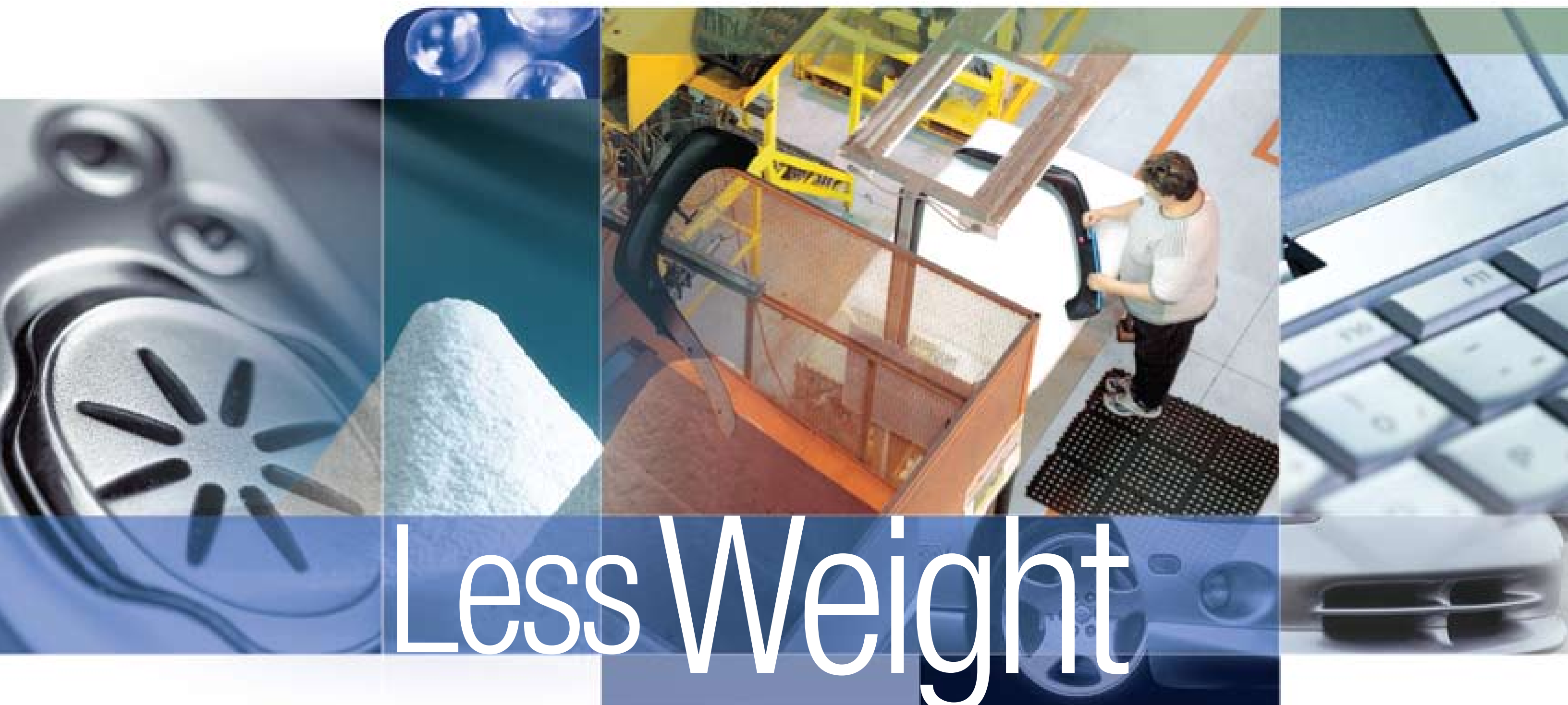
3M™ Glass Microspheres

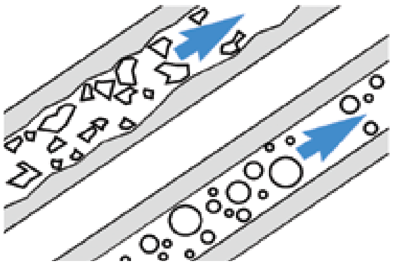
Compounding and Injection Molding Guidelines



Less Weight More Muscle

LESS WEIGHT MORE MUSCLE

3M™ Performance Additive iM30K is the world's first hollow glass microsphere capable of withstanding injection molding and extrusion pressures of 30,000 psi. The product is 40% stronger than 3M's previous leading high strength glass microspheres and, at 17 microns, is approximately half their size.



Unlike irregularly-shaped fillers, 3M glass microspheres roll easily over one another. This helps increase volume loading capacity, reduce shrinkage, reduce warpage and lower resin demand. It can also help reduce warpage in many molded plastic parts.

Introduction

3M™ Glass Microspheres are advanced, low-density additives used in a variety of industrial applications. They are available in a wide range of densities and crush strengths, including our newest glass microsphere: **3M™ Performance Additive iM30K**, capable of surviving most compounding and molding processes. These microscopic spheres of soda-lime/ borosilicate glass are water insoluble, chemically stable and offer a high strength-to-weight ratio.

Because of their spherical shape, glass microspheres behave like tiny ball bearings, causing them to flow within a liquid polymer much better than common mineral fillers. As a result, the impact on rheology (viscosity, melt-flow, etc.) is significantly less than the impact caused by mineral fillers. A benefit of this is the ability to form highly-filled parts and/or parts with more complex geometries more easily. This can mean lower mold temperatures and lower injection pressures than would be possible when molding polymers filled with mineral fillers. In addition, the spherical shape (aspect ratio of 1.0) often improves the dimensional stability of the polymer composite, resulting in less shrinkage and warpage.

3M glass microspheres are compatible with most common thermoplastics, including polypropylene, nylon, ABS and others.

Courtesy of AP Plasman

3M Glass Microspheres for Compounding/Injection Molding

Glass Microspheres Type	**Density** (g/cc)	**Isostatic Crush Strength** (psi)*
iM30K	0.6	28,000
S60HS	0.6	18,000
S60	0.6	10,000
K46	0.46	6,000
S38HS	0.38	5,500

* Isostatic Crush Strength refers to the pressure at which an average lot of material has 90% or higher survival.

Note: The purpose of these guidelines is to provide basic information to customers for use in evaluating and developing their own processes for compounding and injection molding using 3M glass microspheres. The information provided is general or summary in nature, and is offered to assist the customer. The information is not intended to replace the customer's careful consideration of the unique circumstances and conditions involved in the use and processing of 3M glass microspheres and other products. The customer is responsible for determining whether this information is suitable and appropriate for the customer's particular use and intended application.

Compounding

To compound polymers with 3M™ Glass Microspheres, 3M recommends the use of a compounding extruder, such as a twin-screw extruder or a Buss Kneader, with a downstream feedport for adding the glass microspheres to the polymer melt. The extruder screw flights beyond this point should be set up to impart a minimum amount of shear stress. Distributive mixing elements, such as gear mixers, are preferred. Aggressive dispersive mixing elements, such as reverse flight elements and kneading blocks, are not recommended. Single screw extruders are generally not recommended because they typically do not have a downstream port and often contain "barrier" designs or other narrow tolerance/high shear features. A system designed for adding chopped fiberglass to a polymer would be a suitable starting point when developing a low shear extrusion system for glass microspheres.

Feeding

In order to minimize glass microsphere breakage, it is preferable to add the glass microspheres downstream from where the polymer is melted, rather than into the feedport with the polymer pellets. An auger-driven side feeder at the downstream port, rather than a simple open hopper, will provide the most consistent feeding behavior. Although not as critical as feed location or method, it is further advisable to minimize extruder screw speed and to minimize extruder outlet pressure.

Glass microspheres should be fed with an automated feeder. Although a volumetric feeder should produce satisfactory results, a gravimetric feeder – ideally one equipped with a twin shaft – is preferred. It is recommended that the microspheres be supplied to the feeder automatically; for example, using an automated vacuum feed system with a pre-hopper.

Like other fillers, glass microspheres can entrain some air into the polymer during feeding and compounding. If entrained air in the final compounded pellets is undesirable, use a vacuum vent downstream of the glass microsphere feed port. Information on glass microsphere handling can be found on pages 6–7.

Glass microspheres will become fluidized when aerated (which often occurs when initially filling a hopper) and this may lead to flooding of the hopper. To help prevent flooding, it is recommended that the feeder discharge be covered until the hopper is filled with glass microspheres. Upon filling, the glass microspheres at the bottom will become de-aerated, and the feeder discharge may be uncovered in order to begin compounding. The hopper level should be maintained to at least 30% of its filled capacity, to prevent flooding during operation.

Pelletizing

Any pelletizing method suitable for the polymer of choice is suitable for a system containing glass microspheres. For plastics highly-filled with glass microspheres, it might be advisable to use an under-water strand pelletizer or water slide pelletizer.

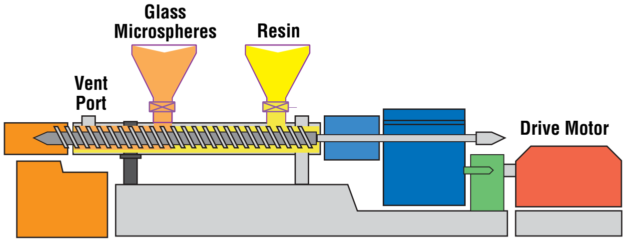


Fig. 1 Typical setup on a twin-screw extruder

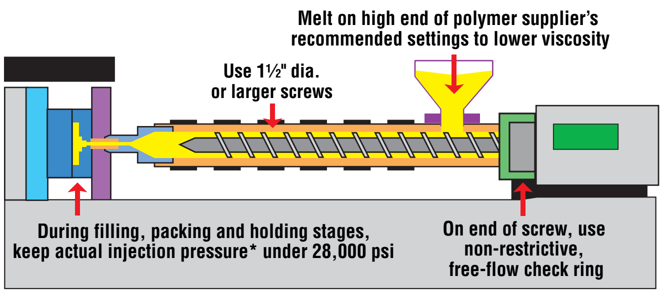
Injection Molding

3M™ Glass Microspheres, can be used with all high performance engineered thermoplastics, such as TPO, TPU, PBT, PEEK, PPS and nylon. Their high strength and spherical shape minimize warpage and shrinkage, providing more control over finished part dimensions.

This also gives them the ability to form highly-filled parts more easily, allowing lower mold temperatures and lower injection pressures.

Operating Parameters

Barrel Sizing	Compression Ratio	Injection Speed Low injection speed recommended.
iM30K	Low compression screw, typically 2:1 to 3:1	**Note:** Glass microsphere-filled materials are subject to surface defects at high injection velocities. Careful control of the velocity profile will help to avoid or minimize these defects.



* Use intensification factor to calculate actual injection pressure – see page 5.

Processing Start-Up

All thermoplastics require unique start-up conditions. Some even require slightly different start-up conditions, depending upon the grade and the supplier. Because the addition of 3M glass microspheres will change the viscoelastic properties of the polymer, 3M recommends observing the following guidelines:

1. Slightly reduce the usual fill and screw speeds. At higher loading percentages, these speeds may need to be reduced even further.
2. Set the temperature at the upper end of the operating range in all zones.

Experimentation to optimize results is recommended.

Equipment and Tooling Considerations

Although **3M™ Performance Additives iM30K** and 3M™ S60HS Glass Microspheres are quite strong, they can be broken under extreme conditions. Therefore, part/mold design and processing should attempt to minimize the shear stress on the material.

A general-purpose, three-zone screw (feed, compression and metering) is recommended for processing compounds mixed with 3M high-strength glass microspheres. A L/D ratio of 16:1 to 22:1 is recommended for the metering section of the screw. The transition or compression zone should have a ratio between 2:1 and 2.5:1. For single flight extruder screws, 3M recommends that the feed and transition stages consist of 7 flights each, and the metering stage 6 flights. Dispersive mixing screws, such as barrier, vented or double wave, are not recommended for use with 3M glass microspheres. Distributive mixers are acceptable.

To allow smooth melt flow, a 100% "free flow , highly polished," fluted screw tip valve assembly is recommended. A generous nozzle/sprue orifice dimension (0.25 in./5.5mm) is recommended. The nozzle orifice or sprue orifice should be without sharp edges and have suitable dimensions of at least 0.25 inches.

For optimum mold filling, gate designs should incorporate full, round runners – the runner is cut in both plates – with an area of 0.5 square inches (comparable to about 0.125 radius). Modified trapezoidal runners, which do not require special alignment features (like the full round runners) can also be used. The cross-sectional area of the modified trapezoidal runner should be the same as a full round runner, which is 0.5 square inches.

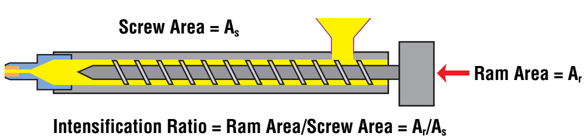
The sprue used for processing hollow glass microspheres should be short, having a radius of 0.125 inches towards the nozzle, which is then tapered to 0.172 inches at the other end.

3M recommends using end-gated and/or fan-gated designs. Direct gating, with high injection pressures, can cause excessive microsphere breakage. A minimum gate thickness of 0.06 inches should be used.

Unlike other highly-filled plastics, those filled with 3M glass microspheres do not contribute to premature mold and tooling wear. 3M recommends the following:

- For long production molds, use tool steel hardened to Rockwell C-60+; for example, 4-20SS, S-7, H-13.
- Vent cavities at the end of the fill to minimize trapped gasses
- Use largest-possible size gates
- Reduce injection speeds
- Machining marks can increase wear. A 4 microinch (.0001mm) or better finish is recommended. Mold plating can also extend mold service life.
- Fan or parallel, edge gated designs have shown less bubble breakage, compared to direct gated designs
- The pressure used to inject the resin into the mold should be below 25,000 PSI, as calculated using the hydraulic pressure multiplied by the machine's intensification ratio = screw area/ram area (see diagram below, generally around 10X). Hydraulic pressure generally is reduced by increasing the melt temperature of the resin.
- Some resin systems can be sensitive or degraded by the presence of the bubbles.The bubbles are pH basic and can react with PC and PC blends (PC/ABS), Polyester and some Fluoroplastics. Please contact your 3M representative for applications in these resins.

Courtesy of AP Plasman



Temperature Settings

Compounds containing 3M glass microspheres typically require higher mold temperatures than unfilled polymers. Melt on the high end of the polymer supplier's recommended temperature settings, to help lower viscosity and achieve a smoother, blemish-free surface.

Regrinding

Regrinding creates the potential for excessive glass microsphere breakage, which can result in loss of desired physical properties of the polymer. It is recommended that regrind be mixed with adequate quantities of virgin pellets, and part testing be performed to ensure desired results are achieved.

Troubleshooting

Problem	Possible Cause	Possible Solution
Increased part density (higher than theoretical)	Excess glass microsphere breakage	Reduce melt pressure during mold filling and packing stages
Mold not completely filled (“short shot”)	Viscosity increase caused by addition of glass microspheres	Increase mold temperature
Surface Defects	Viscosity change; non-uniform dispersion of glass microspheres	Reduce injection speeds and/or increase mold temperature

Courtesy of AP Plasman

Bag Unloading Guidelines

Bulk Bag

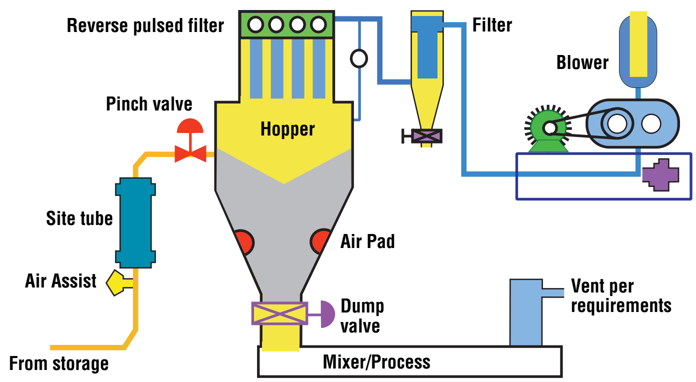
3M™ Glass Microspheres are available in approximately 50 cubic foot (1.4 cubic meter) bulk bags with a polyethylene liner and ten-inch bag lifting loops. The liner has a 22 in. (50.56m) diameter by 26 in. (0.66m) long discharge spout in the base. The filled bag size is approximately 45 in. W × 45 in. L × 46 in. H (1.14m × 1.14m × 1.17m). Bags are stacked two per pallet then wrapped with a stretch film. The maximum shipped height is 104 in. (2.64m). The pallet is a two-way entry type. Typical shipping is in a “high cube” trailer or a 40 foot “high cube” seagoing shipping container. Bags are not returnable.

Vacuum Conveying

The vacuum transport system is a pull only conveying system. The pull system operates at a negative pressure, below atmospheric pressure. It may use a venturi, two-stage fan or a positive displacement blower (illustrated) to move the air that carries the material. The vacuum system will move material at higher line velocities than the pump system. The advantage is that it does not leak particles into the work area. This system is not prone to line plugging problems. The primary filter is usually cleaned with pulsed, high-pressure, clean, dry air. A secondary filter is placed after the receiver filter in order to protect the fan or blower. An adjustable vacuum relief valve regulates vacuum in the receiver. Typical suction is 50 to 100 inches of water column. A hopper sight panel and cone aeration is suggested.

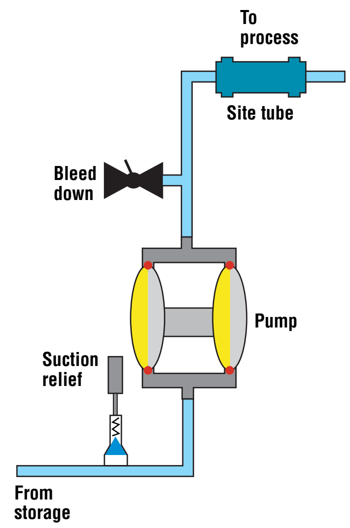
Sight Windows and Sight Tubes

Sight windows and sight tubes allow observation of material flow in order to locate a problem in the transfer system. Suggested mounting locations are at the pump outlet or the bottom of vertical legs, or optionally at the receiving vessel entrance. Sight tubes use Pyrex™ glass or transparent PVC schedule 80 tubing. Grounding with a wire across the length of the sight tube is suggested. Polycarbonate material is suggested for windows.



Double Diaphragm Pump

Typically, a three-inch pneumatic double-diaphragm pump is used to move lightweight powders. It is a lower cost method that effectively transfers aerateable low bulk density powders. The air-driven pump is a combination pull/push, vacuum-pressure conveying system. The pump pulls material by vacuum into its inlet, then pushes the material along the conveying line with pressure. In the pressure conveying system poor line connections will leak dust into the workplace. The pump should be placed closer to the process rather than near the box in order to pull material a longer distance. This will reduce line plugging. Purge air added into a pump chamber when it is pushing material into the line helps to decrease pump plugging and stalling. Often a vacuum relief valve is mounted close to the pump suction port. A bleed down valve at the pump outlet is suggested for relieving pressure from a plugged line or pump. Purging of the pump and the conveying system with air or other compatible gas is suggested before and after glass microsphere transfer.



Flow Aids

Air assists in the conveying line are used to keep conveying lines trouble-free. They are typically mounted at the bottom of vertical line legs and about every fifty feet in horizontal line runs. Air pads mounted near the discharge port in hoppers are suggested to help fluidize material for easy transfer.

Conveying Lines and Hoses

Conveying lines connect the various system components for glass microsphere handling. Typically, a transfer system uses 3 in. (76mm) components. Glass microspheres should be transferred with a line velocity of less than 1200 ft/min (300 m/min). Lines with long radius bends or sweeps are suggested instead of ninety degree elbows. Lines can be combinations of rigid and flexible materials. All conveying lines and all components should be electrically grounded. Hoses with a smooth inner bore and a conductive drain wire are suggested. The drain wire must be connected to metal connectors. Flexible lines may range from braided chemical hose, semitransparent PVC, clear polyurethane to interlocking metal hose. Note, however, that some hoses are limited to use above 20°F (-7°C).

Safety and Handling

Before using or handling 3M™ Glass Microspheres, please read and follow the precautions and directions for use contained in the product label and Material Safety Data Sheet.

Due to the low weight and small particle size of 3M glass microspheres, dusting may occur while handling and processing. To minimize the dusting potential, injection molders and compounders should consider the following during handling:

- Do not open glass microspheres packages until they are ready to use.
- When opening the packages, place an air siphon near the package to pull away airborne particles. A dust collection system may be required–check your local OSHA regulations.
- Remove the glass microspheres with a suction wand (with slight positive pressure aeration) and transfer to a closed mixing tank inside fully-contained piping. If a closed mixing tank is not available, use dust collection equipment as close as possible to the point of entry. Pneumatic conveyor systems have been used successfully to transport glass microspheres without dusting from shipping containers to batch mixing equipment. Equipment vendors should be consulted for equipment recommendations.
- Static eliminators should be used to prevent static buildup.

For worker protection, please consider the following:

- Use chemical safety goggles for eye protection when working with 3M glass microspheres.
- For respiratory system protection, wear an appropriate NIOSH-approved respirator. Refer to the 3M glass microspheres Material Safety Data Sheet for additional information about personal protective equipment.
- Use an appropriate ventilation/dust collection system in the work area.

United States
3M Energy and Advanced Materials Division
800 367 8905

Brazil
3M do Brasil Ltda.
5519 3838 7000

Canada
3M Canada Company
800 364 3577

Europe
3M Belgium N.V.
32 3 250 7521

India
3M India Limited
Bangalore
9080 2231414

China
3M China Ltd.
86 21 6275 3535

China
3M Hong Kong Limited
852 2806 6111

Taiwan
3M Taiwan Limited
886 2 2704 9011

Korea
3M Korea Limited
82 2 3771 4114

Japan
Sumitomo 3M Limited
813 3709 8250

Philippines
3M Philippines, Inc.
63 2 813 3781

Singapore
3M Singapore Pte. Ltd.
65 454 8611

Malaysia
3M Malaysia Sdn. Berhad
60 3 706 2888

New Zealand
3M New Zealand Ltd.
64-9-444-4760

Australia
3M Australia Pty., Ltd.
61 2 9498 9333

Other Areas
651 736 7123 (U.S.)

Energy and Advanced Materials Division
3M Center
Building 223-6S-04
St. Paul, MN 55144-1000
www.3M.com/microspheres

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