Proposal for Experimental use of Thermo-Plastic Pavement-Striping Materials

James H. Havens
Kentucky Highway Materials Research Laboratory
MEMORANDUM

TO: K. B. Johns
Director of Traffic

FROM: W. B. Drake
Director of Research

SUBJECT: Proposal for Experimental Uses of Thermoplastic Pavement Striping Materials

Attached is the preliminary proposal for the experimental project noted above. This proposal is submitted in accordance with your request and is the result of several discussions between the Traffic and Research Divisions.

Mr. Jas. H. Havens, Assistant Director of Research, drew up this proposal and will, of course, be available for further discussions or modifications, if you find such to be necessary. We believe that the project as outlined will qualify for interstate experimental construction as prescribed in BPR's PPM 60-2 and subsequent memoranda issued on the use of thermoplastic pavement striping materials.

We will be pleased, of course, to co-operate in all phases of the project.

WBD:dl
Encs.
PROPOSAL

for

EXPERIMENTAL USE OF THERMO-PLASTIC,
PAVEMENT-STRIPING MATERIALS

Each year the Kentucky Department of Highways uses approximately 120,000 gal. of traffic paint for striping new pavements and re-striping old ones. Currently the cost of this paint is in the order of $2.30 to $2.40 per gal. These paints are usually applied at the rate of 14.5 gal. per mile of continuous 4-inch line. However, the greater portion of the paint (white only) is applied in the pattern of a skip-line (15-ft. line, 25-ft. skip). Thus, at a material cost of $288,000, the Department is able to place some 8,300 miles of equivalent, continuous line. A recent estimate indicates the cost of application to be $4.69 per mi. of continuous line and the cost of the material to be $35.24. This is equivalent to a total cost of $39.93 per mi. of continuous line or 7.6 mils per lineal foot of 4-in. line.

For the past 10 years or so, the Department has been procuring traffic paints on the basis of competitive, field-performance testing wherein the "best buy" is adjudged on the basis of least-cost-per-mile-per-day-of-useful-life. Although the performance and cost ratings are customarily established from observations from transverse test lines (producing accelerated wear) over a period of 6 to 9 months, the actual service-life of the paints purchased in this manner seems to be about one year plus one season. Of course, actual service-life varies greatly with the severity of traffic, snow-abrasion and other circumstances. In fact, under extreme conditions, re-striping is done as often as three or four times per year. Typically, the "best-buy" paints have consisted of alkyd-type vehicles, ground limestone and magnesium silicate extender pigments, and titanium-type white or chrome-yellow prime pigments.

It is of interest likewise to enumerate some of the peculiarities that have been observed in the performance of traffic paints:

1. Better paint performance is obtained on bituminous pavements than on portland cement concrete pavements.

2. Paints give poor performance on new concrete pavements - attributed to high lime content of new concrete.

3. Re-striping over an existing, worn stripe enhances performance.

Practically all of the traffic paints used in Kentucky during the past 10 years have been reflectorized with about 4 lbs. of glass beads per gallon, inter-mixed with the paint. Glass beads tend to be worn flat under traffic if they are retained too long in the paint binder. Ideally, then, beads should be dispersed throughout the thickness of the paint film,
and there should be a more-or-less balanced rate of wear for the glass beads and the paint binder so that, as the paint wears, new beads would become exposed. Whereas paints are necessarily applied thin (about 15 mils), i.e. due to drying and attendant shrinkage, they could be over-coated at intervals of a few days in order to build up appreciably greater thicknesses.

So-called thermo-plastic resin and catalyzed thermo-setting resin binders may be applied at thicknesses in the order of $\frac{1}{8} \neq \frac{1}{32}$ in. and thereby provide a considerably longer service-life. However, an interesting comparison may be made by considering that $\frac{1}{8}$ in. equals 125 mils; whereas, each application of paint (15.0 gal./mi., 80% non-volatiles) would give about 12 mils dry thickness. Thus 10 applications of paint equals $\frac{1}{8}$-in. application of resin. Experience over the past 10 years has proven that re-painting a stripe each year (on the average) would provide an adequate line at a cost of less than 10 cents per foot for the total period. It does not follow necessarily that 10 applications of paint in one month would provide an adequate stripe for 10 succeeding years or that a $\frac{1}{8}$-in. application of resin would last 10 times longer than a single application of paint at locations which normally need painting four times each year.

Since 1950, or thereabout, highway engineers have been alert to developments in hot-melt, thermo-plastic, striping materials which might be applied at thicknesses of about $\frac{1}{8}$ inch, which would offer longevity and performance commensurately equal to that of paints on a cost-per-mile-per-day basis, and which would provide some relief from the inconvenience of frequent re-striping in urban areas where the rate of wear is high. The original idea for this kind of material apparently was conceived in England during or following World War II. The hot-melt compound consisted essentially of gum-rosin, plasticising oil, pigment and filler. Gum-rosin has the particular characteristic of remaining "sticky" or "tacky" (for this reason it is usually considered to be undesirable in good varnishes). Early experiments with this compound, in Texas, indicated that stripes of this material collected "road-scum" unnecessarily and did not give a good appearance. Subsequently, a considerable portion of alkyd resin was blended with the rosin, and this greatly improved performance and appearance. Materials of this general type were used on a trial basis and to a limited extent in Lexington and Frankfort in 1957 or 1958. The performance in these trials was not altogether satisfactory and was greatly disproportionate to the cost of striping.

Hot-melt plastic stripes are presently estimated to cost $.18 to $.35 per lineal foot of 4-in. stripe, installed. The apparent price difference between (about 20:1) plastic striping material and paints used in Kentucky would demand that the plastic stripes provide 20 times greater service-life or otherwise provide some accountable economic benefits. The present attitude or thinking in regard to this matter was appropriately stated by G. M. Williams, Assistant Commissioner for Engineering, Bureau of Public Roads in Circular Memorandum, dated August 31, 1961, which is quoted, in part, as follows:
"We wish to emphasize that while plastic pavement markings are admittedly more durable than paint, the weight of information available at the present time does not support the contention that they can be economically justified on the basis of performance alone. However, there is a lack of sufficient well-documented evidence to make a precise evaluation possible. States considering the use of plastic markings should be urged to proceed with planning for experimental construction along the lines outlined above with the understanding that federal funds may participate in the total cost of plastic markings for the purpose of evaluating the relative merits of the various kinds of marking materials."

PROPOSAL

Pursuant to the foregoing review and the other conditions outlined in Mr. Williams' August 31st Circular Memorandum, it is proposed that the Kentucky Department of Highways, with the invited participation of the Bureau of Public Roads, establish a number of experimental projects for the purpose of studying and evaluating the performance and costs of hot-melt plastic, striping materials in comparison to traffic paints currently in use. In accordance with Bureau of Public Roads' Policy and Procedure Memorandum 60-2, June 22, 1959, preliminary plans, specifications and estimates are attached hereto. The principal features of the proposed projects are enumerated below:

1. Experimental Materials

The experimental materials shall consist of and be limited to hot-melt thermoplastics. It is proposed, therefore, that two materials of this type, marketed under the trade names and by the respective manufacturers listed below be applied by the respective manufacturers, or their authorized agents, at the locations designated by and in accordance with the attached plans and specifications. The subject materials and manufacturers are:


"Catatherm", Cataphate Corporation, Box 28, Sta. F, Toledo, Ohio; and P.O. Box 2066, Jackson, Miss.

2. Control Materials

It is proposed that the two experimental lane-marking materials be compared, in all significant senses and accountable respects, to paints purchased and used by the Kentucky Department of Highways during the current
year and during each succeeding year of the test period. Thus, several reference paints are contemplated - each having been selected on the basis of performance testing and least-cost-per-mile-per-day-of-useful-life and each having an accountable in-service history.

3. Experimental Work

It is proposed that the application and installation of the experimental materials, as allocated to the respective participants and as shown on the plans, be negotiated with and contracted to the respective manufacturers, or their authorized agents, and that the contractor be made solely responsible for the preparation of the pavement surface and all such work as he may deem necessary or essential to the performance of his material.

It is further proposed that the Kentucky Department of Highways furnish and apply the control paints as described herein and as shown on the plans.

4. Basis for Comparison and Evaluation

Inasmuch as these materials are intended to render a visual-type of service, day and night, it seems particularly appropriate and sufficiently discriminatory to rely principally upon visual observations and appearance ratings as a basis for comparison and evaluation. Of course, appearances may be recorded photographically from time to time and insofar as practicable. These records may be supplemented occasionally with instrumental measurements, i.e. by the use of the Hunter Night Visibility Meter.

It is proposed, therefore, that the final evaluation of the materials in the test be based upon adjudged performance and costs and that these two factors be integrated according to the formula given below:

$$U = \frac{CM \times GM \times CA}{D \times \frac{RP - RR}{RP - RG}}$$

where:

- $U$ = Cost per mile per day of useful life
- $CM$ = Cost of material, per gal.
- $GM$ = Gallons of material applied per mile
- $CA$ = Cost of application, per mile
- $D$ = Days of test
- $RP$ = Rating of line adjudged to be perfect (10)
- $RR$ = Rating of line adjudged to need replacement (3)
- $RG$ = Adjudged final rating of line at end of test period.
Note 1: For experimental stripes, CM x GM x CA will be taken as the manufacturer's quoted large-volume price per mile of continuous line.

Note 2: Control lines are to be renewed as frequently as may be necessary to maintain a serviceable stripe. Since it may not be desirable always to withhold renewal until the rating of the existing stripe depreciates to 3, it is proposed that the control lines be re-painted at least once per year and that the existing lines be rated immediately prior to their renewal.

The cost-per-mile-per-day-of-useful-life for each of these reference paints shall be computed from the Department's purchase cost, per gallon, CM; number of gallons per mile, GM; and cost of application, CA; as determined by the Department at the time of purchase (same values as used in determining the least-cost-per-mile-per-day-of-useful-life in the performance testing program). However, the actual rating of the reference lines at the time of renewal and the actual number of days in-service shall be used to compute "U". The U's thus obtained for each of the reference paints shall be weighted and averaged according to their time in-service and in proportion to the total test period.

Note 3: Ratings shall be based on three factors, each of which is considered to be of equal weight or importance; they are:

1. General Appearance - includes such features as color, dirt retention, etc.

2. Film Condition - includes such features as edge chipping, scaling and percent loss in area.

3. Reflectorization - includes only night-time visibility.

Each of the aforementioned factors shall be assigned ratings according to the following schedule:

<table>
<thead>
<tr>
<th>Numerical Rating</th>
<th>Adjudged Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Perfect, new stripe</td>
</tr>
<tr>
<td>9</td>
<td>Good, adequate but not perfect</td>
</tr>
<tr>
<td>8</td>
<td>&quot; &quot; &quot; &quot; &quot; &quot;</td>
</tr>
<tr>
<td>7</td>
<td>Fair, less than desired</td>
</tr>
<tr>
<td>6</td>
<td>&quot; &quot; &quot; &quot; &quot;</td>
</tr>
<tr>
<td>5</td>
<td>Poor, inadequate</td>
</tr>
<tr>
<td>4</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>3</td>
<td>Poor, inadequate</td>
</tr>
<tr>
<td>2</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>1</td>
<td>Very poor, inadequate</td>
</tr>
<tr>
<td>0</td>
<td>&quot; &quot;</td>
</tr>
</tbody>
</table>
The over-all rating shall be determined as the average of the adjudged ratings for each of the three factors. A stripe or material shall be considered to be out-of-test when the adjudged rating for one of the three factors is 3 or less.

5. Plans, Specifications, and Estimates

Specifically, it is proposed that four one-mile sections of 4-lane, interstate highway (2 sections of portland cement concrete pavement and 2 sections of bituminous concrete pavement) be selected as the test-sites and that the two experimental materials and control paint be placed as centerlines -- 15-ft. lines followed by 25-ft. skips, each material recurring in successive order -- on each mile-section (1 mile of skip-stripe each direction, each site). There would be a total of 8 miles of skip-stripe, as follows:

\[15/40 \times 8 \text{ mi.} = 3 \text{ mi., equivalent continuous line, or } 3 \text{ mi.} = 1 \text{ mi. of continuous line, each material.}\]

It is proposed, too, that transverse lines (continuous) of each of the three materials be installed at the termini of each of test sites, i.e.:

\[4 \text{ sites } \times 4 \text{ termini } \times 24 \text{ ft.} = 384 \text{ ft. (each material)}\]

The Department further proposes to install thicker paint lines at each terminus, as follows:

1. One line - 2 applications, 3 days apart
2. One line - 3 applications, 3 days apart

\[4 \text{ sites } \times 4 \text{ termini } \times 24 \text{ ft. } \times 2 \text{ applications} = 768 \text{ ft.}\]
\[4 \text{ sites } \times 4 \text{ termini } \times 24 \text{ ft. } \times 3 \text{ applications} = 1152 \text{ ft.}\]

Equivalent length, single-application, continuous line = 1910 ft.

**Summary (by Materials)**

<table>
<thead>
<tr>
<th>Material</th>
<th>Length</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perma-Line</td>
<td>5280' / 384'</td>
<td>5664 ft.</td>
</tr>
<tr>
<td>Catatherm</td>
<td>5280 / 384</td>
<td>5664 ft.</td>
</tr>
<tr>
<td>Ky. Paint</td>
<td>5280' / 384' / 1910'</td>
<td>7574 ft.</td>
</tr>
</tbody>
</table>

**Preliminary Estimates (Cost)**

<table>
<thead>
<tr>
<th>Material</th>
<th>Cost</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perma-line</td>
<td>5664 ft. @ $.45 per ft.</td>
<td>$2548.80</td>
</tr>
<tr>
<td>Catatherm</td>
<td>5664 ft. @ $.45 per ft.</td>
<td>2548.80</td>
</tr>
<tr>
<td>Ky. Paint</td>
<td>7574 ft. @ .0076 per ft.</td>
<td>5155.16</td>
</tr>
</tbody>
</table>

$5155.16
Note: Costs per foot of hot-melt materials were estimated on the basis of limited quantities; whereas, cost of paint stripes were estimated on the basis of the average costs of the Department's striping program (large-quantity basis). These estimates, therefore, do not represent realistic values for comparative cost evaluation. A more realistic, large-quantity cost of the plastic materials is thought to be in the order of $.20 per foot, and a more realistic estimate of the cost to the Department of installing the control-paint stripes is thought to be in the order of $1500.00. Hence, the actual cost of the project, including all aspects of construction, is not reflected in the above estimate. Of course, no attempt has been made to estimate costs of inspection, testing, or reporting.

BIBLIOGRAPHY (Preliminary)


EXHIBITS

2. Manufacturer's Specifications for "Catatherm".
3. Manufacturer's Specification for "Perma-Line".

RELATED PAPERS AND CORRESPONDENCE

CIRCULAR MEMORANDUM TO: Regional and Division Engineers

FROM: G. M. Williams, Assistant Commissioner for Engineering

SUBJECT: Experimental projects for pavement markings on Federal-aid system highways

The June 14, 1961, circular memorandum issued by the Federal Highway Administrator on the cited subject made reference to one named thermo-plastic product that might be proposed by a State highway department for use in a Federal-aid highway project for marking or striping pavement surfaces, such use to be as an experimental feature under the provisions of PPM 60-2. In answer to inquiries directed to Public Roads, it was not the intent to limit the experimental usage to the one named product. Any of the products of the class of thermo-plastics, thermo compounds, or other types of plastic materials used for pavement marking purposes, may be proposed by a State highway department for use as an experimental feature of a Federal-aid highway project, and if considered satisfactory for such use may be approved by Public Roads.

The fact that our circular memorandum of June 14, 1961, did not mention any specific limitation on the number or lengths of projects or the quantity of plastic pavement markings that would be approved as experimental construction has been interpreted in some cases to mean that no limitation is intended. As a result some sections several miles in length have been proposed. Such an interpretation is incorrect. It is intended that the number and lengths of experimental sections be limited to only those required to obtain sufficient comparative information on performance and costs to properly evaluate the relative merits of various types of paint and plastic markings on different types of pavement and under varying conditions.

In order to assure that experimental installations involving plastic markings and proposed for Federal participation in the cost thereof will be limited as intended and will be designed and constructed to accomplish their intended purpose, the following general guidelines are given:

1. The experimental construction should in general be limited to an overall length of approximately one mile within which sections of striping paint are alternated with sections of plastic marking materials. We believe sections of such length involving alternate combinations of materials will be sufficient to obtain comparative results.
2. Several locations involving different physical conditions, different traffic densities, and different types of highway surfaces are desirable.

3. In addition to the standard paint used by the State, several paints of other types having good service records might be included. The New Jersey alkyd paint and the California or New Jersey chlorinated rubber paint are suggested.

4. Worn paint stripes should be repainted at the usual frequency or at intervals to make their visibility equivalent to that of plastic markings. This practice should be continued until the plastic material is no longer considered satisfactory.

5. Records of all original and maintenance costs for materials, labor, equipment, etc., should be kept in order to obtain reliable information on the long-term economy of each material.

6. Data should be obtained to show traffic density, day and night visibility, and other pertinent performance factors. These data should be collected at regular intervals.

We wish to emphasize that while plastic pavement markings are admittedly more durable than paint, the weight of the information available at the present time does not support the contention that they can be economically justified on the basis of performance alone. However, there is a lack of sufficient well-documented evidence to make a precise evaluation possible. States considering the use of plastic markings should be urged to proceed with planning for experimental construction along the lines outlined above with the understanding that Federal funds may participate in the total cost of plastic markings for the purpose of evaluating the relative merits of the various kinds of marking materials.
SPECIFICATIONS

for

REFLECTORIZED THERMO-PLASTIC PAVEMENT MARKING
MATERIAL (CATAHERM)

1. General

These specifications cover reflectorized Thermo-Plastic pavement material of a type that is applied to the road surface in a molten state, by mechanical means. The material, when properly applied, shall be plainly visible to the motorist both day and night. Nighttime visibility shall be by reflex-reflection induced by ordinary automobile headlights.

2. Scope

These specifications shall be the standard for such requirements as material characteristics, method of application, retention of characteristics, guarantee, application rate and packaging.

3. MATERIAL CHARACTERISTICS

a. The material shall be a pure, hot-melt, essentially non-volatile thermoplastic compound especially developed for traffic markings.

b. The Thermo-plastic marking material shall be installed in both white and yellow color at various widths depending upon its use, and thickness from 3/16th inch to 1/8th inch uniformly applied, such as Catatherm or an approved equal.

c. White thermoplastic material after drying shall be pure White, free from dirt or tint. Yellow thermoplastic material after drying, shall be Federal Yellow in shade, as specified in Federal Specifications TT-P-115, Section E-1C. The reflectorized material shall have the property of angular reflectivity.

d. The material shall harden sufficiently within 8 minutes at 90°F. and 5 minutes at 50°F. after application to allow traffic over the line without pick up or impression.

e. The temperature versus viscosity characteristic of the plastic material shall remain constant through repeated reheatings; and shall be the same as the master batch. There shall be no obvious change in color of the material as a result of repeated reheatings, or from batch to batch.

f. In the plastic state, the material shall not give off fumes which are toxic or otherwise injurious to persons or property. The material shall not break down or deteriorate if held at the plastic temperature for long periods of time, or by reason of repeated reheating to the plastic temperature.
g. Not less than 75% of the spheres shall meet the following requirements:

1. The surface of the spheres shall be smooth, lustrous, and free from film scratch and pits.
2. The spheres shall be clear and transparent and shall not be oblate in shape or fused spheroids (Roundness of beads may be tested by means of the Wald Roundness Tester).
3. The spheres shall show high autocollimating efficiency. Not more than 1% shall be black, amber or milky.
4. The spheres shall be of such size, shape and character as to permit their embedment in the freshly applied thermoplastic compound so as to secure their proper retention and permit the immediate refracting and reflecting of headlight rays.

h. After application and proper drying time, the material shall show no appreciable deformation or discoloration under normal traffic nor under air and/or road temperatures ranging from minus 20°F to plus 130°F.

i. Glass beads shall be uniformly mixed throughout the material at the rate of not less than 800 pounds of beads per ton of material. Immediate reflectance shall be accomplished by an application of beads to the surface of the compound at the time the thermoplastic material is applied. These beads shall be applied uniformly at a rate of one pound of beads per 100 ft. of 4" wide line. The applied beads shall show an immediate average reading of not less than 30 when tested by a Hunter Night Visibility Meter in accordance with ASTM D1011. A mechanical beader of approved design must be used.

j. The stripe shall have a uniform cross section and shall maintain its original dimensions and placement. The exposed surface shall remain free from tack. Ductility of the material shall be such as to permit normal movement with the road surface without chipping or cracking, and such as to prevent dimensional distortion as a result of traffic impact within the temperature range specified. The stripe shall not be slippery when wet.

k. The softening point of the thermocompound shall not be less than 200°F as measured by the ball and ring method (ASTM designation: E28-58T). The density of the material shall be uniform throughout and not more than 120 pounds per cubic foot.

l. The compound shall not deteriorate by contact with sodium chloride, calcium chloride, or other mild acids, alkalis or other chemicals used against formation of ice or roadways or streets or because of the oil content of pavement materials or from oil droppings from traffic.

m. The thermoplastic compound must conform to the following acceleration tests:
(1) Water absorption of the compound prepared as actual installation. 24 hours immersion at 25°C shall not absorb more than one half of one percent water by weight.

(2) Color retention of thermocompound: After 100 hours exposure to ultra violet light being the equivalent to accelerated sunlight exposure, there shall be no darkening of color when subjected to the "Standard Method of test for colorfastness of Plastics to light," ASTM D620-57T.

(3) Cracking Tests comprising the following consecutive exposures: 8 hours at minus 20°F, 8 hours at 70 to 76°F, 8 hours at 120 to 130°F. There shall be no cracking, checking, flaking or separation from the substrate.

n. There shall be no aggregate used in the thermocompound other than reflective glass beads. (The term aggregate is defined here as any material having a plus 200 mesh grain size.) The pigment used for the thermocompound shall be of a high grade pure titanium dioxide. The pigment shall be supplemented by a high quality finely ground white calcium carbonate with a compressive strength of 5000 pounds per square inch. The pigment shall be uniformly dispersed throughout the thermoplastic compound.

o. Throughout the life of the base material it shall have at least the following range of percent reflectivity as measured with the Hunter Multipurpose Reflectometer or its equivalent using magnesium oxide as a standard. (ASTM designation D97-55).

White: Day and Night 75 - 85% reflectivity
Yellow: Day 65 - 75% reflectivity
Night 75 - 80% reflectivity

p. To insure the best possible adhesion, the compound, as specified shall be installed in a melted state at a minimum temperature of 375°F, and the material shall not scorch or discolor if kept at this temperature for several hours.

q. The material used shall be a product especially compounded for traffic stripes, and shall be applied by the contractor using factory trained specialists.

4. APPLICATION

a. The material shall be applied to the pavement surface by an extrusion method wherein one side of the shaping die is the pavement and the other sides are contained by, or are a part of, suitable machinery for heating, mixing, and controlling the flow of the material. The finished lines shall have well defined edges and be free of waviness. All of the equipment necessary to the preheating and application of the material shall be so designed that the temperature of the material can be controlled within the limits necessary to its pourability for good application. The equipment shall be so designed to permit agitation of the material to prevent scorching, discoloration or excessive high temperatures of any part of the material.
b. The equipment shall be so equipped as to permit preheating of the pavement immediately prior to application of the material.

c. The applicator shall be mobile and maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc.

d. The applicator shall be capable of containing a minimum of 125 pounds of molten material.

e. The shaping die shall be so constructed that the top surface of the line will form a slight arch. The minimum thickness of the line as viewed from a lateral cross section shall be not less than 3/32nds of an inch at the edges, nor less than 1/8th of an inch in the center. The measurements shall be taken as an average throughout any 36-inch section of the line. Any line or lines in excess of 3/32nds inch, which may be specified in the invitation to bid, shall be subject to the same method of determining line thickness.

f. The material, when formed into traffic stripes, must be readily renewable. When an application is made over an existing stripe the total line thickness shall meet the minimum requirements established by the Vendee, subject to specifications outlined in the previous paragraph. The new line when applied over an old line of compatible material, shall bond itself to the old line in such a manner that no splitting or separation takes place during its useful life.

g. When a new line is to be laid over an old line the vendor reserves the right to inspect the existing line before making the new application or guaranteeing his material.

5. PACKAGING

The material shall be packaged in strippable cartons which contain 50 pounds net of the material. The carton shall be clearly marked so as to indicate the contents, color of material, manufacturer's name, batch number of the material, and manufacturer's batch number. The cartons must conform to the minimum specifications set forth by the I.C.C.

6. WARRANTY

a. The Thermo-Plastic material outlined in these specifications shall be warranted against failure due to defective materials and workmanship in manufacture. The material shall be guaranteed to perform a useful service of not less than nine times the useful service of a good quality paint stripe applied under similar road surface conditions.
b. ALTERNATIVE GUARANTEE (For approved pavements carrying 30,000 vehicles per day or less)

The successful bidder shall guarantee to replace, without cost to the customer, that part of the pavement markings installed under this contract which, in the opinion of the Engineer in charge, have not remained to perform useful service as follows:

(1) Crosswalks and Stop lines

- 90% of the total of any one intersection for 1 year
- 75% of the total at any one intersection for 2 years
- 50% of the total at any one intersection for less than 3 years

(2) Lane Lines, Edge Lines, and Center Lines:

- 90% of a unit for 1 year
- 80% of a unit for 2 years
- 60% of a unit for 3 years

A "unit" is defined as any length of highway having installed thereon 2,000 lineal feet of line of specified width in any combination or pattern.

The replacement material installed under this guarantee shall be guaranteed the same as the original material, from the date of the original installation.
SPECIFICATIONS FOR FURNISHING LABOR, MATERIALS AND EQUIPMENT TO INSTALL THERMOPLASTIC COMPOUND PAVEMENT MARKINGS (PERMA-LINE)

DESCRIPTION: Traffic reflectorized stripes shall be placed in the lines of roadways as shown on the plans or specified and the stripes shall be installed along the centerline and edges of driving pavements, and in other locations as steering lines, lane lines, stop lines and crosswalk lines as shown on the plans or as directed.

I. GENERAL

This specification is intended to set minimum limits of the nature, characteristics and method of application for thermoplastic compound pavement marking material. The term "thermoplastic compound" in these specifications is used to define a substance machine applied to the pavement surface in a hot molten state and which, after cooling to the ambient temperature, forms a traffic marking stripe of a quality and appearance as specified in subsequent sections of these specifications.

II. SCOPE

Under these specifications the contractor shall furnish all of the material, equipment and labor to apply thermoplastic compound for pavement markings.

This specification shall be the standard for the following requirements:

A. Material
B. Material, hot characteristics
C. Material, cold characteristics
D. Method of application
E. Drying time
F. Retention of characteristics
G. Samples for test
H. Qualifications of contractor
I. Warranty

III. DETAILED SPECIFICATIONS

A. Material

1. The material shall be a product especially compounded for the traffic marking.
2. The material shall be a thermoplastic compound, consisting of dolomite thermoplastic resin and other materials, all to be light and stable.

3. The filler, to be incorporated with the resins as binder, shall be a white, calcium carbonate with a compressive strength of five thousand pounds (5000 lbs.) per square inch. The pigment used shall be T-102 Titanium Dioxide.

4. The composition and quality of the material shall be such as to produce an excellent weather and wear resistant traffic line marking.

5. The material shall be delivered to the job site in containers as processed by the manufacturers.

6. Each material container shall be clearly and adequately marked to indicate the color of the material, the process batch number or similar manufacturer's identification and the manufacturer's name and location.

7. The property of the material that gives power to reflect light shall be accomplished by automatically applying reflectorizing beads to the surface of the completed line at a uniform rate of approximately one pound of glass beads to every 120 ft. of 4" lines, and to other widths in the same proportion.

8. Beads applied to the surface of the completed stripe shall be applied by an automatic bead dispenser attached to the liner in such manner that the beads are deposited almost instantly upon the completed line. The bead dispenser shall be equipped with an automatic cut-off control synchronized with the cut-off of the setting material.

B. MATERIAL, HOT CHARACTERISTICS

1. At the pouring temperature, the material shall have stable chemical and physical characteristics.

   a. In the molten state, the material shall not give off fumes which are toxic or otherwise injurious to persons or property. The material shall not break down or deteriorate if held at the pouring temperature for long periods of time, or by reason of repeated reheating to the pouring temperature of the compound.
b. The temperature versus viscosity characteristics of the material shall remain constant through repeated reheatings, and shall be the same from batch to batch. There shall be no change in color of the material as a result of repeated reheatings or from batch to batch.

c. The pigmented binder shall be well dispersed and free from all skins, dirt, foreign objects, or such ingredients as will cause bleeding, staining or discoloration, due to dissolution of asphalt in the pavement.

C. MATERIAL, COLD CHARACTERISTICS

After application and proper drying, the material shall show no appreciable deformation or discolouration under local traffic conditions and in an air and/or road temperature range of 10 degrees Fahrenheit to 120 degrees Fahrenheit.

1. The stripe shall maintain its original dimensions and placement. The exposed surface shall be free from tack. Cold ductility of the material shall be such as to permit normal movement with the paved surface without chipping or cracking; and such as to prevent dimensional distortion as a result of traffic impact within the temperature range specified.

2. The stripe shall not be slippery when wet. The material shall not lift from the pavement during freezing weather.

3. The stripe shall have a uniform cross section. Pigment shall be evenly dispersed throughout the material. The density and character of the material shall be uniform throughout its thickness.

4. Material shall not deteriorate by contact with sodium dioxide, sodium chloride, mild acids or alkalis or other chemicals used in street cleaning or road clearing operations (such as snow and ice removal).

5. The white thermoplastic material, after drying, shall be pure white, free from dirt or tint.

6. The yellow thermoplastic material, after drying, shall be "Federal" yellow in shade, as specified in Federal Specifications TT-P 115, Section E-1c.
D. METHOD OF APPLICATION

1. The contractor shall buff surfaces to clean off dirt, glaze and grease where necessary.

2. There shall be sprayed on the surfaces, where the lines are to be installed, just prior to installation of the lines, a binder sealer for adhesion. The binder sealer material shall be sprayed in sufficient quantities to entirely cover the surface on which thermoplastic line is to be laid.

3. The material shall be applied to the pavement by an extrusion method, wherein one side of the shaping die is the pavement and the other sides are contained by, or are part of suitable machinery for heating, mixing and controlling the flow of the material.

4. The machinery shall be constructed so that all mixing and conveying parts, up to and including the shaping die, maintain the material at the pouring temperatures. The pouring temperatures shall be such as to assure a permanent bind between the material and the pavement surfaces and in no case shall be less than 375°F.

5. Machinery shall be so constructed as to assure continuous uniformity in the dimensions of strip. The thickness of the material on the pavement shall be no less than 3/32 inch nor more than 1/8th inch, measured as an average in any one foot of length.

6. The material may be installed in variable widths from 4" to 12 inches.

7. Shaping die shall include a cutoff device, remotely controlled to provide clean, square stripe ends to provide a method for applying "skip" lines. The use of pans, aprons or similar appliances, which the die overruns, will not be permitted.

8. The material, when applied, shall have uniform dispersion of binder, color pigment and glass beads for reflectorization on the surface.

9. The air temperature, at the time of application of the compound shall not be less than 55°F., and the ground temperature not less than 45°F.
E. DRYING TIME

1. Under this specification the term "drying time" shall be defined as a minimum elapsed time after application, after which the stripe shall have, and retain, the characteristics required by the preceding section. In addition, the drying time shall be established by the minimum elapsed time after application, after which normal local traffic will leave no impression or imprint on the new stripe.

2. The drying time shall not exceed a characteristic straight line curve; the lower limits of which are five minutes at 45°F, the upper limits of which are 20 minutes at 90°F, both ambient air temperatures measured at a maximum relative humidity of 70%.

F. RETENTION OF CHARACTERISTICS

The thermoplastic material used under this specification shall be so compounded and applied as to retain, for the life of the stripe, the original characteristics of bond to the road surface, ability to resist distortion by traffic impact or normal climate changes and resistance to natural discoloration.

G. SAMPLES FOR TEST

1. Each bidder shall be prepared to submit samples of the thermoplastic compound he proposes to install in the shape of a line 4" wide and 12" long, on a base acceptable to State Engineers, for the purposes of laboratory testing of hot and cold characteristics.

2. State Engineers may elect to accept a certification from a commercial testing laboratory, which, in the opinion of the Engineers, is adequate proof that the material and method of application are in compliance with this specification.

3. In addition to the above, each bidder shall be prepared to make a sample installation at a site to be selected by State Engineers, to demonstrate that the method or machinery used for the application produces a line of uniformity satisfactory to these specifications.

H. QUALIFICATIONS OF CONTRACTOR

1. The successful bidder shall be prepared to furnish information to prove that there has been successfully installed by his personnel and equipment and/or by the personnel and
equipment of the original material manufacturer, thermoplastic pavement marking compound in substantial single quantities (totalling more than 1,000,000 sq. ft.) in towns, cities, highways, bus terminals, parking lots, etc. throughout the United States.

2. The contractor shall use only men who are experienced in the work of installing thermoplastic compounds.

3. The contractor shall use only application methods and equipment, as approved by the original material manufacturer.

I. WARRANTY

1. Thermoplastic compound pavement marking material furnished and installed under this specification shall be guaranteed by the contractor against failure due to wear or poor adhesion, which results from defective materials or methods of application.

2. The contractor shall guarantee, in writing, at least 50% of the footage he has installed at each location to remain in place and be in an effective condition for at least four years for center lines, three years for lane lines and two years for stop lines and crosswalks. The contractor shall replace, at his expense, any pavement markings which, in the opinion of the State Engineers, fail to meet the conditions guaranteed.

IV. BIDDING

The contractor shall bid his price per linear foot for the thermoplastic compound pavement marking material to be installed in place by the contractor. The State reserves the right to make additions or deletions to the locations shown on the invitation; such additions or deletions not to exceed 20% of the total approximate value of the contract. Exact footage applied will be determined at time of application and the contractor will be paid on the basis of this exact footage at the quotation per linear foot. In the event the application of the thermoplastic compound becomes unduly delayed by weather or other conditions such as to prevent the completion of the work the contractor will be paid for the number of linear feet of compound installed multiplied by the quoted cost per linear foot.
V. Before final payment of the stripe work, the contractor shall furnish security for this work in the form of a surety bond, or by depositing cash or securities in the sum of 10% of the contract bid price for the stripes and guaranteeing the maintenance of the material for the stipulated period as herein provided.
PROPOSED TEST SITES
Experimental, Thermo-plastic,
Pavement-stripeing Materials