Proposed Special Specification for Reflectorizing Glass Spheres

James H. Havens
Kentucky Highway Materials Research Laboratory

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MEMO TO: W. P. Ringo
Director of Traffic

In response to your request for a specification that will apply to glass beads for reflectorizing surfaces of signs, paints, and other night driving aids, we recommend the attached material which is drawn up in the form of a proposed specification. In general, the procedures and ranges of performance characteristics conform with things that have been discussed by the A.S.T.M. Subcommittee on Traffic Paints. Actually, A.S.T.M. has not adopted a specification, but probably they will have one within the next year or two.

You will note the refractive index and size distribution or gradation are referred to in the specification, but the actual requirements are left open and subject to information contained in each invitation for bids. This provides a leeway within which you can obtain beads best suited for the use which you have planned.

In general, we would expect prices to increase as the refractive index increases, but also the reflective qualities of the beads become greater. The difference between a bead with a refractive index of 1.5 (which is equivalent to ordinary glass) and a refractive index of 1.75 is so great that the effectiveness of the sign would be increased tremendously through the use of beads with the higher refractive index rather than beads of ordinary glass. You can be certain that prospective vendors are in a position to know the refractive indices of their beads, and they will not hesitate to bid with a requirement of this sort in the invitation. Incidentally, the test that we think should be used is included in the specification and it is not difficult to perform.

In his memorandum which is attached, Mr. Havens has outlined some of the considerations that you will want to give to refractive index and to size distribution. He will be glad to discuss this further if you wish, and after you have some beads of different characteristics on hand he would welcome the opportunity of making observations in different places where they are applied in order to give you some specific data on the effects of changes in refractive indices and bead sizes.
On the assumption that you will want to bring this up with the Specifications Committee eventually, I am taking the liberty of sending to Mr. Oberwarth sufficient copies to take care of all the members of that committee.

L. E. Gregg
Assistant Director of Research

LEG: DDC
Attachment
Copies to: D. H. Bray
Specifications Committee Members
MEMO TO:  L. E. Gregg
Assistant Director of Research

SUBJECT:  Proposed Special Specification for Reflectorizing Glass Spheres

In regard to the Special Specification we are proposing for reflectorizing glass spheres, the following recommendations and suggestions may be of use as a guide in selecting the general requirements (Part 1, GENERAL) of the spheres for various uses:

1. Refractive Index - It is suggested that the reflective efficiency of glass spheres with respect to their refractive indices be adjudged from the theoretical relationship shown as Fig. 7 in our report, "Spherical Lens Optics Applied to Retro-Directive Reflection." It is further recommended that favorable consideration be given to the selection of refractive indices within the range of 1.75 to 2.00 whenever economically justifiable, particularly for application to non-traffic surfaces such as signs, curbs, and islands.

   It is recognized that highly refractive glasses may not prove economically expedient for application to traffic surfaces such as centerlines, zone-stripe, or other traffic surfaces where extremely large quantities of the material would be involved. For these uses, it is suggested that the refractive index be specified as 1.50 or greater.

2. Size Distribution or Gradation - The selection of optimum gradations can be guided only to the extent of generalities and the method of application; i.e., dropping or pre-mixing.

   A. Application by Dropping - In order to assure firm anchorage in the binder, the diameter of the sphere should not exceed twice the thickness of the paint film. Estimating the average dry-thickness of the paint at 0.015 in., the corresponding maximum size sphere would be about 0.030 in. or equivalent to sizes passing the No. 20 sieve. Also, they should not be much smaller than 0.015 in., equivalent to the No. 50 sieve, because of the likelihood of total submersion and its consequences on non-traffic surfaces.
The gradation of sizes between these natural limits may be tempered somewhat by the fact that when purchases are to be made by the pound, greater economy may be derived from the selection of smaller spheres. That is, the projected reflecting area covered per pound of glass increases as the diameter of the spheres decreases. If the diameter of the sphere is reduced by one half, it takes eight times as many spheres to equal the same weight.

From the standpoint of application to non-traffic surfaces, lighter applications of paint binder and the use of commensurately smaller spheres may further extend this economic outlook. However, this possibility would have to be time-tested and proven by experience. For the present, at least, the following gradation is being recommended for use by the dropping or dusting method of application:

- 99% - 100% passing the No. 30 sieve
- 40% - 60% passing the No. 40 sieve
- 20% - 40% passing the No. 50 sieve
- 0% - 5% passing the No. 100 sieve

B. Application by Pre-Mixing - Pre-mixed spheres are, of course, not suitable for use on non-traffic surfaces. However, in view of the widespread use paints pre-mixed by manufacturers, it is not anticipated that extensive purchases of this type of sphere will be made for that particular use. These spheres are necessarily smaller in size to insure workability of the pre-mixed paint and to prevent settling. In addition to their possible use in pre-mixing, these sizes may prove to be very satisfactory for application, by dusting, to spray or brush coated fine-ground paints such as enamels for signs or guard rails.

With these two possibilities in mind, the following gradation is being proposed:

- 99% - 100% passing the No. 60 sieve
- 40% - 60% passing the No. 100 sieve
- 0% - 2% passing the No. 200 sieve

It is intended that these general requirements be modified in accordance with the practical aspects related to the use of the materials and in accordance with experience derived from observations related to application performance and serviceability characteristics. It is suggested that service comparisons be made and that records of sources and character of all materials be maintained.

James H. Havens
Research Chemist
COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS

SPECIAL SPECIFICATION NO. ___
GLASS SPHERES FOR REFLECTORIZING PAINTS,
MARKING MATERIALS AND SIGNS

This Special Specification No. ___ covers the material requirements for glass spheres to be used in the reflectorization of centerlines, zone stripes, guard rails, curbs, special signs, or any other night driving aid or safety expediency where the system of reflectorization by paint and glass spheres is applicable. This specification shall not be applicable to glass spheres incorporated by the manufacturer as an integral part of a paint-glass sphere system such as the pre-mix type paint. It shall cover all bulk quantities of the glass purchased separately for application to any selected paint-binder by such methods and dispensing apparatus devised or selected by the Department.

1. GENERAL:

Each invitation for bids shall state the general requirements for the spheres with respect to the refractive index of the glass and the size-distribution, or graduation, of the spheres commensurate with the degree of reflectivity desired and the particular use intended.

2. QUALITY REQUIREMENTS:

A. General - The spheres shall be clean, free of debris, oil, moisture, and dust. They shall flow freely and shall not cake or adhere together after one cycle of wetting and drying.

B. Color - The glass spheres shall be water-clear or shall not visibly alter the characteristic color of paint-binders or the light reflected therefrom.

C. Shape and Oddities - The particles shall be spherical in shape and shall not include more than 30% irregular shaped, milky, black, scratched, or frosted particles. Conformance with this requirement shall be determined by microscopic count.

D. Chemical Stability - The glass shall be resistant to the influence of weather such as moisture, dilute acids, and alkalies. The spheres shall withstand immersion in water, dilute acid, and alkali in accordance with the procedure outlined in paragraph C under Method of Tests.
E. Resistance to Crushing - The glass spheres shall be hard and resistant to crushing in accordance with paragraph F under Methods of Test.

3. SAMPLING:

A sampling shall consist of not less than one and not more than three 1000-gram portions taken at random from each shipment. Samples shall be submitted to the laboratory in glass jars, tins, paper or cloth bags, and shall be appropriately labeled and sealed.

4. METHODS OF TEST:

A. Color - Color shall be determined visually under daylight-type lamps or sunlight. A bulk sample observed in a white cloth or paper bag, or other uncolored container, shall appear white.

B. Shape and Oddities - A representative portion of the sample shall be dusted onto the adhesive side of a strip of adhesive-coated transparent tape (Scotch Tape) which may be secured to a glass plate by additional pieces of tape at each end. The mounted specimen shall be observed with the aid of a microscope of suitable magnification and 100 adjacent particles observed for oddities.

Three 100-particle counts shall be made on each sample and the average of the number of odd-shaped, black, scratched, or frosted particles shall be reported as the percentage of undesirable particles.

C. Chemical Stability - A 10-gram portion of the sample shall be placed in each of three beakers and covered with 100 ml. of 1 N sulfuric acid, 1 N sodium hydroxide, and 100 ml. of water, respectively. They shall be allowed to stand undisturbed for 24 hours. The spheres shall then be washed six times by decantation using either distilled or tap water, and dried. The contents of each beaker shall then be observed microscopically for evidence of etching or dissolution. In no case shall the particles show etching or frosting nor shall they adhere together after washing and drying.

D. Refractive Index - Refractive index tests shall be performed on such portions of the sample as may be applicable under the requirements set forth in the invitations for bids (Part 1, GENERAL). The tests shall be made by comparing the refractivity of the sample with standard refractive-index liquids in accordance with recognized immersion-method procedures (as applied to chemical microscopy and optical mineralogy).
E. Size Distribution, or Gradation - A 1000-gram sample shall be thoroughly shaken in a nest of U.S. Standard Sieves which shall include only those sieves corresponding to the size requirements set forth in the invitations for bids. (Part I, GENERAL). The quantity retained on each sieve shall be weighed and expressed as percentage by weight of the total sample.

Note: A portion of the material retained on each sieve may be used to test for resistance to crushing, (Para. F).

F. Resistance to Crushing - Crushing-strength tests shall be made only on those size-fractions as shall be applicable under the size requirements set forth in the invitations for bids (Para. I, GENERAL) and as retained upon the corresponding sieves required under Para. E.

A 50-lb. capacity, platform-type, dial-reading scale whereon is placed a smooth steel plate shall comprise the loading platen. A random selection of the particles from each sieve-fraction shall be dusted onto the platen, and compressive force applied to individual particles with a hard flat-pointed punch held by hand and using body weight. The load shall be read at the instant the particle crushes and shall be corrected for the dead load of the accessory plate.

A minimum of 10 unselected particles representing each fraction shall be so tested. At least 7 of 10, or 70% of the total, shall equal or exceed the values specified below:

<table>
<thead>
<tr>
<th>No. of Sieve</th>
<th>Minimum Crushing Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>30 lbs.</td>
</tr>
<tr>
<td>40</td>
<td>20 lbs.</td>
</tr>
<tr>
<td>50</td>
<td>14 lbs.</td>
</tr>
<tr>
<td>60</td>
<td>8 lbs.</td>
</tr>
<tr>
<td>70</td>
<td>4 lbs.</td>
</tr>
</tbody>
</table>

5. PACKAGING:

The spheres shall be packaged in heavy paper-lined cloth, or multiple-layered paper bags, or metal containers. The net weight of the package shall not exceed 100 lbs. Packages broken open or torn upon delivery to the Department shall be replaced by the vendor.