

FIELD GUIDE
GLASS BEAD



INTRODUCTION

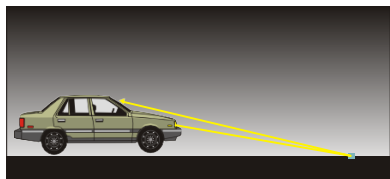
This field guide is intended to serve as a quick reference for the proper installation of glass beads in order to assure quality and long-lasting reflective pavement markings. If you have any questions about proper installation techniques, or any other information contained herein, please contact your local sales representative or Swarco Customer Service.

GLASS BEADS & RETRO-REFLECTIVITY

Glass Beads

Glass beads perform an important function of traffic safety because of their retroreflective properties, which permit the motorist to clearly see the pavement markings at night as well as in daytime.

The optical property of glass bead spheres by which they direct light back to the driver (auto headlight) is known as retroreflection. The intensity of the retroreflected light returned to the source of illumination is one measure of the quality of the road marking.



Measuring Reflectivity

Reflectivity can be checked by using an instrument called a Reflectometer. This is usually a portable device that is engineered to measure the intensity of retro-reflected light at a given geometry (30-meter geometry is the standard) and distance typical of a car headlight. Reflectivity is reported in millicandelas per square meter per lux ($\text{mcd}/\text{m}^2/\text{lux}$).



Example of a Reflectometer: LTL 2000

30-meter geometry means that the distance from the observer to the illuminated point of interest is 30 meters in length. By using mathematical models and equations, the instrument simulates this condition and electronically takes the measurement of the reflected light of the pavement marking line.

For more accurate readings and consistent data, we recommend you:

- always read and follow the manufacture's instructions,
- calibrate equipment before using,
- consult agency specifications,
- choose 30 foot sections of the newly applied line and take an average of 10 readings (one every 3 feet) in each section.

For further questions on measuring reflectivity or measuring equipment, consult reflectometer manufacturer and government agency specifications

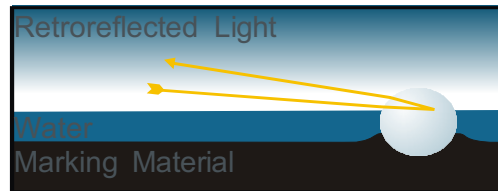
Wet / Night Visibility

Under dry conditions, conventional glass beads provide effective retro-reflective visibility. However, in **wet / night conditions**, conventional glass beads are not as effective because a thin film of water covering the road marking will tend to deflect more light away from the driver, rather than reflect the light back to the driver (Specular Reflection). To improve wet / night reflectivity, larger glass beads and profile markings are used because their top surface can remain above the water film and will reflect the light back to the driver, thereby improving retro-reflectivity and driver safety.

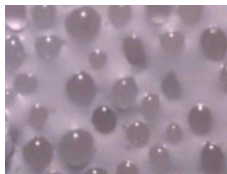
Factors That Affect Retro-reflectivity

In general, retro-reflectivity is influenced by the following:

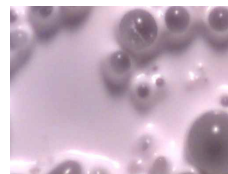
1. **Bead Coverage**
2. **Gradation**
3. **Color / Clarity / Defects**
4. **Roundness**
5. **Binder Quality**
6. **Embedment**
7. **Refractive Index**
8. **Other Application Variables (road surface, weather, etc.)**



Good bead coverage or an even distribution of glass beads is one important factor that will contribute to good retro-reflectivity.



Proper bead coverage and distribution



Poor bead coverage and distribution

Gradation refers to the size distribution of glass beads that can be used in an application. The gradation is usually determined by the State, Federal, or contractor specification.

Typical road marking specifications will range from 20 -100 U.S. Mesh. Large bead gradations can range from 12 - 30 U.S. Mesh.

The gradation or size distribution of glass beads can affect reflectivity depending on the binder thickness and type of road marking being applied. The small beads can sink in certain applications, leaving only the larger beads visible above the surface. On the other hand, if the

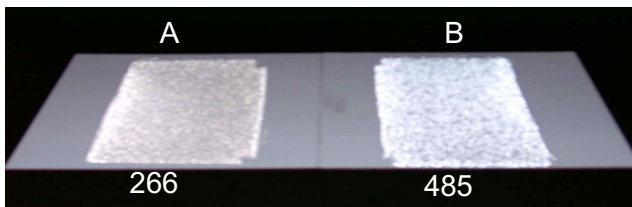
bead gradation is too large, traffic may prematurely knock the beads out of the binder system (especially with a thin, dry mil thickness binder).

Color and clarity of the glass bead will also affect reflectivity. The more transparent the glass bead and the fewer the defects or bubbles, the better the refracted image and light return.

Roundness of the beads affects the focus, refractive angle and area for light to return. Non-spherical beads will not reflect uniformly, leading to loss in overall reflectivity. Most specifications require minimum rounds from 70% to 80% for conventional beads, and 80% to 90% for large beads.

Binder color and quality will also affect retro-reflectivity levels. Binders with higher pigment loads will generally improve reflectivity even with the exact same beads. Other binder qualities such as thickness, formulation, and material composition are contributing factors to both reflectivity and the longevity of a pavement marking.

Samples (A) and (B) are two different types of waterborne paint with the exact same glass beads. Note the difference...



- **Embedment** refers to the depth the drop-on glass beads fix into the binder material. Proper embedment should be in the range of 50% - 60% of the bead diameter in order to maximize performance.

If the embedment is too deep (> 60%), not enough of the bead will be exposed to capture the light and return it to the driver. If embedment is too shallow (<50%), the beads will have a tendency to prematurely pop out of the binder material.



Good glass bead embedment



Shallow (<50%) glass bead embedment



Deep (>50%) glass bead embedment

Proper glass bead embedment is a function of many variables including binder viscosity, glass bead coating, size of the glass bead, solvent used, ambient temperature, binder temperature, equipment design and binder application.

- **Viscosity** is a measure of the flowability of the binder material - the less viscous, the more flowable the material. In the case of thermoplastic, when more heat is applied to the binder, the more it flows. (Caution: overheating of thermoplastic is not recommended)

The viscosity directly affects the way the binder will suspend the glass beads. For example, if the thermoplastic is too hot, it will allow the beads to sink faster and leave too little of the bead exposed. If the binder is not hot enough or too viscous, the beads will stay on top of the material and not embed deeply enough.

Each type of marking material or binder has different temperature and handling characteristics, so it is very important that the binder manufacturer's recommendation are followed and closely monitored during the application in order to ensure proper bead embedment.

- **Coatings** may also be added to the surface of the glass beads in order to help improve good bead embedment and adhesion. The proper coating helps promote better suspension in the binder material and improved bead adhesion.
- Glass **bead size** can make a difference when it comes to good embedment. For instance, a binder system that has long drying time and/or large mil thickness may allow smaller gradation beads to sink and become buried. In such cases larger beads may be better suited.
- **Solvent** composition and **temperature of a binder** can also make a difference in the embedment of glass beads. These factors play a major role in the viscosity, pot life, and cure time of a binder. The longer it takes for a material to cure or dry, the greater the chance that glass beads have in sinking into the material. Of equal importance are **ambient temperatures** and **equipment design**. These factors can affect the way a binder system cures and the way glass beads embed into a binder system respectively.
- The **Refractive Index** of the glass bead will determine the degree of focus that will return retro-reflected light to its source (i.e. the headlight) and is a function of different glass chemistries. In theory, the higher the index, the sharper the focus and the higher the retro-reflectivity, assuming all other variables remain constant. Conventional glass beads have a refractive index value of 1.5 which typically meets most D.O.T. and federal requirements.

GLASS BEAD COATINGS

Special chemical coatings are often applied on the surface of glass beads in order to promote adhesion to binder marking materials, or impart moisture resistance, or improve flotation properties.

General Types of Coatings		
	Abbreviation	Purpose
Adhesion Coatings	AC	Promote chemical bonding to different marking materials
Moisture Resistant Coatings	MR	Maintain free flow of beads and prevent clumping.
Flotation Coatings	FT	Prevent sinking and promote better bead suspension

#Single applications or combinations of these coatings are possible, depending on the specified material requirements. Some coatings are required according to State or Federal specifications. Otherwise, please consult with a representative to help find the proper coating for your application and binder material.

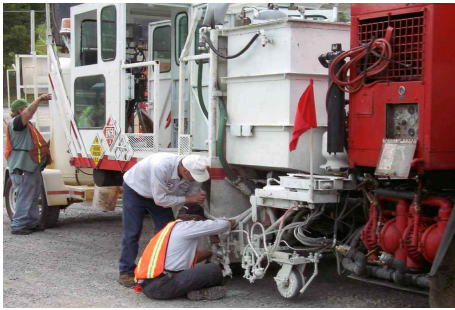
HANDLING AND STORING GLASS BEADS

Contamination of glass beads, either moisture or foreign debris, can cause malfunction of application equipment and lead to considerable delays. Therefore we suggest the following tips to help prevent such problems:

- Store material in an enclosed, dry environment.
- If outdoor storage is unavoidable, make sure the beads are entirely and securely covered with a water impermeable material.
- Keep pallets on dry ground above water level.
- Only open packaging shortly before use.
- Never leave packaging open; always cover beads after use or opening.

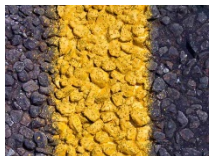
QUALITY CONTROL & APPLICATION RECOMMENDATIONS

A successful application requires proper preparation and adjustments. This applies to any and all pavement marking materials that you are using.



A successful application requires proper preparation and adjustments. This applies to any and all pavement marking materials that you are using.

- Make sure the road surface is properly cleaned and dried.
- Make sure that ambient temperatures are adequate and acceptable for application of pavement marking material. Many materials require a minimum air and surface temperature of 50°F and rising.
- If applying over an existing line, consult with agency, engineer or manufacturer prior to installation.
- When dealing with a rough or oxidized surface on asphalt or Portland cement, make sure that it is properly treated to ensure a good bond with the pavement marking material. Consult with the manufacturer of the pavement marking material and follow their recommendations.
- When dealing with rough, highly textured or chip seal surfaces, be aware that thickness of material will not be uniform. For best performance consider adding additional material to the recommended thickness to obtain a more consistent line.
- Highly textured and rough surfaces may also require additional drop-on glass beads.



Highly textured chip-seal surface



Smooth Asphalt

Choosing Your Application Requirements

Most projects will specify the materials and parameters you must meet to complete the job. If not, ask yourself the following questions to help ensure optimum results:

1. Bead Gun: Gravity or pressurized?
2. Bead Loading: How much should be applied per unit area?
3. Thickness of Binder Material: How many mils should be applied?
4. Application Speed: What speed will the binder material permit? At what striping speed will the beads embed properly and uniformly?
5. Glass Bead Gradation: Large, small, or a blend? What are the agency requirements?
6. Binder and Color: Which binder material will best meet requirements (longevity, cost, road surface, etc.)?
7. Single or Double Drop System: Will a single drop or double drop achieve the best results?

Equipment Checklist

Make sure your equipment is functioning properly so as to allow for a smooth and time efficient application. The equipment needs to be approved and accepted by a project engineer or agency.

- All devices and instrument that hold and move pavement marking materials should be in place and functioning properly.
- If the binder needs specific heating, make sure the properly recommended temperatures are set.
- Check extrusion dyes, spray guns, or nozzles for proper operation.
- Make sure the bead tanks are properly cleaned, have no cracks or leaks, and are dry (check for condensation if left outside overnight).
- Inspect the hoses that transport the beads from the tank to the bead gun (clean, no cracks, leaks, or moisture).
- Inspect the glass bead gun and make sure it is not damaged or bent. If it is a pressurized flow gun, check the valve outlet for damage or blockage.
- If using a gravity flow gun while applying large beads, make sure to calibrate the bead rate and adjust bead gun outlet valve accordingly. If not otherwise specified, follow glass bead manufacturer's recommendations and tips.

Calibrating Thickness

After the equipment has been checked and the weather conditions are acceptable, a short trial application is recommended before the full run.

Tools and devices required:

- Tar paper
- Duct tape
- Latex or heat resistant gloves
- Acetone
- Hammer
- Wire Brush
- Knife
- Micrometer or wet mil gauge
- Magnifying glass
- Camera (optional)
- Draw down plates
- Reflectometer



Determine Proper Mil Thickness

- Choose a panel type depending on the binder material you are working with (see table below).
- Measure the thickness of the panel using a caliper or micrometer and record.
- Tape these panels on the road surface area to be striped and make sure that they are secured.
- Apply a trial run onto the panels.
- Allow for cooling or drying and measure from the bottom of the panel to the top of the binder.
- Wear safety gloves!
- Use acetone or other organic solvent to clean micrometer.
- Subtract the measurement of the panel to get the approximate material thickness. Measure across entire line cross section to get average line thickness.
- Repeat above steps until proper thickness is achieved. Apply on road surface and measure again, if possible.
- If surface is highly textured or rough (i.e. Chip seal), calibrate thickness on aluminum plate and add additional material to recommended thickness. Inspect the line for uniformity, proper width and bead embedment.

Panel Materials That Can Be Used For Measuring The Line

	Aluminum	Duct Tape	Tar Paper
Water Bourne Paint	X	X	
Solvent Bourne Paint	X	X	
Thermoplastic	X	X	X
Methyl Methacrylate	X	X	
Epoxy	X	X	X
Polyurethane	X	X	
Polyurea	X	X	
Polyester	X	X	X

Quality of Line

Apply A Test Line With Glass Beads

- Make sure the bead gun and equipment are calibrated.
- Shoot a 50 ft line with drop on glass beads.
- Inspect the line when cured or dried for proper line width and uniformity.
- Brush off loose beads. Check the embedment and distribution of the glass beads with magnifying glass.

Glass Bead Adhesion Spot Test

The following two field-test methods are simple, quick methods to spot check for good bead adhesion while you are in the field. They are not quantifiable and serve only as an indicator during the application process.

The “Pull Tape” Test

- After the binder material has cured, sweep line to remove excess glass beads.
- On the surface of the line, apply a piece of duct tape, apply hand pressure and let it sit for a minute.
- Grab one end of the tape, pull hard and quickly in a single motion.
- Inspect the bottom of the tape and check for glass beads. With a magnifying glass, check the number of craters in the binder to get an estimate on glass bead loss (see picture).*

The “Wire Brush” Test

- Remove excess glass beads from the surface of the material with a household broom.
- Use a wire brush to go over the surface of the line for approximately 10 seconds.
- With a magnifying glass, count the number of craters to get an estimate on bead loss (see picture).*

*Note - If lost beads have binder material stuck to them, it is a good indication that the beads bonded well to the material.



Example of craters caused by beads loss

Quality Control During The Application

Operators should regularly check for the following during the striping operation:

- Distribution and uniformity of glass beads on the entire surface of the line.
- Embedment of the glass beads. You want 50-60% embedment for optimum results.
- Check to see if the beads are over-coated or splattered with paint. This can dramatically reduce retro-reflectivity.
- Inspect line for excessive bead sinking into the binder..
- Maintain constant parameters (temperatures, speed, pressures, etc.).
- Check application for reflectivity levels and record results in daily striping log.

Trouble Shooting Table

PROBLEM	POSSIBLE CAUSE	WHAT TO DO
Beads are clumping prior to entering gun	Moisture has accumulated and caused beads to clump	Replace with dry beads.
Concentration of beads on one side of the line	Bead gun is clogged	Clean bead gun orifice and dispenser.
	Incorrect alignment	Adjust gun alignment
	Clumped beads	Keep glass beads away from moisture.
Excessive glass bead use	Worn out gun orifice	Repair orifice or part
	Too much air pressure	Decrease the pressure
Too many beads in middle of line	Incorrect Alignment	Adjust alignment
	Bead gun control screw needs adjustment	Adjust control screw
	Bead gun shroud not correctly adjusted	Adjust shroud to correct width
	Bead tank pressure to low	Increase pressure
Glass beads are sinking	Bead gun too close to line	Adjust gun height to no less than 4"
	Pressure too high on bead gun	Reduce Pressure
	Material thickness too high vs bead loading	Correct mil thickness
	Very low binder viscosity	Adjust viscosity
Poor glass bead embedment	Bead gun too far from line	Adjust height to no less than 4"
	Binder curing too fast or slow	Adjust application temp. of binder
	Paint or binder gun not aligned correctly	Adjust alignment
Overflow of beads on roadway	Bead gun shroud too wide	Reduce the shroud width
	Bead gun too far from line	Lower bead gun height
	Excessive bead pressure	Reduce bead pressure
Pulsating bead application	Not enough tank pressure	Adjust increase in pressure or check compressor
	Blockage in bead tank line	Inspect and clean line
Reflectivity	Improper glass bead embedment	With a magnifying glass, make sure the embedment is 50-60%
	Insufficient glass beads	Adjust bead gun rate
	Binder quality	Consult Manufacturer
	Too many beads on line for the binder thickness	Reduce your bead loading and increase your striping speed

Terms & Definitions:

Ambient Temperature - the surrounding temperature at a given place and time.

Bead Loading - the concentration or weight of glass beads on a line per unit area.

Bonding - the process by which two or more separate materials adhere or fuse together via a thermal, chemical or mechanical link, i.e. Beads bonding to the binder.

Calibration - method used to standardize a process to obtain consistent and reproducible measurements.

Chip Seal - highly textured road surface composed primarily of exposed gravel rocks and asphaltic binder

Coatings - special chemicals used to treat surfaces of glass beads to impart a special quality or characteristic (i.e. flowability, adhesion)

Embedment - portion of a material or object that lies beneath the surface of another material.

Glass Bead Gradation - system used to quantify separate sizes of glass beads based on their diameters.

Gravity Flow Gun - apparatus that dispenses glass beads by simply using gravity and no other external force.

Mil Thickness - commonly used method to measure a binder material thickness: 1Mil=0.001 inch

Oxidized Surface - chemical process that results in the deterioration and physical decomposition of a surface material.

Pressurized Flow Gun- apparatus that dispenses glass beads by using air pressure as the external force.

Reflectometer - special instrument used to measure the amount of retro-reflected light.

Refraction - the bending of a light beam at the interface between two transparent media.

Retro-reflectivity - the amount of light that is returned from a glass bead back to the source.

Viscosity - resistance of a fluid to flow.

Wet/Night Visibility - a concept commonly used to describe the amount of brightness provided by a pavement marking under wet/night conditions.