3M Science. Applied to Life.™

3M™ Glass Bubbles

# Start something big, by thinking small.

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Imagine a fleet of jet aircraft that can fly further on less fuel. More efficient ways to drill for oil 10,000 feet below sea level. Cars with a smaller carbon footprint. Paint that helps keep homes cooler on hot, sunny days.

In all these ways and more, one tiny product is making a big difference. Incredibly light and surprisingly strong, 3M™ Glass Bubbles are found in more places than you'd expect. **From the depths of the sea to the edge of space, and everywhere in between, these tiny spheres help the world go 'round.**

# Envision a new world of possibilities.

## Tiny bubbles. Big impact.

Derived from nature's simplest shape, 3M™ Glass Bubbles are free-flowing powders consisting of thin-walled hollow glass microspheres. They have a high strength-to-density ratio, so they are both lightweight and strong enough to survive processing. Made of soda-lime borosilicate glass, these additives are chemically inert and water resistant. 3M glass bubbles feature a smooth, nonporous surface, and their spherical shape offers a variety of advantages over irregularly-shaped additives or fillers.

3M glass bubbles are used as additives in an astonishing variety of products. For example, they reduce the weight of cement used to reinforce oil wells and are used in underwater pipe insulation, making it possible to extract more oil from the bottom of the sea. As an ingredient in the plastic parts of your car, glass bubbles help reduce vehicle weight – improving fuel efficiency, so you don't have to fill up as often. 3M glass bubbles can be formulated into quick-drying, low-shrinkage spackling and other construction materials. And they provide a wide range of additional benefits in applications ranging from sporting goods to solar reflective paint.

Around the world, 3M glass bubbles are helping to increase productivity…meet new design challenges…enhance product performance…and turn "what's possible" into "what's next."

# Applications for 3M™ Glass Bubbles

## Rubber & Plastic

- Injection molded components and extruded profiles
- Sheet molding compounds (SMC) and bulk molding compounds (BMC)
- Automotive, aerospace and marine transportation
- Electronics and appliances
- Furniture and molded décor
- Packaging films
- Polymer/wood composites and siding
- Sporting goods

## Construction Materials

- Caulks and sealants
- Cultured marble
- Mastics
- Paints and coatings
- Potting compounds
- Preformed concrete
- Putties
- Spackling
- Spray-up/lay-up

## Mining, Oil & Gas

- Buoyancy modules and risers
- Deepsea pipe and flowline insulation
- Emulsion explosives
- Lightweight cement slurries
- Low-density drilling fluids
- Syntactic foam

# The science of the spheres

The spherical shape of 3M™ Glass Bubbles provides a variety of inherent advantages over irregularly-shaped mineral fillers or glass fiber.

## Reduced resin demand

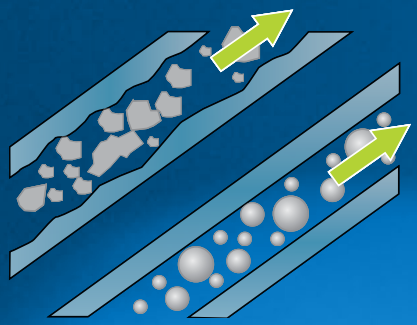
The sphere offers the least surface area per volume of any shape. That allows 3M glass bubbles to help reduce resin demand in a variety of applications — for lower raw material costs.

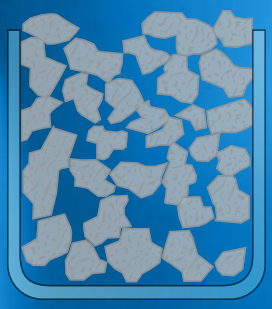
## Specific Surface Area

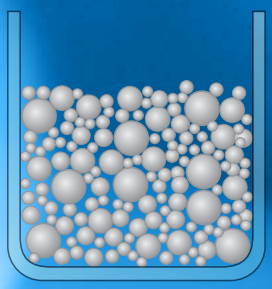
| Filler Product | Surface Area ($m^2/g$) |
|---|---|
| 3M™ Glass Bubbles | **1.9–2.7** |
| Talc | 3.2–14 |
| Clay | 7.0–21 |
| $CaCO_3$ | 1.0–10.5 |

## Improved flow

Because of their spherical shape, glass bubbles behave like tiny ball bearings, easily rolling over one another. This can help improve the flow of many materials to which 3M glass bubbles are added, and can make it easier to form final parts with complex geometries.







## Higher volume loading

Because they enable lower resin demand, 3M glass bubbles can also allow higher filler loading at equivalent viscosities. That can mean less solvent is needed to maintain a workable viscosity, resulting in lower shrinkage and significant weight reduction in certain applications. And for hydrocarbon based solvent systems this may result in a relatively low VOC system.

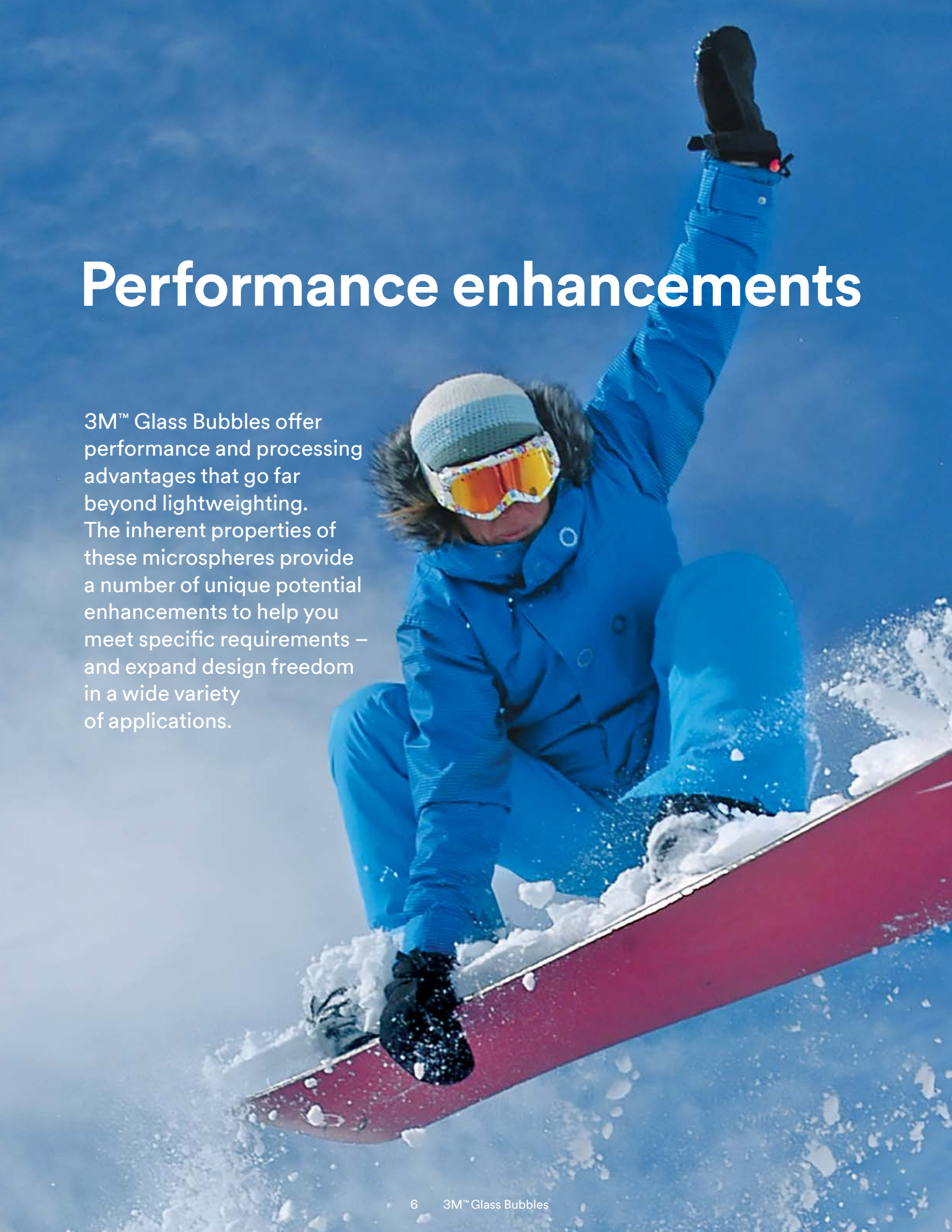
## Cost effectiveness

Lightweight 3M glass bubbles occupy up to 20x more space than an equal weight of typical mineral filler. This means that, when you consider the cost per unit volume instead of price per pound, 3M glass bubbles can be a cost-effective choice in many applications – especially when you factor in the enhancements possible with 3M glass bubble technology.

**Calcium carbonate** **3M™ Glass Bubbles**

# Performance enhancements

3M™ Glass Bubbles offer performance and processing advantages that go far beyond lightweighting. The inherent properties of these microspheres provide a number of unique potential enhancements to help you meet specific requirements – and expand design freedom in a wide variety of applications.



## Weight reduction

3M™ Glass Bubbles are used to reduce weight in applications from plastics, thermosets and sheet- or bulk-molded composites to structural foams and elastomers. 3M™ Glass Bubbles iM16K, for example, enable weight reductions of 15% or more in many polypropylene systems, and 18% or more in glass fiber-filled polyamide parts. All without requiring significant material or process changes, and without compromising the mechanical integrity of the finished product.

The resulting lighter weight parts not only have greater consumer appeal, but can also contribute to environmental sustainability through better fuel economy.

## Dimensional stability

3M glass bubbles can reduce shrinkage and warpage in plastics, spackling compounds, wood composites and other materials – helping to reduce rejects and reprocessing. They allow high filler loading, which can improve part stiffness and dimensional stability, and allow molten polymer to cool homogenously, helping prevent sink marks and uneven solidification. Plus, 3M glass bubbles provide more uniform stress distribution to help prevent warpage in plastics filled with high aspect ratio fillers.

## Productivity & cycle time

In injection molding and extrusion processes, low-density 3M glass bubbles displace mass that would otherwise need to be heated or cooled. As a result, glass bubble-filled resins cool faster – helping manufacturers produce more parts per hour while achieving weight reduction targets. Cooling time reductions of up to 15–25% have been reported in production-scale use.

## Sustainability

The benefits of lightweighting have an obvious impact in the transportation sector, but customers across many industries can benefit from the lower cost of shipping lightweight parts.

In addition, some plastics made with 3M glass bubbles may be recyclable, and can be re-ground as many as five times with minimal change in properties. The glass bubble fraction of these plastics raises few, if any, issues during disposal, because they are made from an inert glass.

## Thermal insulation

The addition of 3M™ Glass Bubbles to a resin system can decrease thermal conductivity, depending on the grade and amount of microspheres used.

The low thermal conductivity of 3M glass bubbles makes them ideal for use in thermally insulating syntactic foams for deepsea applications. Other potential applications include “cool-touch” steering wheels and other interior automotive components subject to heating by the sun, and interior paints that help reduce condensation in moist environments.

# Performance enhancements

## Water Resistance

3M glass bubbles are made of soda-lime borosilicate, which is a true glass with inherently greater water resistance than borosilicate glass bubbles (water glass). 3M glass bubbles maintain integrity even when boiled in water for more than 40 minutes—whereas borosilicate glass bubbles dissolve.

## Buoyancy

Their combination of high strength and low density has made 3M glass bubbles a “go-to” additive for syntactic foams used in buoys and buoyancy modules. These foams can help prevent a drill riser casing from collapsing under its own weight at depth; on ROVs, they allow for high net buoyancy rated to any ocean depth. In other applications, 3M glass bubbles have been used to make rubber fishing boots and other articles light enough to float.

## Nail and screw acceptance

Wood/polymer composites can be harder to work with than real wood, because it is difficult for nails and screws to penetrate the dense polymer. The addition of 3M glass bubbles provides greater void volume: the glass bubbles break when a screw or nail is driven into the composite. This makes the material more easily “nail-able,” like real wood—so it takes less time and less pressure to nail or screw into composite decking.

## Machinability and sandability

Parts or tooling compounds containing 3M glass bubbles can often be easier to cut, sand, machine and shape. They also provide better surface definition and render sharper contours and corners in extruded profiles. Glass bubble-filled autobody filler is easier to file and sand with less gouging, and with less clogging of tools.

## Dielectric constant

The hollow nature of 3M glass bubbles gives them a low dielectric constant, making them useful for producing lightweight materials with desired electrical properties. Applications include printed circuit boards, radomes and packaging materials

## Harmonics

The addition of 3M glass bubbles can reduce noise and vibration, helping improve harmonics of the finished part.

## Antiblock & permeability

When used as antiblocking agents, 3M glass bubbles can help create space between film layers to prevent them from adhering to each other. And because 3M glass bubbles are made of inorganic glass, they will not absorb penetrant molecules — helping reduce the overall permeability of materials to which they are added.

## Solar reflectivity

The spherical shape of 3M glass bubbles reflects light effectively in all directions. Their unique optical properties may make 3M glass bubbles useful for producing light diffusing panels and solar reflective films, building materials, paints and coatings. Potential applications include greenhouses, exterior walls, roof coatings, or outdoor storage or refrigerated tanks.

## Surface appearance

Class A paintable surface finishes have been successfully achieved using 3M glass bubbles with smaller particle sizes. Other grades of 3M glass bubbles can be used to deliver custom aesthetic effects such as translucency, gloss control in coatings, or “pebble finish” texturing on appliances and electronics. The hollow nature of glass bubbles also causes light to scatter, delivering a clean-looking white surface at a lower weight than titanium dioxide ($TiO_2$).

## Typical Physical Properties

(Not for specification purposes.)

| Property | 3M™ Glass Bubbles |
|---|---|
| Shape | Hollow spheres with thin walls |
| Composition | Soda-lime-borosilicate glass |
| Color, unaided eye | Off-white, powdery |
| Crush strength (90% survival) | 250–27,000 psi |
| True density | 0.125–0.60 g/cc |
| Median particle size | 18–65 microns |
| Softening temperature | 600°C (1112°F) |
| Thermal conductivity | 0.05–0.20 W•m-1•K-1 @ 20°C |
| Dielectric constant (@ 100 MHz) | 1.2–1.9 |

3M glass bubbles are available in a wide range of grades with varying densities, crush strengths and particle diameters. Here are some general guidelines to get you started:

### For polymer applications

For high-pressure applications or high-shear processes such as injection molding, consider our iM Series.

For general weight reduction applications that don't require high-shear processing, consider our K and S Series.

For a smoother surface finish, consider grades with a smaller particle size, such as iM16K, S60 or K42HS.

For applications requiring improved mechanical properties such as impact strength and stiffness, consider 3M glass bubbles with surface treatment.

### For oil & gas applications

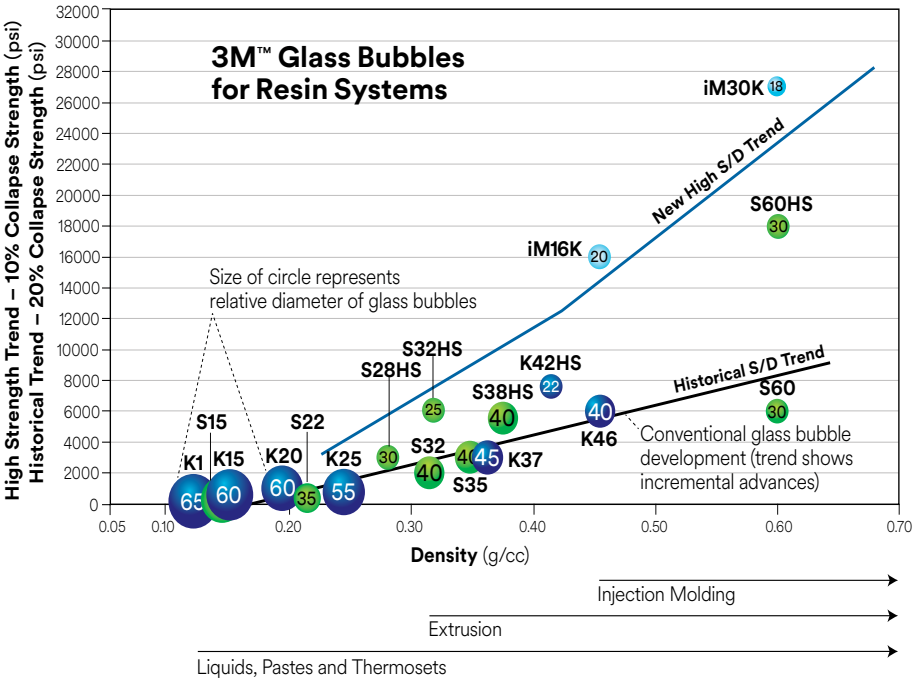
For drilling fluids and cements, consider our HGS Series.

For syntactic foams for thermal insulation and buoyancy, consider our S Series.

More than one option may be appropriate for your product or process. Contact your 3M technical representative for help selecting the optimal grade for your application.

## Strength, density and size:

Find the right balance for your application.



## Typical Physical Properties

(Not for specification purposes.)

| Grade | Crush Strength, psi | Minimum Fractional Survival, % | True Density, g/cc | Particle Size (50%), microns by volume* |
|---|---|---|---|---|
| **3M™ Glass Bubbles - K, S, iM and XLD Series** | | | | |
| **K1** | 250 | 80% | 0.125 | 65 |
| **K11** | 200 | 80% | 0.11 | 65 |
| **K15** | 300 | 80% | 0.15 | 60 |
| **S15** | 300 | 85% | 0.15 | 55 |
| **S22** | 400 | 80% | 0.22 | 35 |
| **K20** | 500 | 80% | 0.20 | 60 |
| **K25** | 750 | 80% | 0.25 | 55 |
| **S32** | 2,000 | 80% | 0.32 | 40 |
| **XLD3000** | 3,000 | 90% | 0.23 | 30 |
| **S28HS** | 3,000 | 90% | 0.28 | 30 |
| **S35** | 3,000 | 80% | 0.35 | 40 |
| **K37** | 3,000 | 80% | 0.37 | 45 |
| **S38** | 4,000 | 80% | 0.38 | 40 |
| **S38HS** | 5,500 | 80% | 0.38 | 40 |
| **S38XHS** | 5,500 | 90% | 0.38 | 35 |
| **S32HS** | 6,000 | 90% | 0.32 | 25 |
| **K46** | 6,000 | 80% | 0.46 | 40 |
| **K42HS** | 7,500 | 90% | 0.42 | 22 |
| **S42XHS** | 8,000 | 90% | 0.42 | 22 |
| **S60** | 6,000 | 90% | 0.60 | 30 |
| **iM16K** | 16,000 | 90% | 0.46 | 20 |
| **S60HS** | 18,000 | 90% | 0.60 | 30 |
| **iM30K** | 27,000 | 90% | 0.60 | 18 |
| **3M™ Glass Bubbles - Floated Series** | | | | |
| **A16/500** | 500 | 80% | 0.16 | 60 |
| **A20/1000** | 1,000 | 88% | 0.20 | 60 |
| **H20/1000** | 1,000 | 80% | 0.20 | 60 |
| **D32/4500** | 4,500 | 80% | 0.32 | 40 |
| **H50/10,000 EPX** | 10,000 | 90% | 0.50 | 35 |
| **3M™ Glass Bubbles - HGS Series** | | | | |
| **HGS2000** | 2,000 | 80% | 0.32 | 40 |
| **HGS3000** | 3,000 | 80% | 0.35 | 40 |
| **HGS4K28** | 4,000 | 80% | 0.28 | 30 |
| **HGS4000** | 4,000 | 80% | 0.38 | 40 |
| **HGS5000** | 5,500 | 80% | 0.38 | 40 |
| **HGS6000** | 6,000 | 80% | 0.46 | 40 |
| **HGS10000** | 6,000 | 90% | 0.60 | 30 |
| **HGS8000X** | 8,000 | 90% | 0.42 | 22 |
| **HGS18000** | 18,000 | 90% | 0.60 | 30 |
| **HGS19K46** | 19,000 | 80% | 0.46 | 20 |

*3M QCM 193.2

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