EXPERIENCE WITH REFLECTORIZED TRAFFIC PAINT

Bailey Tremper, *Materials and Research Engineer*, and C. E. Minor, *Assistant Materials Engineer, State of Washington, Department of Highways*

SYNOPSIS

Glass beads increase the night visibility of painted traffic stripes to a greater degree than other available materials. Smaller beads offer advantages in economy and service life over the larger sizes formerly used. With small beads the range in types of suitable paints is greatly extended since the special quality of high capillary rise around the beads is of less importance. Methods of test for paints for use with beads are the same, with a few exceptions, as those used for plain traffic paints.

Beads were originally applied by gravity to the fresh surface of the stripe. This method, called "over-lay", has been succeeded in Washington by a "pre-mix" method in which the beads are mixed with the paint just prior to application. Beads are retained in the stripe, initially and during service, more uniformly when the pre-mix method is used. When striping machines are not well adapted to the use of pre-mix beads the "fog-coat" method is used as an alternate. In this method, beads placed by over-lay are given a second light application of paint to aid in their retention during service.

Data are given on the use of the pre-mix and fog-coat methods. Longer service life of these stripes makes them available economically for many roads not previously treated with reflectorized stripes.

Field brightness measurements of traffic stripes 6 to 8 months old, supplemented by later visual surveys, show that those applied by the pre-mix method retain a uniform and adequate degree of brightness throughout their life. The useful life of pre-mix stripes is considerably longer than that of a similar stripe without beads. The fog-coat stripe is inferior to the pre-mix stripe in uniformity but results in better bead retention than the over-lay stripe.

The prime requirement of a traffic stripe is visibility. Regardless of the presence of an adequate film of paint, if it cannot be seen clearly by the vehicle operator it fails to perform its intended function. During daylight mere contrast in color with the pavement surface usually results in sufficient visibility. Color contrast by itself is not adequate, however, for good visibility at night. The stripe must possess the quality of reflecting part of the rays of the vehicle's headlights back to the eyes of the driver.

Night visibility, therefore, becomes the most important factor. This quality is achieved more readily on bituminous than concrete surfaces because of the greater number of faces perpendicular to the light source and because of greater color contrast. Although this is true, there is still opportunity for improvement of night visibility of plain paint stripes on bituminous pavements. The night visibility of stripes on concrete pavements can be improved by deeper transverse brooming of the concrete during finishing operations. Deep brooming does not necessarily increase the margin of brightness of the stripe over the pavement but it increases the brightness of the surface as a whole and thus reduces the need for a stripe of the highest reflective qualities.

For the reasons given, the discussion will deal mainly with factors producing good night visibility on concrete pavements. It is the author's conclusion that a paint that gives good service on concrete will, in the absence of bleeding, perform satisfactorily on bituminous surfaces.

Having achieved good night visibility, other properties of the paint need consideration. These may be listed briefly as storage properties, viscosity, hiding power, color retention, drying time, flexibility, resistance to abrasion, durability and, if glass beads are used, ability to retain them under traffic and adverse weather conditions.

METHODS OF IMPROVING NIGHT VISIBILITY

Night visibility in a traffic stripe may be promoted by freedom from gloss, roughness in texture, or embedment of reflective particles.

Paints that give satisfactorily flat films when dry initially may become polished and glossy under traffic and thus lose their effectiveness at night.

Roughness of texture may be obtained by adding fine siliceous or other material to the paint. Such additions may impart good reflective properties initially but few such materials are able to resist abrasion sufficiently well to maintain roughness of film throughout the life of the stripe. The addition of fine, hard-grained sand, either before or immediately after the application of the paint, has been disappointing after a few months service although initially the reflective characteristics were fairly good.

Angular particles of glass confer reflective properties to the stripe to about the same degree as natural sand but are more resistant to abrasion. Very much greater reflection is obtained from glass beads that are substantially perfect spheres in shape.

A comparison of the night visibility of paint films to which several materials were applied to the surface while still fresh was made in a device adapted from the apparatus described by Mattimore (*1*)[1]. In this device the film, illuminated and viewed through a small angle, is compared to the adjustable field of a Macbeth illuminometer. This device cannot be used satisfactorily with yellow paint, however, and, since this has been the standard color in the State of Washington, other means of measurement were required. This was done by placing a panel containing the test film beside a yellow ground glass panel which was used as a standard. Both panels were in a light-tight box and were illuminated equally. The arrangement was on a scale equivalent to a light source 3 ft. above, and the point of viewing 5 ft. above the roadway surface with the reflecting surfaces 60 ft. distant. The duller of the two surfaces was then tilted toward the light source until the brightness of the two was equal. The angle through which it was necessary to raise the duller specimen provided a means of comparison. While this method did not afford a strict measure of reflectance at the desired angle, it did give a mathematical comparison of the night visibilities of different stripes compared to a common standard. The results of a few such tests are given in Table 1.

The natural sands included in these tests were from various local deposits in the State. The white sand was made by crushing white limestone. It is interesting to note that in Nos. 2, 3 and 4, neither color, shape, size nor opacity of the particle made any significant difference in visibility. The spherical glass beads, however, imparted a marked increase in visibility.

Brightness developed through the use of glass beads undoubtedly is dependent on the index of refraction of the glass. The index of the beads used in these tests was from 1.50 to 1.52. Recently, beads are becoming available in which the index is greater than 1.60. A marked increase in brightness is to be expected but the authors have not as yet made tests to evaluate the increase.

TABLE 1

Type of Stripe	Visibility Range (compared to standard glass plate at 60 ft.)
	ft.
1. Untreated paint film	45–80
2. Paint + natural sand	209–228
3. Paint + crushed white sand	228
4. Paint + crushed glass	210–230
5. Paint + spherical glass beads	850

USE OF BEADED STRIPES

Beaded stripes were first used in Washington in 1938. The resulting increase in visibility was so great that it became apparent that their use would be of great benefit in the reduction of eye-strain and the prevention of accidents at night. Although reflectorized stripes are at present applied on only part of the State highway system, it may be assumed that eventually all but the most lightly traveled highways will be so striped. For reasons to be discussed later, the cost of such stripes may not greatly exceed that of plain paint.

SIZE OF BEADS

The first beaded stripes consisted of a film of a proprietary paint to which was applied, immediately after spraying, about 6 lb. of beads per gallon of paint. The beads ranged

[1] Italicized figures in parentheses refer to list of references at the end of the paper.

in size from 0.033 in. to 0.012 in. The thickness of the paint film (applied at the rate of 15 gal. per mile of 4-in. stripe) was only 0.013 in. It is apparent that the beads would not be held firmly in place unless the paint had a marked affinity for glass and had the surface tension necessary to cause it to be drawn up to approximate mid-height of the bead. These properties were present to a marked degree in the proprietary paint but it was difficult to obtain equally satisfactory paints competitively through specifications.

Consideration of the effect of the size of the bead led to the following conclusions:

The number of beads per pound would be increased eight-fold if the average diameter were halved.

With the diameter decreased to one-half, the area in plan view of glass per unit area of paint would be doubled.

Although the initial brilliance of the larger beads would be sacrificed to some extent, the brightness during the life of the stripe would tend to be equal or better with smaller beads because of greater number retained.

A lesser weight of small beads per unit area of stripe might be used with satisfactory results.

These considerations have led to the use in recent years of beads considerably smaller in average diameter than those used initially. Present specifications of the Washington Department of Highways for glass beads are given in the Appendix A. It is the opinion of the authors that the use of smaller beads has been well justified by economy and performance. A range in sizes from the maximum down to approximately the U. S. No. 200 sieve is of advantage as the paint film wears thin in service.

TYPES OF PAINT SUITABLE FOR SMALL BEADS

The use of small beads greatly enlarges the number of types of paint formulations that can be used to retain them successfully. If the diameter of the bead is not much greater than the thickness of the paint film, that property of the paint (possessed more strongly by cooked-varnish types) by which it is drawn up high around the bead becomes of minor consequence.

Cold-cut formulations have been preferred in Washington because the resulting paint is likely, more than the cooked type, to have the intended properties. The skill of the varnish maker is so much of a factor in cooked vehicles that it is difficult to assure the desired results through specification by formula. The formula type of specification is regarded as the most advantageous to the purchaser because all bidders compete to furnish the same article.

METHODS OF TESTING TRAFFIC PAINTS

The critical stage in the ability of the paint to retain the beads under traffic appears to be during freezing weather following rain. At these times the larger beads, in particular, are lost more rapidly from the stripe. The abilities of paints to retain beads under these conditions varies greatly. A test for bead retention under wet, freezing conditions has not been developed to the stage that numerical values can be assigned but the following procedure will serve to distinguish between paints that are good or poor in this respect.

A panel to which the paint and beads have been applied is immersed, after aging, in water for 24 hours. It is then placed in a cold room until its temperature is below 32 F. Upon removal, a binocular microscope with low magnification is focused on the film. A needle is used to test the ease or difficulty with which individual beads may be detached. The difference between paints may be pronounced.

Given an adequate degree of adhesion between paint and beads under wet, freezing conditions, it appears that any paint that will give good service on the road can be used successfully with small beads.

Other methods of test for bead-retention paints in the laboratory of the Washington Department of Highways are those commonly used for traffic paint. A brief reference to the methods, however, will serve to list them and point out features that may be unique in that laboratory.

Fineness of grind is determined with the North Standard Graduated Fineness Gage.

Viscosity is tested with the Krebs-Stormer instrument. Other tests have been used but this method is believed to best measure consistency as it affects spray application.

Hiding power is determined on the wet film with a Pfund Cryptometer. This method is rapid and gives results that are sufficiently significant for traffic paint.

Condition after storage is observed with a spatula for ease of breaking up the settled layer. Degree of skinning is observed after subjecting a partly filled can of paint to elevated temperature. This is not a critical property with cold-cut paints.

Color retention is observed by comparing a panel exposed under a sun lamp, or out-of-doors, to a panel stored in darkness.

Bleeding is determined by spray application of the paint to prepared asphaltic concrete panels.

Drying is determined by a modification of the Tentative Method for Dry to No-Pick-Up Time of Traffic Paint, ASTM Designation: D711 - 46T. The modifications consist in using a rubber-tired wheel weighted to 25 lb. instead of the specified 35 lb. and in using a wet film considerably thicker than the specified 4 mils.

The test film is prepared according to the method of Dunn and Baier (*2*) on an 8- by 30-in. glass plate which is supported on a metal frame that can be adjusted for inclination between 0 deg. and 35 deg. with the horizontal. A ½-in. round guide bar is supported about 2 in. above the longitudinal center line of the plate. A rectangular steel box 2 in. wide by 4 in. long by 1 in. deep with an adjustable "doctor blade" forming one side and with small steel pins to fit along the guide bar is placed at one end of the glass panel. After raising the plate to the desired angle, the box is partially filled with paint and released to slide down the glass panel, leaving a uniform film 4 in. wide behind it. Measurement of the wet film thickness of traffic paint is difficult because of rapid evaporation. The thickness of the film applied by a doctor blade varies with the speed with which it is moved (*2*). In the drying time test the clearance of the blade is set at 20 mils. The angle of inclination of the plate is set to a value, determined by test, that gives a dry to no-pick-up time of 45 min. at 70 F. with a reference paint. The paint used for reference is one that dried to no-pick-up under traffic in 45 min. under average weather conditions.

The method gives good reproducibility in the laboratory and duplicates average results obtained in the field. Since this method of test has been used, with a specification for 45 min. maximum drying time, there have been far fewer complaints of slow drying on the road than were received previously.

Abrasion resistance is determined by a device similar to that described by Hickson (*3*). The abrading wheel carries a rubber ring of eraser stock. It rests upon and is driven by, a concrete disk revolving at 40 rpm. The disk is 15 in. in diameter by 2 in. thick. It is made of concrete proportioned to give minimum air voids and is vibrated thoroughly while the concrete is setting. The disk is cured and aged several months and then ground to a true plane on a lap. A number of these are on hand and have been in use for years. Paint films are removed with solvent. Occasional dressing on a lap serves to keep the surface clean and true.

Test stripes, 2- by 4-in., with a nominal wet thickness of 10 mils are applied using a conventional draw-down applicator. Duplicate panels of each paint are applied at opposite ends of the diameter of the disk. A reference paint is applied to each disk. Since eight panels can be placed on it, three test paints can be accommodated.

After air-drying at room temperature for 24 hours, the prepared disk is placed under an infra-red lamp and cured at 120–130 F for 24 hours. After an additional 24 hours at room temperature the panels are ready for the abrasion test. The first 1000 revolutions are run with the films dry, after which they are kept wet. Abrasion resistance is expressed as the ratio of the area remaining intact compared to that of the reference paint. For close differentiation, a planimeter is used and ratios are determined after several periods of abrasion. Reasonably close checks between duplicate samples on the same disk are usually obtained. The rate of wear varies with the condition of the abrasion wheel, however, and it is necessary to use the reference paint on each disk.

Flexibility tests are made on dried films applied to 1- by 12-in. annealed copper strips. These are stretched in a tension machine and the elongation at rupture of the film is measured. The direct elongation test is believed to give a more significant result than the bend test. The value of flexibility in traffic paints has been questioned but it is apparent that too great a degree of brittleness is conducive to chipping under traffic. Goetz (*4*) reported that the five best paints observed in field tests all gave films that were soft after air-drying for 24 hours. This finding is in agreement with observations of the authors.

EXPERIMENTAL FIELD STRIPES

As a check on the adequacy of laboratory examination, outdoor service tests of 30 paints were conducted in 1946. These involved proprietary paints, paints made commercially under formula specifications, and a number of special formulations made in the laboratory.

Stripes 4 in. wide and 8 ft. long were placed transversely across the center line of a concrete pavement of a heavily-traveled city street. The location at the center of the street was chosen to avoid the oil stain in the middle of the traffic lanes. Paints were applied with a lineograph head at measured rates which, in most cases, were from 16 to 18 gal. per mile.

Observations of wear were made at intervals and were recorded by the numerical system of ASTM method D821-45T. Records were kept of the performance at the outer ends of the stripes which were subjected to heavy traffic and in the middle third where traffic was more moderate. At the end of 5 months the ends of half of the stripes had worn to rating No. 3 or poorer. At the end of 10 months the middle portions of half the stripes had worn to rating No. 4 or poorer, and the rating of the better paints was from No. 5 to No. 7.

These service results were compared to those of the laboratory tests of the paints. The comparison indicates that the laboratory abrasion test, as described in this paper, was a quite dependable measure of performance on the street. The correlation was somewhat better with the middle third than with the ends of the stripes. Of the 18 paints having an ASTM rating of No. 5, or higher, in the middle third of the stripe after 10 months, all but two had a laboratory abrasion resistance of more than 90 percent of the standard. Of the paints having an ASTM rating of No. 4, or less, the highest laboratory abrasion resistance was 83 percent for one paint, with no others above 50 percent. On the basis that a rating of 90 percent or higher in the laboratory abrasion test indicates paints that give superior service on the street, it rated them properly in 93 percent of the tests.

APPLICATION OF BEADED STRIPES

Prior to 1947, beaded or reflectorized stripes in Washington were constructed by the over-lay method in which the beads were dispensed by gravity directly onto the fresh paint immediately behind the spray gun. Critical examination of the stripes prepared by this method revealed a decided lack of uniformity with respect to night visibility. A section several hundred feet in length with extremely good visibility would be followed by a section of very poor visibility. The difference could not be explained by differences in pavement type, texture, age or alignment. The fluctuation in visibility was a definite safety hazard. Variations in visibility were due to variations in the amount of beads retained by the paint. This appeared to be caused by variations in the thickness of the paint film, non-uniform application of the beads through the dispenser, and loss of falling beads by wind action.

The development of a proprietary paint containing very small beads mixed directly in the container led to experiments in which beads were mixed with the regular striping paint. Beads as small as those used in the proprietary paint were not available commercially, but those ranging in size from U. S. No. 40 sieve to U. S. No. 100 sieve could be obtained. If mixed in the can ahead of use, however, they caused a severe settling problem. If the beads were not added until the paint was in the pot of the striping machine it was concluded that it would be possible to keep them in uniform suspension. An advantage of this system is that the quantity of beads per gallon of paint can be varied as frequently as desired.

In the pre-mix type of application the fresh paint has little better night visibility than unbeaded paint. After exposure to traffic for a few weeks, however, sufficient paint is worn from the surfaces of part of the beads to result in a satisfactory degree of brightness.

Initial experiments in applying the paint-bead mixture directly through the spray gun showed that many details needed to be adjusted before the method would prove practical for general use. The first test did demonstrate, however, that it was entirely possible to spray a thick, rather granular mixture through the existing equipment.

The striping machine used in these experiments is illustrated in Figure 1. It consists of a truck on which is mounted an air-compressor and a paint storage pot of 300-gal. capacity, circular in cross section with a conical bottom. The paint is fed under pressure to spray guns at the rear of the truck. "Air curtains" are used in place of metal plates to confine the paint spray to the desired width of stripe. Agitation of the paint in the pot is accomplished by a paddle driven by an air motor.

The paint used in the initial tests had a viscosity of approximately 60 KU at 70 F. and the beads were predominantly 40 to 60 mesh in size. Agitation was insufficient to effect uniform suspension of the beads and consequently there was considerable variation in the proportions of the mixture during the run. Sufficient agitation was later obtained by lengthening the paddle so that it covered the entire area of the bottom of the pot and installing four small air jets in the bottom. More recently the paint has been prepared with a viscosity of 70 to 75 KU at 70 F. and somewhat smaller beads have been obtainable. Settlement problems in the paint pot have thus been eliminated. The use of air agitation conceivably might cause undesirable gelation in some paints but no trouble has been experienced with the cold-cut type that has been used.

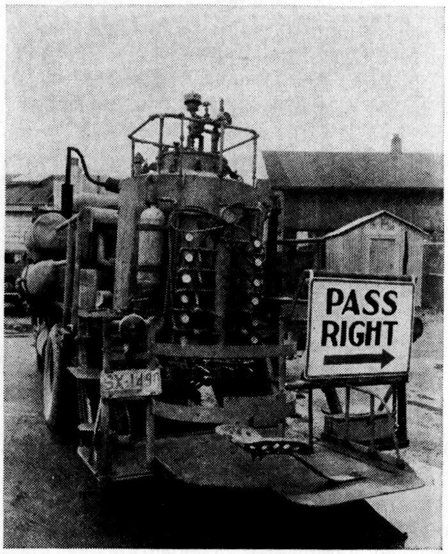

Figure 1. Traffic Paint Striping Machine

The striping machine was equipped originally with standard steel pipe and fittings from the pot to the spray guns. A tendency for beads to collect in this line was eliminated by the substitution of copper tubing and connections.

In addition to bead settlement a number of other factors were investigated during preliminary trials. These are described below.

A serious loss of beads through rebound from the pavement surface was noted in the first trial. The amount of loss was determined by placing 12- by 18-in. steel panels on the road to receive the paint as the machine passed over it. Immediately after reaching the panel the machine was stopped long enough to collect a sample of the paint directly from the paint gun. Determination of the percentage of beads in the paint sample and on the panel provided a measure of loss through rebound. Adjustments were made in the spray gun to give the required application rate at the lowest possible nozzle pressure. This resulted in a reduction in loss through rebound but a more important factor was found to be the thickness of the applied paint film. The curve of Figure 2 indicates a direct relation between film thickness and initial retention of beads. It is concluded that a minimum rate of application of 16 gal.

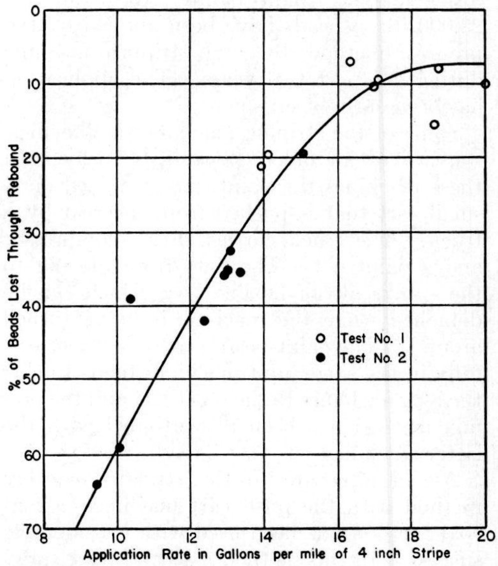

Figure 2. Variation in Loss of Beads through Rebound with Thickness of Paint Film

of mixture per mile of 4-in. stripe is necessary to assure satisfactory bead retention. Sixteen gallons of the mixture consists of 13.4 gal. of paint and 54 lb. of beads if the beads are added at the rate of 4 lb. per gal.

Fear was expressed that the use of the paint-bead mixture would cause serious wear on the parts of the spray gun. Two years experience with this method has indicated that wear is entirely negligible. In fact it has been noted that more careful attention to proper adjustment of the nozzle has resulted in less wear than was experienced formerly with plain paint. Approximately 25,000 lb. of beads have been applied by the pre-mix method by one striping machine during the past two years. The application has been entirely satisfactory.

Some of the striping machines in Washington are of an older, "push-cart" type. In these machines the paint gun is carried on a small cart that is pushed from the rear by a truck. The truck carries an air compressor and a paint pot. The lines from the pot to the sprays are of flexible hose which can be detached while the machine is being turned around. The paint-bead mixture used sucessfully in the single-unit machines tends to clog the long feed lines to the push cart and the pre-mix method has been discontinued with the latter machines.

As an alternate to the straight over-lay method with the push cart machines, a fog-coat method has been used with considerable success. In this method a second light spray of paint follows bead application by gravity dispenser. This results in better bead retention during service but initial retention is still subject to variations discussed above under the over-lay method. The use of tandem spray guns necessitates careful attention in balancing quantities delivered by each gun but it is entirely practical of accomplishment.

Figure 3 shows the superiority of the fog-coat method over the straight over-lay method. Paint was applied to the two panels which were placed on the pavement during a test run. The panel on the left was taken with the fog-coat nozzle in operation. Shortly thereafter the fog-coat spray was shut off to obtain the panel on the right. The panels were subjected to the same number of revolutions in the laboratory abrasion machine. The total amount of paint on the fog-coated panel was less than 10 percent greater than that on the straight over-lay panel but the resistance to loss of beads through abrasion was improved at least 25 percent. Field brightness measurements after several months of service are presented in a succeeding section. These show the superiority of the fog-coat method over the straight over-lay method.

RATE OF BEAD APPLICATION

Reflectorized traffic stripes were applied originally with 6 lb. of beads per gallon of paint, or 90 lb. per mile for a spreading rate of 15 gal. of paint per mile. Through the use of smaller beads and the pre-mix method of application it is estimated that the quantity of beads can be reduced to 50 to 60 lb. per mile with satisfactory results on heavily traveled highways. Application as low as 30 lb. per mile are satisfactory on lightly traveled roads.

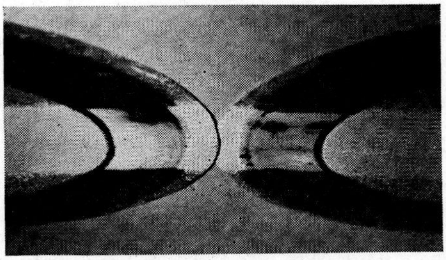

Figure 3. Relative Abrasion Resistance of Beaded Stripes by Fog-coat and Over-lay Methods

SERVICE LIFE OF BEADED STRIPES

The use of beads in paint greatly increases the life of the stripe as shown by laboratory abrasion tests and by service records. The brightness of stripes worn quite thin and retaining relatively few beads is surprisingly good. Many portions of a pre-mix stripe applied during the summer of 1947 still have good day and night visibility after 16 months service. This stripe is on a four-lane divided concrete highway carrying 9000 vehicles per day. It is evident that the advantages of a reflectorized stripe can be obtained at a cost that is considerably less than might at first be assumed.

FIELD BRIGHTNESS MEASUREMENTS

In January and February of 1948 extensive field brightness measurements of different traffic stripes that had been in service 6 months or more were made. A portable photo-electric photometer, loaned by the Minnesota Mining and Manufacturing Company, was used for the measurements. The instrument is based on a modification of the photometer originally developed by the New Jersey Zinc Co. for research work on the visibility of plain painted stripes (*1*) and is constructed to measure brightness from 50 to 100 ft. ahead of the light source. The photometer is, however, used in bright daylight for evaluating night brightness of actual traffic stripes exposed to highway traffic. Extensive laboratory tests have shown that relative night brightness, as indicated by the photometer, is the same that is observed by the average vehicle operator.

Measurements were taken on unbeaded stripes and on four different types of beaded stripes, namely (1) over-lay stripe, (2) fog-coat stripe, (3) pre-mix stripe, and (4) a proprietary pre-mixed stripe. Some 600 individual measurements were taken. Three to five individual readings were taken at each point of measurement and the results averaged in order to compensate, as far as possible, for small differences in surface roughness of the pavement which are, of course, magnified in the small scale photometer. Readings were taken on tangents in order to obtain as good a comparison as possible between the various types of beaded lines.

The brightness of the beaded stripes varied from 2 units to a maximum of 9.5 units with an over-all average of slightly over 4.0 units. The brightness of the pavement itself varied from 1 to 4 units, depending on its age and surface texture. The average brightness of the pavement was 1.8 units. In order for the stripe to be visible at night, its brightness must be greater than that of the adjacent pavement. When the difference is 2 units or more the stripe is readily seen at night by the vehicle operator except under conditions of heavy rainfall.

An analysis of the results of the field brightness measurements lead to the following conclusions concerning the efficiency of the various stripes:

1. The brightness of the unbeaded lines on cement concrete pavement after service throughout the winter months was not measurably greater than the pavement surfaces on which they were placed.

2. While the over-lay stripes were characterized by erratic brightness, the average of some 150 individual readings indicated that the brightness diminished rapidly when less than 18 gal. of paint per mile were applied. Thus when beads are applied at the rate of 6 lb. per gallon of paint, the over-lay stripe requires 18 gal. of paint and 108 lb. of beads per mile of pavement. At $2.00 per gal. for paint and $0.20 per lb. for beads, the material cost is $57.60 per mile.

3. The fog-coat stripe gave more consistent over-all brightness than did the over-lay stripe. Satisfactory results can be obtained by reducing the quantities to 16 gal. of paint and 80 to 90 lb. of beads per mile, which, using the above prices, represents a material cost of $48.00 to $50.00 per mile.

4. The pre-mix stripe gave the most consistent over-all brightness of any of the three types of beaded stripes. The critical amount of material necessary for satisfactory performance is about 16 gal. of mixture per mile. The field tests also showed that a mixture composed of 4 lb. of beads per gallon of paint was satisfactory. Sixteen gallons of the 4-lb. mixture is composed of 13.4 gal. of paint and 54 lb. of beads, which represents a material cost of $37.60 per mile, or only 65 percent of the cost of the over-lay stripe.

CONCLUSIONS

1. Spherical glass beads are the most efficient addition to paint for imparting good night visibility to traffic stripes.

2. The most desirable maximum size of beads is that which will pass a U. S. No. 60 sieve.

3. If these small beads are mixed in the paint before spraying, the resulting stripe after several weeks exposure to traffic will have uniform and adequate night visibility throughout its life.

4. The use of glass beads with traffic paint extends its service life to an important degree.

5. Economies are possible through the use of small beads in the pre-mix method that make it possible to obtain the advantages of a reflectorized stripe at moderate cost.

REFERENCES

1. MATTIMORE, H. S., "Highway Traffic Line (Zone) Paint". *Proceedings*, Highway Research Board, Vol. 5, p. 177 (1925).
2. DUNN, E. J. JR. AND BAIER, C. H., "Applicator for the Preparation of Uniform Paint Films". *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 13, No. 6, p. 427 (1941).
3. HICKSON, E. F., "Some Properties and Tests of Traffic or Zone Paints", National Paint, Varnish and Lacquer Assn., Circular No. 532, April 1937.
4. GOETZ, WILLIAM H., "Field and Laboratory Investigation of Traffic Paints", *Proceedings*, Highway Research Board, Vol. 21, p. 233 (1941).

APPENDIX A

SPECIFICATIONS FOR GLASS BEADS FOR TRAFFIC LINE STRIPE WASHINGTON STATE DEPARTMENT OF HIGHWAYS, 1948

Glass beads for traffic line stripe shall consist essentially of transparent, water-white glass particles in spherical shape.

The refractive index shall not be less than 1.52 relative to air when illuminated with a "daylight" lamp at normal room temperature.

At least 90 percent of the beads by count shall be free from any of the following imperfections:

(a) dark specks of a diameter greater than one-fourth that of the bead.
(b) air inclusions of a diameter greater than one-half that of the bead.
(c) incipient fractures.
(d) departure from an apparently true spherical shape.

The beads shall meet the following requirements for size:

Percent Passing U. S. No. 40 sieve	100
" " " 60 ", minimum	80
Percent Passing U. S. No.200 sieve, maximum	5

All percentages are by weight.

The beads shall be packed in clean leak-proof containers that will not cause contamination of the beads with foreign materials such as lint. The net weight of the package shall not exceed 100 pounds.

The vendor shall agree to indemnify and save harmless the State of Washington and the Director of Highways and his duly authorized representatives from damages and trial expenses arising from all patent infringement suits brought on account of the purchase of glass beads furnished by the vendor and their use with paint for striping pavements in the State of Washington, provided that prompt notice of any such suit is given to the vendor and the vendor is permitted to defend the suit by competent counsel of its selection.