		-5	-17	-30	-44	-59	-75	-94	-114	-136	-161	-188	-220	-256							
18.00		-5	-17	-29	-43	-57	-73	-91	-110	-131	-155	-181	-211	-244							
20.00		-5	-16	-28	-42	-56	-72	-89	-107	-128	-150	-175	-203	-235							
24.00		-5	-16	-28	-40	-54	-69	-85	-103	-122	-143	-166	-192	-221	-254						
28.00		-4	-15	-27	-39	-53	-67	-83	-99	-118	-138	-160	-184	-211	-242						
30.00		-4	-15	-27	-39	-52	-66	-82	-98	-116	-136	-157	-181	-207	-237						
36.00		-4	-15	-26	-38	-51	-64	-79	-95	-112	-131	-151	-174	-198	-225	-256					
42.00		-4	-14	-25	-37	-50	-63	-77	-93	-109	-127	-147	-168	-191	-217	-245					
48.00		-4	-14	-25	-37	-49	-62	-76	-91	-107	-125	-143	-164	-186	-211	-238					
60.00		-4	-14	-25	-36	-48	-61	-74	-89	-104	-121	-139	-158	-179	-202	-227	-255				
72.00		-4	-14	-24	-35	-47	-60	-73	-87	-102	-118	-135	-154	-174	-196	-220	-246				
96.00		-3	-13	-24	-35	-46	-59	-71	-85	-99	-115	-131	-149	-168	-189	-211	-235	-262			
120.00		-3	-13	-24	-34	-46	-58	-70	-84	-98	-113	-129	-146	-164	-184	-206	-229	-254			
168.00		-3	-13	-23	-34	-45	-57	-69	-82	-96	-111	-126	-143	-160	-179	-199	-221	-245			
FLAT		-3	-13	-23	-33	-44	-55	-67	-79	-92	-105	-119	-134	-150	-167	-184	-203	-223	-245		

TABLE 12A: English (°F)For severe design conditions: 90.0°F Ambient • -9.0 ± 0.1 Btu/hrft² 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	-433														
0.75	40	-2	-48	-144	-220	-314	-349														
1.00	31	-5	-53	-110	-174	-253	-331	-437													
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	-164	-199	-237	-279	-326	-378	-436					
30.00		34	15	-4	-26	-49	-74	-100	-129	-161	-195	-232	-273	-319	-369	-426					
36.00		34	16	-3	-24	-47	-71	-96	-124	-154	-186	-222	-260	-303	-350	-402					
42.00		35	16	-2	-23	-45	-68	-93	-120	-149	-180	-214	-251	-291	-335	-384	-438				
48.00		35	17	-2	-22	-43	-66	-91	-117	-145	-175	-208	-244	-282	-325	-371	-423				
60.00		35	17	-1	-21	-42	-64	-88	-113	-140	-169	-200	-233	-270	-309	-353	-400				
72.00		35	18	0	-20	-40	-62	-85	-110	-136	-164	-194	-227	-261	-299	-340	-385	-435			
96.00		36	18	0	-19	-39	-60	-83	-107	-132	-159	-187	-218	-251	-286	-325	-367	-412			
120.00		36	18	0	-18	-38	-59	-81	-104	-129	-155	-183	-213	-245	-279	-316	-356	-399	-446		
168.00		36	19	1	-17	-37	-57	-79	-102	-126	-151	-178	-207	-237	-270	-305	-343	-384	-428		
FLAT		36	19	2	-15	-34	-54	-74	-96	-118	-141	-166	-192	-219	-248	-279	-311	-346	-384		

TABLE 12A: Metric (°C)For severe design conditions: 32.2°C Ambient • -9.0 ± 0.1 Btu/hrft² Heat Flow Limit • 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	-1	-28	-57	-118	-168	-231	-258														
0.75	4	-19	-44	-98	-140	-192	-212														
1.00	0	-20	-47	-79	-114	-158	-212	-261													
1.50	3	-14	-50	-77	-110	-148	-201	-261	-261												
2.00	4	-13	-34	-57	-84	-116	-158	-204	-261												
2.50	5	-21	-41	-64	-90	-126	-164	-209													
3.00	7	-8	-25	-44	-67	-96	-127	-163	-217												
4.00	7	-6	-22	-39	-62	-86	-113	-153	-191	-236											
5.00	8	-4	-18	-37	-56	-77	-108	-137	-170	-209	-255										
6.00	9	-2	-18	-33	-51	-76	-99	-125	-155	-190	-230										
8.00		-2	-15	-34	-50	-69	-90	-113	-139	-169	-203	-243									
10.00		-3	-16	-30	-45	-62	-81	-101	-125	-151	-181	-215	-254								
12.00		-2	-15	-28	-43	-59	-76	-96	-118	-142	-169	-200	-235								
14.00		0	-11	-24	-38	-53	-70	-88	-109	-131	-157	-185	-218	-255							
16.00		0	-11	-23	-36	-51	-67	-85	-104	-126	-150	-176	-207	-241							
18.00		0	-10	-22	-35	-50	-65	-82	-101	-121	-144	-169	-198	-230	-266						
20.00		0	-10	-22	-35	-49	-64	-80	-98	-118	-140	-164	-191	-221	-256						
24.00		1	-9	-21	-33	-47	-61	-77	-94	-112	-133	-155	-180	-208	-239						
28.00		1	-9	-20	-32	-45	-59	-74	-91	-108	-128	-149	-173	-199	-228	-260					
30.00		1	-9	-20	-32	-45	-59	-73	-89	-107	-126	-147	-169	-195	-223	-254					
36.00		1	-8	-19	-31	-43	-57	-71	-86	-103	-121	-141	-162	-186	-212	-241					
42.00		1	-8	-19	-30	-42	-55	-69	-84	-100	-118	-136	-157	-179	-204	-231	-261				
48.00		1	-8	-18	-30	-42	-54	-68	-83	-98	-115	-133	-153	-174	-198	-224	-252				
60.00		2	-7	-18	-29	-41	-53	-66	-80	-95	-111	-129	-147	-167	-189	-214	-240				
72.00		2	-7	-18	-28	-40	-52	-65	-79	-93	-109	-125	-143	-163	-184	-207	-232	-259			
96.00		2	-7	-17	-28	-39	-51	-63	-77	-91	-106	-122	-139	-157	-177	-198	-221	-247			
120.00		2	-7	-17	-28	-39	-50	-63	-76	-89	-104	-119	-136	-153	-172	-193	-215	-239	-265		
168.00		2	-7	-17	-27	-38	-49	-61	-74	-87	-102	-116	-132	-149	-167	-187	-208	-231	-255		
FLAT		2	-6	-16	-26	-37	-47	-59	-71	-83	-96	-110	-124	-139	-155	-172	-191	-210	-231		

RECOMMENDED INSULATION THICKNESSES FOR PERSONNEL PROTECTION

SURFACE TEMPERATURE $\leq 140^{\circ}\text{F}$ (60°C)

TABLE 13: English (inches)

Hot Pipe Worst Case 80.0°F Ambient for Surface Temperature $\leq 140.0^{\circ}\text{F}$: 0.40 Surface Emittance • 0.0 mph Average Wind Velocity

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
DEG F	FOAMGLAS® INSULATION THICKNESS, INCHES															
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	2.5	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	3.0	3.5	3.5	3.5	3.5	4.0	4.0	4.0	4.5
700.0	2.5	2.5	2.5	3.0	3.5	3.5	3.5	4.0	4.0	4.5	4.5	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 $\leq 60.0^{\circ}\text{C}$: 0.40 Surface Emittance • 0.0 kmph Average Wind Velocity

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
DEG C	FOAMGLAS® INSULATION THICKNESS, MM															
93.3	38.1*	38.1*	38.1*	38.1*	38.1*	38.1*	38.1*	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1
148.9	38.1*	38.1*	38.1*	38.1*	38.1*	38.1*	38.1*	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1
204.4	38.1*	38.1*	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	50.8	50.8	50.8	50.8	50.8	50.8
260.0	38.1	38.1	38.1	50.8	50.8	50.8	63.5	63.5	63.5	63.5	63.5	76.2	76.2	76.2	76.2	76.2
315.6	50.8	50.8	50.8	63.5	63.5	76.2	76.2	76.2	88.9	88.9	88.9	88.9	101.6	101.6	101.6	114.3
371.1	63.5	63.5	63.5	76.2	88.9	88.9	88.9	101.6	101.6	114.3	114.3	127.0	127.0	127.0	127.0	139.7
426.7	63.5	76.2	76.2	88.9	101.6	114.3	114.3	127.0	139.7	139.7	152.4	152.4	152.4	165.1	165.1	190.5
482.2	76.2	101.6	101.6	114.3	127.0	127.0	152.4	152.4	165.1	177.8	177.8	190.5	190.5	203.2	203.2	241.3

MAXIMUM HEAT FLOW = 194.1 KCAL/HR SQ M

TABLE 13A: English (inches)

Hot Pipe Worst Case 80.0°F Ambient for Surface Temperature $\leq 140.0^{\circ}\text{F}$: 0.90 Surface Emittance • 0.0 mph Average Wind Velocity

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
DEG F	FOAMGLAS® INSULATION THICKNESS, INCHES															
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	2.0	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	4.5	5.0	5.0	5.0	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 $\leq 60.0^{\circ}\text{C}$: 0.90 Surface Emittance • 0.0 kmph Average Wind Velocity

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
DEG C	FOAMGLAS® INSULATION THICKNESS, MM															
93.3	38.1*	38.1*	38.1*	38.1*	38.1*	38.1*	38.1*	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1
148.9	38.1*	38.1*	38.1*	38.1*	38.1*	38.1*	38.1*	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1
204.4	38.1*	38.1*	38.1*	38.1*	38.1*	38.1*	38.1*	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1
260.0	38.1*	38.1*	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	50.8	50.8	50.8	50.8	50.8	50.8
315.6	38.1	38.1	38.1	38.1	50.8	50.8	50.8	50.8	50.8	50.8	63.5	63.5	63.5	63.5	63.5	63.5
371.1	38.1	50.8	50.8	50.8	63.5	63.5	63.5	63.5	76.2	76.2	76.2	76.2	88.9	88.9	88.9	88.9
426.7	50.8	63.5	50.8	63.5	76.2	76.2	88.9	88.9	88.9	88.9	101.6	101.6	101.6	101.6	114.3	114.3
482.2	63.5	63.5	76.2	76.2	88.9	88.9	101.6	101.6	114.3	114.3	127.0	127.0	127.0	139.7	139.7	152.4

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

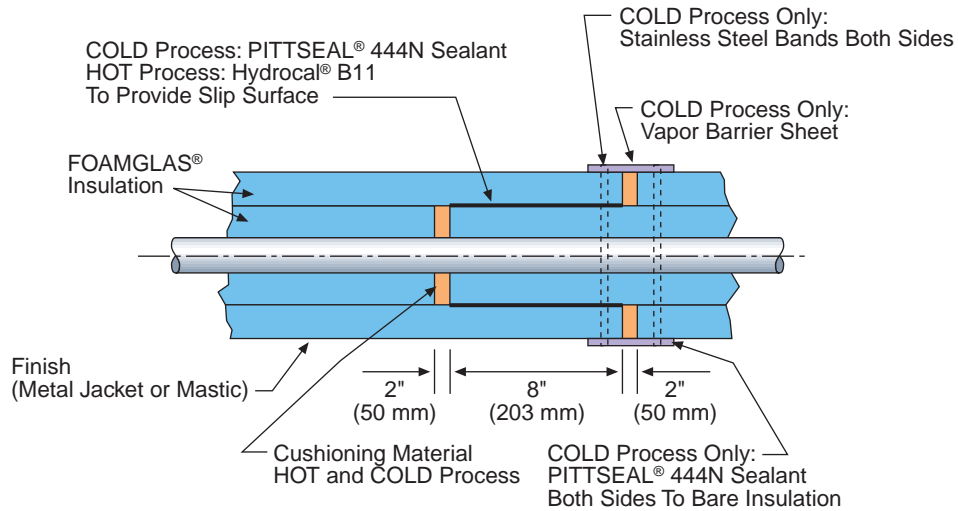


FIGURE 10: Vertical Contraction Joint

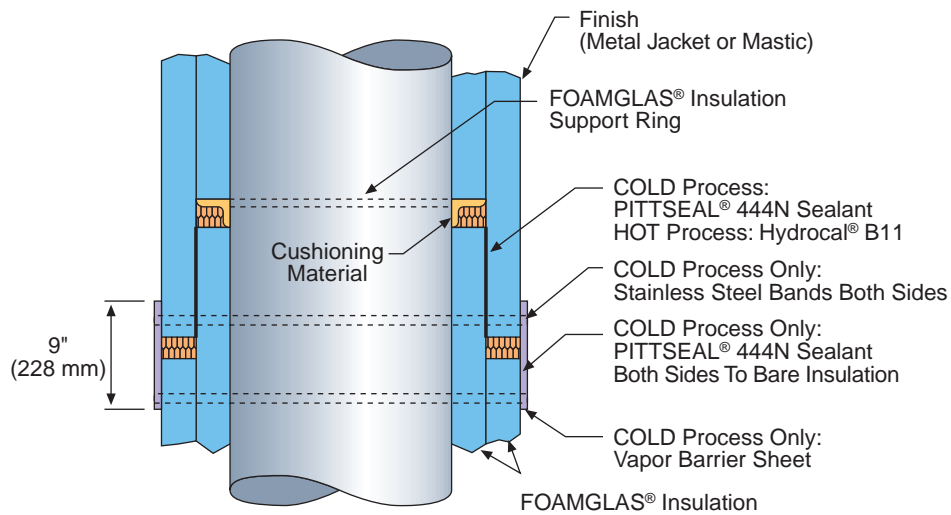
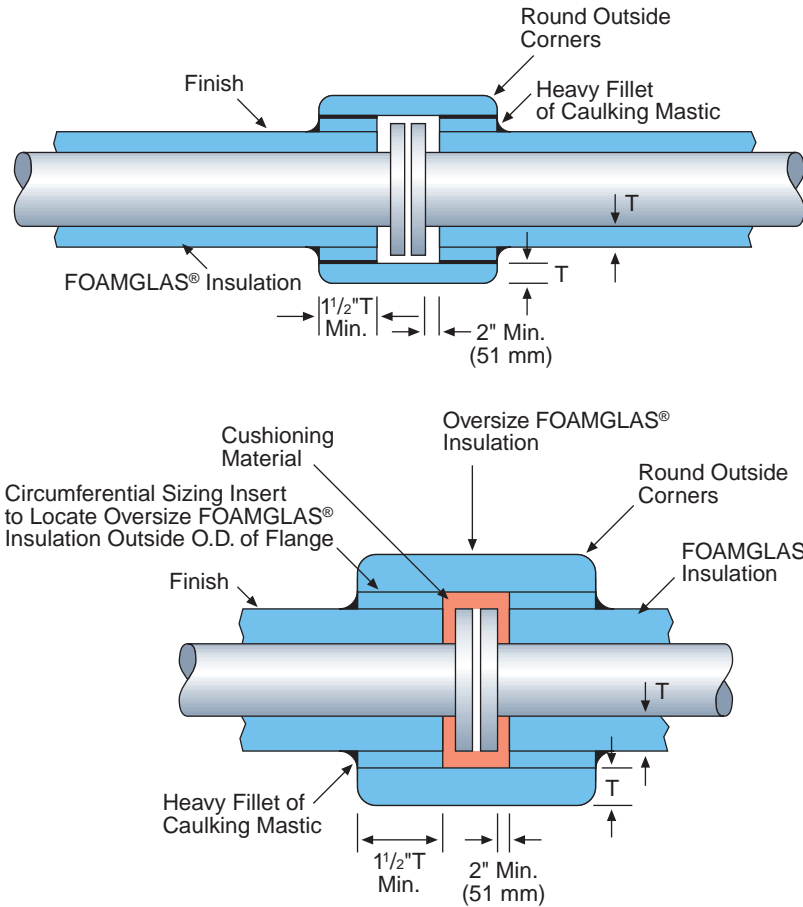
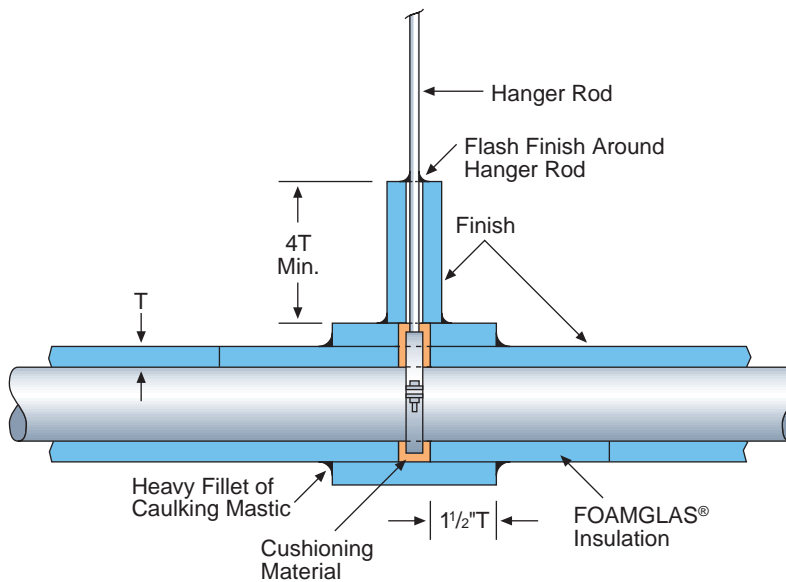


FIGURE 11: Insulation on Line Flanges**FIGURE 12: Pipe Hanger Assembly Insulation**

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).

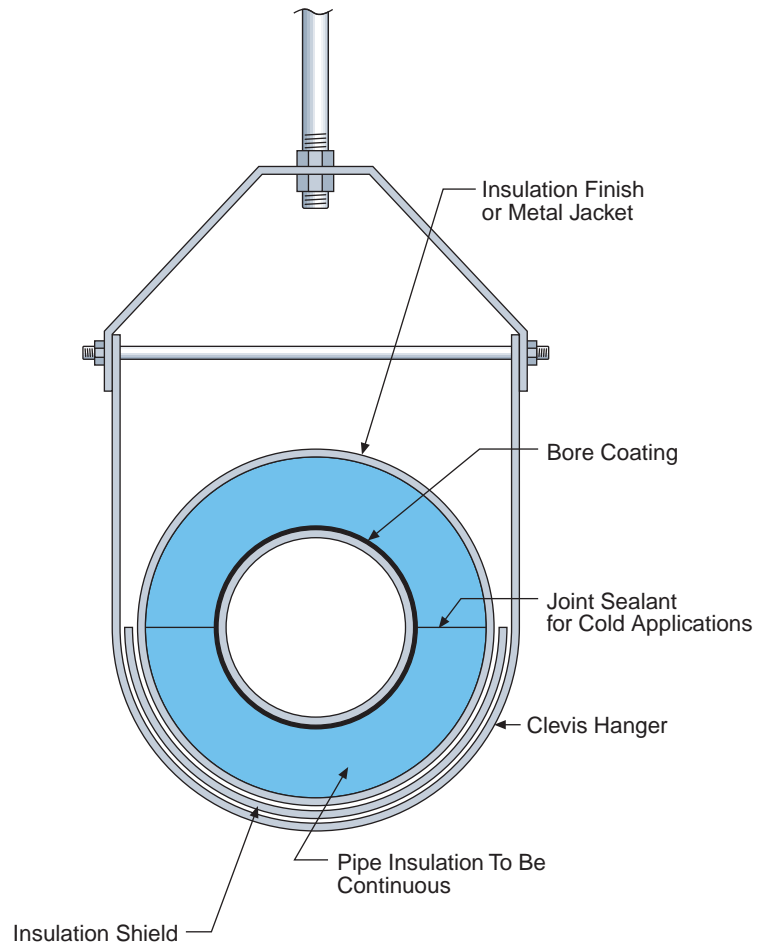
Pipe Supports and Hangers

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)



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 Corporation to ensure that current details and revisions are incorporated. Pittsburgh Corning Corporation 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. On systems which operate below 35°F (2°C), all joints in the insulation should be sealed with a low permeability joint sealant. The use of a joint sealant in the 36°F (2°C) to ambient temperature range may be optional.

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). On systems operating below 35°F (2°C) all joints shall be sealed with joint sealant. The use of a sealant in the temperature range of 35°F (2°C) to ambient is optional. 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.

Adhesives

PC® 88 ADHESIVE. A multi-purpose, two component adhesive for adhering FOAMGLAS® insulation to itself or to other porous or non-porous 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.

PC® HI-TEMP/RTV SILICONE ADHESIVE. A one-part, acetoxycure, silicone adhesive/sealant formulated for use at high temperatures. It cures to an elastomeric solid at room temperature. Service temperature range: -62°F to 500°F (-52°C to 260°C).

PC® RTV 450 SILICONE

ADHESIVE. A one-part, acetoxycure, 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°C).

Sealants

PITTSEAL® 444N SEALANT. Non-setting 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.

PITTSEAL® 727 SEALANT.

A specially formulated styrene-butadiene rubber sealant used for sealing joints in FOAMGLAS® insulation systems, and to seal protrusions and metal jacket laps. Stainless steel compatible. Preferred for chilled water applications.

Coatings

PITTCOTE® 300 COATING. Vapor and weather barrier asphalt coating especially formulated for use with FOAMGLAS® insulation. Service temperature range: low to moderate.

PITTCOTE® 404 COATING.

A highly flexible acrylic latex coating used with FOAMGLAS® insulation where a superior weather barrier coating is required. Service temperature range: low to moderate.

Fabric

PC® FABRIC 79. An open mesh synthetic fabric for reinforcing PITTCOTE® 404 or PITTCOTE® 300 coating over FOAMGLAS® insulation. Service temperature range: low to moderate.

Jacketing

PITTWRAP® jacketing is a 125 mil (3.2 mm) thick heat-sealable, multi-ply laminate for protecting underground FOAMGLAS® systems with outer surface temperatures below 190°F (87.7°C).

PITTWRAP® 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. PITTWRAP® jacketing may also be factory-applied on the insulation.

PITTWRAP® SS jacketing is a 70 mil (1.8 mm) 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. PITTWRAP® SS jacketing may also be factory-applied on the insulation.

PITTWRAP® SS jacketing consists of a polymer modified bituminous compound reinforced with a woven glass fabric and a 1 mil (0.03 mm) aluminum top film and release paper backing.

PITTWRAP® CW Plus jacketing is a 50 mil (1.3 mm) thick self-sealing, modified bituminous membrane for protecting underground FOAMGLAS® insulation systems on chillwater and hot service* pipelines. Manual pressure seals the jacketing without the use of a torch or heater. PITTWRAP® CW Plus jacketing may also be factory-applied on the insulation.

PITTWRAP® CW Plus jacketing consists of a polymer modified bituminous compound reinforced with a glass fabric and a 1 mil (0.03 mm) aluminum top film and release paper backing.

PITTWRAP® CW30 jacketing is a 30 mil (0.8 mm) thick self-sealing, modified bituminous membrane for protecting above ground FOAMGLAS® insulation systems on chillwater and hot service pipelines. Manual pressure seals the jacketing without the use of a torch or heater. Metal jacketing must be used over the PITTWRAP® CW30 jacketing for UV protection. PITTWRAP® CW30 jacketing cannot be factory-applied on the insulation.*

PITTWRAP® CW30 jacketing consists of a polymer modified bituminous compound reinforced with a 4 mil (0.1 mm) high density cross laminate polyethylene top film and release paper backing.

* Do not use in underground tunnels/trenches where jacketing will be exposed to air temperatures in excess of 140°F (60°C).

Miscellaneous

ANTI-ABRASIVE 2A. An oil modified urethane coating designed for use as a bore coating or anti-abrasive coating for FOAMGLAS® insulation. Temperature range: very low to moderate.

HYDROCAL® B-11. A reactive gypsum product which when mixed with water forms an inorganic, non-combustible adhesive or coating for fabricating or bore coating FOAMGLAS® insulation.

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 and above temperatures to 900°F (482°C) where stress-crack corrosion is a concern with stainless steel.



LEARN MORE AT...
www.foamglasinsulation.com

ADDITIONAL BROCHURES AVAILABLE FOR PITTSBURGH CORNING CORPORATION FOAMGLAS® PRODUCTS:

Underground Direct-Buried Applications (FI-213)
StratFab® System (FI-222)
AdVantage® System (FI-227)
Chilled Water Brochure (FI-188)
Roofing/Plazas/Parking Decks (FB-180)

FOR COMPLETE DATA ON FOAMGLAS® INSULATION SYSTEMS, CONTACT PITTSBURGH CORNING'S MARKETING DEPARTMENT

CORPORATE HEADQUARTERS
800 Presque Isle Drive
Pittsburgh, PA 15239-2799
724-327-6100
800-359-8433
Fax: 724-325-9704

SALES OFFICES
Houston, Texas
713-664-1191
Fax: 713-664-2641

INTERNATIONAL
Pittsburgh Corning
International Sales
Corporation
724-327-6100
Fax: 724-733-4815

CANADA
Edmonton, Alberta
780-424-2640
Montreal, Quebec
514-866-9100

PITTSBURGH CORNING
FOAMGLAS®
INSULATION



The information contained herein is accurate and reliable to the best of our knowledge. But, because Pittsburgh Corning Corporation has no control over installation, workmanship, accessory materials or conditions of application, NO EXPRESS OR IMPLIED WARRANTY OF ANY KIND, INCLUDING THOSE OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, IS MADE as to the performance of an installation containing Pittsburgh Corning products. In no event shall Pittsburgh Corning be liable for any damages arising because of product failure, whether incidental, special, consequential or punitive, regardless of the theory of liability upon which any such damages are claimed. Pittsburgh Corning Corporation provides written warranties for many of its products, and such warranties take precedence over the statements contained herein.

FOAMGLAS®, PC®, PITTCOTE®, PITTWAP®, PITTSEAL®, Advantage®, and StrataFab® are registered trademarks owned by Pittsburgh Corning Corporation.

Hydrocal® is a registered trademark of U.S. Gypsum Company.