Compressive Strength

For many insulation applications (including cryogenic and low-temperature tank bottoms, insulated pipe supports and hangers, underground pipe vessels, parking decks/plazas, roof applications and docks), superior compressive strength performance is a prerequisite. Here, strength is required both in the line of duty itself and in order to withstand external mechanical abuse, such as foot or vehicular traffic.

PROBLEMS

- *Tanks*

  In low-temperature and cryogenic-temperature tank bottom applications, insufficient insulation compressive strength can lead to unacceptable settling. This can result in loss of thermal efficiency, ground heaving and foundation temperatures falling to levels that may cause major failures. And if the settlement is uneven, the steel bottom may rupture and spill the tank's contents.

  For high-temperature tank bottoms, poor insulation compressive strength leads to settlement and thermal performance loss which interferes with a stable environment, causing loss of viscosity control or solidification of the contents.

- *Digester*

  Without reliable, structurally supportive insulation, semi-underground conical digesters working at medium temperatures will settle, lose thermal efficiency and disrupt the stable digester environment.

- *Floors*

  For industrial floors requiring thermal insulation, heavy equipment/machinery loads and vibration or vehicle and foot traffic can seriously compromise the performance of non-load-bearing insulations and lead to unbalanced equipment and process disruptions.

- *Underground Insulated Systems*

  High compressive strength is mandatory for direct burial of insulated pipes and vessels without additional structural support. When properly designed, these applications permit above-ground traffic without any negative effect on the system.

- *Pipe Supports and Hangers*

  An insulation material which has a high compressive strength enables the designer to eliminate potential problems. Direct thermal short circuits can be totally avoided or substantially reduced. Geometrical changes in the steel pipeline, occuring as the result of settlement or failure of the insulated pipe supports, can also be avoided. This reduces the possibility of significant stress on the pipeline, particularly at nozzles, flanges and fittings.

- *Live Loads*

  Pipelines and the tops of spheres and domed tanks are subject to "live loads"—foot traffic, ladders, impact loads and other severe mechanical abuse. These loads can create jacketing gaps or cause damage to vapor barriers permitting water and water vapor to enter the insulation system, reducing thermal efficiency and causing potential corrosion.

- *Roof Decks*

  On fluted, metal decks, equipment dead loads and foot traffic cause insulation boards to fracture, splinter and degenerate, severely compromising the structural integrity of the boards. This can result in split and ruptured membranes.

- *Self-Supporting Walls*

  Insulation in the walls of many industrial buildings, and in some types of chimney construction, must have the mechanical strength to support itself. Walls of storage facilities also require flexural strength to resist wind pressure between the supporting structural members. Without these inherent strengths, the insulation system will collapse.

- *Deformation vs. Compressive Strength*

  Compressive strength is a measure of the stress at which a material fails under load, while deformation is structural distortion of the material, with or without actual failure. For foamed plastics, fibrous and calcium silicate insulations, compressive strength is typically measured when deformation reaches 5% to 25% of the thickness (dependent on the test method used).

  The result of reporting compressive strength at a percentage of deformation (and at various insulation densities) puts the onus on the specifier to determine which deformation data most accurately reflects the real application at hand. Because of the substantial deformation of foamed plastics in service, especially with today's thicker insulation systems, additional engineering considerations must also be taken into account. Otherwise, connections, flanges, etc. may be subject to stresses and potential ruptures.

COMPRESSIVE STRENGTHS OF VARIOUS MATERIALS		
Insulation Material	**Compressive Strength**	
	psi	**kPa**
FOAMGLAS® Insulation	100	689
Polyisocyanurate	15-30 @ 10% def.	207
Polystyrene	10-45 @ 5-10% def.	310
Phenolic	22@10% def.	152
Fiberous Glass	2.3@10% def.	16
Mineral Fiber	10@10% def.	69
Calcium Silicate	100@5% def.	689
Perlite	90@5% def.	620

- *Effects of Time and Temperature on Compressive Strength*

  The specifier should be aware of the potential adverse effects of long-term creep and strength variations caused by high temperatures.

  German studies on foamed plastics by H. Zehender have shown that for phenolics and urethanes, compressive strength at 10% deformation is reduced by more than 50% with a temperature increase from 68°F to 266°F (20°C to 130°C). The reduction is even higher for Polyvinylchloride (PVC) foam.

  In other Zehender tests of temperature influences over time, polyurethane foam under a moderate 3 psi (0.2kg/sq.cm) load at 266°F (130°C) exhibited thickness deformation of up to 10% after 75 days.

  Because deformation and strength reduction can seriously affect performance, higher engineering safety factors are generally assigned to cellular plastics and fibrous materials.

SAFETY FACTORS

- *Effects of Load Direction*

  Another influence which can affect an insulating material's compressive strength is the direction of the load in relation to the foaming direction. This is particularly important with foamed plastics.

  Published data for urethane foam (with densities from 1.8 to 2.3 pcf 28.8 to 36.8kg/cubic m) indicate a compressive strength of 34 psi (2.4kg/sq.cm) parallel to the foam rise and 23 psi (1.6kg/sq.cm) perpendicular to the rise. For phenolic foam (2.2 pcf/35kg/cubic m), it is 25 psi (1.8kg/sq.cm) parallel to the rise, versus 14 psi (1.0kg/sq.cm) perpendicular.

SAFETY FACTORS

		Compressive Strength (PSI)	
Insulation	**Safety Factor_**	**Nominal_**	**Practical_**
FOAMGLAS® Insulation	3	87-175[4]	29-58[4]
Foamed Plastics (ambient)	4	22-45	5.5-11
Foamed Plastics (to 140°F/60°C)	8	22-45	3-5.5
Fibrous Materials	4	2.5-10	0.6-2.5
Perlite Insulation Board	4	90-100	22.5-25

1. Source: I. Sauberbrunn, "Industriefussböden," International Colloquium for Industrial Floors, 1987.
2. From Previous Tables.
3. Compressive Strength Adjusted for Safety Factors.
4. For flat block capped per ASTM C240.

- *Grades of FOAMGLAS® Insulation*

  FOAMGLAS® insulation is available in seven grades—all offering substantial levels of compressive strength. From 87 psi in FOAMGLAS® insulation to 232 psi in FOAMGLAS® insulation HLB 1600, you can make the right compressive strength decision by choosing Pittsburgh Corning FOAMGLAS® insulation.

DENSITY AND COMPRESSIVE STRENGTH

Grade of FOAMGLAS® Insulation HLB Insulation	Nominal Lot Avg. Density		Compressive Strength (Tested According to ASTM C-240/C-165)					
			Average			Lower Spec. Limit		
	Kg/m^3	pcf	N/mm^2	psi	kg/cm^2	N/mm^2	psi	kg/cm^2
HLB 800	120	7.5	0.80	116	8.12	0.55	80	5.6
HLB 1000	130	8.1	1.00	145	10.15	0.69	100	7.0
HLB 1200	140	8.7	1.20	174	12.18	0.83	120	8.4
HLB 1600	160	10.0	1.60	232	16.24	1.10	160	11.2

Note: 0.8 N/mm_=800 kPa

The FOAMGLAS® Cellular Glass Insulation Solution

FOAMGLAS® insulation encompasses a wide variety of compressive strength requirements in its diverse grade offerings. From regular FOAMGLAS® insulation, through the HLB product line, compressive strengths range from 65 psi to 232 psi for flat ware capped as per ASTM C-240.

FOAMGLAS® insulation offers the solution to meet all compressive strength needs.