3M™ Glass Bubbles
For Buoyancy and Thermal Insulation

Go Deep

High strength, low-density hollow glass microspheres for critical deepwater components

3M

At these depths, only the strongest survive

Over the past forty years, oil and gas recovery operations have been pushing farther and farther out to sea – creating a growing need for materials that can survive the harsh, unforgiving conditions encountered in deepwater environments.

During that time, 3M™ Glass Bubbles have proven their ability to help meet those increasingly complex challenges – by delivering an ideal balance of performance, cost effectiveness and long-term survivability.

3M glass bubbles are high strength, lightweight additives used for density reduction, thermal insulation and buoyancy in many kinds of syntactic foam compositions. Available in pressure ratings from 250 to 27,000 psi, and densities ranging from 0.125 g/cc to 0.6 g/cc, 3M glass bubbles help improve reliability and reduce costs in a variety of demanding applications, including underwater pipelines, risers, buoys, ROVs, moorings and other components used in deepwater oil exploration and production.

3M™ Glass Bubbles For Buoyancy

The ideal combination of high strength and low density has made 3M glass bubbles an industry-standard additive for syntactic foams used in buoyancy modules, buoys, moorings, or buoyancy blocks for undersea vehicles. When 3M glass bubbles are formulated with resin, the resultant syntactic foam has a high strength to density ratio to provide maximum net buoyancy for a given depth rating.

On drill string risers, for example, buoyancy modules prevent the steel casing from collapsing under its own weight at depth, and protect the drill string against ocean currents.

Product	Density	Strength	Calculated Density g/cc syntactic foam
K1	0.125	250	0.64
K15	0.15	300	0.65
K20	0.20	500	0.67
XLD3000	0.23	3000	0.68
K25	0.25	750	0.70
S32	0.32	2000	0.73
S35	0.35	3000	0.74

Assumptions for calculated density: 50% by volume loading of 3M Glass Bubbles in a resin system with a cured density of 1.14 g/cc, assuming no air entrainment in the final foam and no glass bubble volume losses during processing.

Photo of insulated manifold courtesy of FMC Technologies, Inc.

Cover image of ROV courtesy of Deep Sea Systems International, Inc.

3M™ Glass Bubbles For Thermal Insulation

The need to operate at greater depths and with longer subsea tiebacks has spurred the development of flowline and riser insulation that is lighter, stronger and offers lower heat transfer.

Conventional flowline constructions, such as "pipe-in-pipe," are proving to be impractical and too costly for use at today's greater depths of 10,000 ft (3,000 m) and more. Although pipe-in-pipe offers the best U-value (insulating value) and longest cool-down times, the added weight and bulk of its construction can make it more difficult and costly to lay, and too heavy to support in deeper waters, of particular concern for risers.

As an alternative, wet insulated pipe – consisting of a single pipe coated with 3M glass bubble-filled syntactic foam insulation – is less than half the weight of pipe-in-pipe, making it more practical for use at greater depths and in longer runs. Because this construction reduces overall pipeline diameter, more pipe can be wound per spool, requiring fewer and smaller ships – making installation faster, easier and more economical. Because of these and many other factors, wet pipe insulation now accounts for the majority of all new deep water subsea flowlines.

The high strength and low thermal conductivity (0.06 to 0.20 W • m^{-1} • K^{-1} @ 20°C) of 3M glass bubbles make them ideal additives for use in wet pipeline and riser insulation. These inert particles are compatible with all other typical components of the insulating system, including polyurethane, polypropylene and epoxy. What's more, 3M glass bubbles are virtually insoluble in water, providing better utility in underwater applications.

Meeting today's challenges

Rapid advances in technology are enabling the development of new glass bubbles with unprecedented strength to density ratios – allowing their use to depths of 13,000 feet, with a safety margin of 50%.

These newest members of the 3M glass bubble family give manufacturers more flexibility to design insulation systems that meet the specific requirements of individual applications:

3M™ Glass Bubbles S42XHS are extra high strength bubbles that allow operators to achieve higher pressure ratings, to go deeper than ever before.

3M™ Glass Bubbles XLD 3000/XLD 6000 are extra low density bubbles that offer significantly less weight, for better thermal conductivity at a given depth rating.

At today's greater depths, syntactic foam insulation, made with 3M™ Glass Bubbles, offers a more practical, light weight alternative to pipe-in-pipe constructions, as in this insulated flexible flowline, for example.

Strength	3M™ Glass Bubble	Bubble Crush Strength (psi)	Bubble Density (g/cc)	Calculated Thermal Conductivity* (W•m^{-1}•K^{-1})
HIGH	S42XHS	8000	0.42	0.166
	XLD6000	6000	0.30	0.143
	K46	6000	0.46	0.173
	S38XHS	5500	0.38	0.158
	S38HS	5500	0.38	0.158
	S38	4000	0.38	0.158
	XLD3000	3000	0.23	0.130
	S35	3000	0.35	0.152
LOW	S32	2000	0.32	0.147

* Calculated Thermal Conductivity of glass syntactic polyurethane (GSPU) foam at 40 volume % loading, assuming a thermal conductivity of 0.19 W • m^{-1} • K^{-1} for unfilled polyurethane. K values calculated @ 25°C.

The 3M glass bubbles shown in this chart are good candidates for use in pipeline insulation. It is essential, however, that the user evaluate all 3M products and determine which product is best suited for the user's specific needs.

Any 3M glass bubble can be surface treated with silane glass treatments to enhance bonding with the resin and to minimize a foam's water pickup at high pressures.

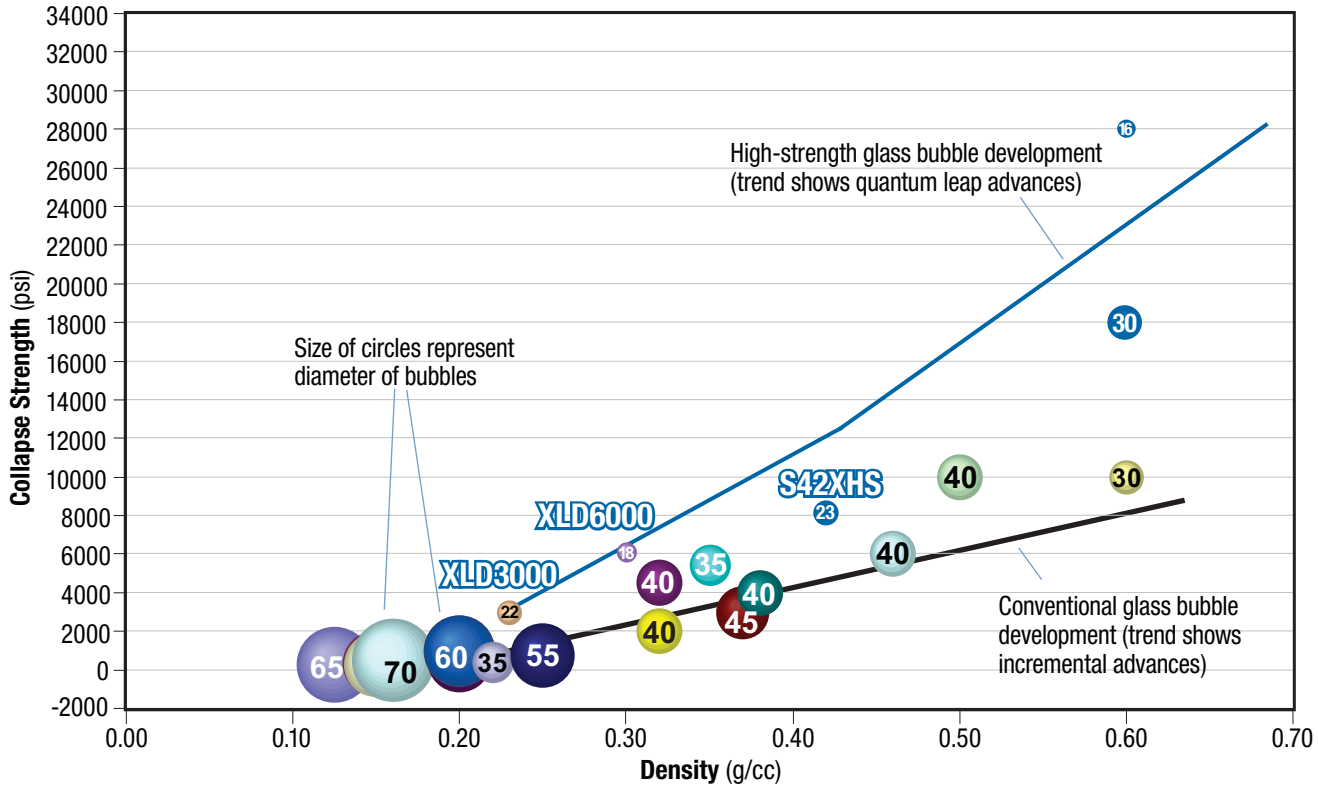
Deep Blue on the Dalia project, Offshore Angola
Photo Courtesy of Technip.

Deep Blue: Technip's deepwater pipelay vessel
Photo courtesy of Technip.

The evolution of 3M™ Glass Bubble Technology

Following their initial development, improvements in glass bubble crush strength tended to be incremental (shown by the lower, black trend line), and were accompanied by corresponding increases in density. In recent years, however, the growing need for high strength, light weight materials in many industrial sectors has led to rapid advances in glass bubble technology (shown by the higher, blue trend line).

3M™ Glass Bubble Product Portfolio
(by relative strengths and densities)



A proud history of innovation

Hollow glass bubble technology was developed by 3M in the 1960s. Riser buoyancy modules and wet pipe flowline insulation using the first glass bubble-filled syntactic foams were capable of surviving down to 5,000 feet. Today, advancements in the strength/density ratio of glass bubbles enable these materials to be used down to 10,000 feet, and development efforts are rapidly progressing to extend those capabilities to as much as 15,000 feet.

3M

3M Oil and Gas Customer Center
19416 Park Row, Suite 190
Houston, TX 77084
www.3M.com/oilandgas

Oil and Gas Business
3M Center, Building 223-6S-04
St. Paul, MN 55144-1000

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