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DEPARTMENT OF
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COOPERATIVE HIGHWAY RESEARCH PROGRAM
REPORT 70-3

INVESTIGATION OF PAINTS AND GLASS BEADS USED IN TRAFFIC DELINEATION MARKINGS

PHASE I

MISSOURI STATE HIGHWAY DEPARTMENT
BUREAU OF PUBLIC ROADS

Missouri Cooperative Highway Research Program.
Report 70-3.

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PHASE I

EVALUATION OF A MISSOURI DISPERSION RESIN-VARNISH TYPE PAINT AND A CHLORINATED RUBBER-ALKYD PAINT UNDER FIELD CONDITIONS

DEPARTMENT OF
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JUN 29 1973

Prepared by

MISSOURI STATE HIGHWAY DEPARTMENT
Division of Materials and Research
and
Division of Maintenance and Traffic

May 1970

in cooperation with

U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration
Bureau of Public Roads

The opinions, findings and conclusions expressed in this publication are not necessarily those of the Bureau of Public Roads.

SYNOPSIS

This field evaluation of a Missouri dispersion resin-varnish type paint and a chlorinated rubber-alkyd paint in a transverse stripe clearly indicates the superiority of the chlorinated rubber-alkyd paint to resist wear. The results indicate that there is approximately 1% increase in expected life for each increase in wet film mil thickness for the Missouri dispersion resin-varnish type paints and 3% increase in expected life for each increase in wet film mil thickness for the chlorinated rubber-alkyd paints when applied in thickness range from 10 mils to 20 mils. The method of visual evaluation of the paint stripes which correlated best with the actual stripe life was the general appearance rating system. Visual evaluation was also made by the abrasion and chipping rating systems as described by ASTM.

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INTRODUCTION

The traffic loads on our highways today are increasing at such a rapid rate that the need for better materials has become quite evident through increases in quantities of materials used and the rapid deterioration of newly painted delineation stripes.

Since prior testing of new paints by the Department has been limited, a joint research project in this area was initiated between the Divisions of Materials and Research and Maintenance and Traffic within the Missouri State Highway Department in cooperation with the Bureau of Public Roads. The scope of this investigation is to study (1) cold applied paints for durability due to wear, (2) hot applied paints for durability due to wear, and (3) to study the compatibility of these paints with various types of glass beads.

This report covers the first phase or the durability study of two cold applied paints, a Missouri dispersion resin-varnish type paint, that has been used within our state for several years, and a chlorinated rubber-alkyd paint, that has been used satisfactorily in other states, applied to asphalt and concrete pavements in wet film thicknesses of approximately 10, 15, and 20 mils, in two colors, white and yellow. Throughout this report the term, Missouri standard paint, will indicate the dispersion resin-varnish type paint.

CONCLUSIONS

The test performed under this phase of the field evaluation of paints used in traffic delineation markings has provided a good analysis of the wear characteristics of the Missouri standard paint and the newly formulated chlorinated rubber-alkyd paint. These paints were applied to asphalt and concrete pavements in transverse stripes of 10±2, 15±2, and 20±2 mil thickness ranges and were evaluated by an observation team of five men.

Evaluation was done by observation of each stripe for general appearance, abrasion, and chipping. The general appearance rating was considered the best and easiest rating to use and was the most consistent of the three ratings to estimate the life expectancy of the stripes.

The white and yellow chlorinated rubber-alkyd paints were significantly better than the Missouri standard paint on the asphalt and concrete pavements. The stripes placed on the asphalt pavement had durability ratings significantly better than the stripes placed on concrete pavement for both paints at all thickness ranges.

The results were evaluated separately with respect to paint type and pavement type to establish relative significance between each thickness range of the paint film. There is a linear relationship with both the Missouri standard and chlorinated rubber-alkyd paints but is more predominate

with the chorinated rubber-alkyd paint. This indicates that as thickness is increased the life expectancy of the stripe increases, per the limits of this test. However, the difference in the rate of wear between the 10, 15, and 20 mil thickness ranges was small for the Missouri standard paint as indicated by the calculated expected life values. There is less than 1 percent increase in expected life for each mil increase in wet film thickness for the Missouri standard paints. The chlorinated rubber-alkyd paint on the other hand does show an appreciable difference in expected life which is also significant. There is a 3 percent increase in expected life for each mil thickness increase in wet film thickness for the chlorinated rubber-alkyd paint.

Generally, the chlorinated rubber-alkyd paint, under the conditions imposed upon it by this test method, performed better than the Missouri standard paint. The life expectancy of the chlorinated rubber-alkyd paint was found to be 16, 20, and 38 percent greater than the Missouri standard paint at the 10, 15, and 20 mil wet film thickness ranges respectively.

IMPLEMENTATION

Based on the relative wear resistant characteristics of the paints studied and considering the size of the Missouri Highway Department's striping program and equipment available to complete this program, indications are that the 15 mil wet film thickness should provide the most economical balance between life of line and striping program requirements. Based on a comparison between a 15 mil wet film thickness and the current 20 mil application rates, a considerable economical saving would be realized. Reduction of film thickness would provide a savings of 70,000 gallons of white traffic paint, 25,000 gallons of yellow traffic paint and 500,000 pounds of glass beads since the bead application is based on wet film thickness. These material reductions constitute an annual striping cost reduction of $235,000.

The comparison between the Missouri Standard paint and the chlorinated rubber-alkyd paint, when applied at 15 mils, indicates an increase life of 20% based on resistance to wear. This increase in life would offset the increased cost of material. With the highly desirable qualities of faster drying and the fact that the chlorinated rubber-alkyd paint should provide a usable traffic marking for a longer period of time, particularly during the winter season, the expanded use of this type of material should be considered.

SCOPE

The field evaluation was confined to the application of paint stripes four inches wide placed transverse to the direction of travel with evaluation in the wheel paths. Duplicate test sections were placed on both the asphalt and concrete pavements.

The asphalt and concrete test sections were located in District 6 on Route 40 TR, St. Louis County (see Figure 1). The outside lane of the west bound dual was used for this test with both sections for each pavement type lying end to end. A 100-foot gap was provided between the sections for identification purposes as well as providing space for installation of a traffic counting loop. The traffic volumes actually recorded in the outside lane of both test locations showed average number of vehicles per day to be 14,940 and 13,290 for the asphalt and concrete pavements respectively.

Each test section was composed of four replicate stripes of each type of paint placed at approximately 10, 15, and 20 mils by wet film measurement for each of two colors, white and yellow, for a total of 48 stripes. All stripes were placed in random order with preassigned line numbers selected from a table of random numbers.

Observations were made at various time intervals by a panel of five men consisting of a:

Materials Research Engineer

Maintenance and Traffic Engineer

Maintenance and Traffic Technician

District Maintenance Superintendent

District General Striper Foreman

ASTM D821-47, D913-51, and D713-66T were used as guidelines for rate of wear attributed to abrasion, chipping, and general appearance respectively.

MATERIALS

Materials used in this phase of our testing program were obtained, where possible, from regular shipments to our Maintenance and Traffic Division for use in the pavement marking program. The Missouri standard white and yellow paints, which were formulated by the specifications shown in Appendix A, were obtained from approved shipments in May, 1969 and April, 1969 respectively. Laboratory analysis of these paints at the time of shipment are shown in Table 1. The method of analysis for each of these properties is primarily based on the methods set forth in "Physical and Chemical Examination of Paints, Varnishes, Lacquers and Colors*" by Henry A. Gardner and G. G. Sward. Many of these procedures are similar to those in ASTM except for quantities of material used.

The chlorinated rubber-alkyd paint was obtained by purchase order to comply with the specifications shown in Appendix B. Laboratory analysis of these paints at the time of shipment are shown in Table 2. The method of analysis for each of these properties is the same as described for the Missouri standard paint.

It is interesting to note by observation of Tables 1 and 2, that the Missouri standard paint is slightly

*Distributed by Henry A. Gardner Laboratory, Inc., Bethseda, Maryland.

higher in percent pigment, longer in drying time, and slightly lower in weight per gallon. Otherwise, these paints appear similar in all other characteristics.

Glass beads applied to the stripes were accepted for use by our specification as shown in Appendix C.

FABRICATION OF TEST SECTIONS

The Missouri standard paint and the chlorinated rubber-alkyd paint, in white and yellow colors only, were placed on asphalt and concrete pavements in a very high traffic area. To identify the stripe by paint type, color, wet film thickness, and line number, the following abbreviated identification was used:

Column 1 indicates the color being either W (white) or Y (yellow).

Columns 2 and 3 indicate the type of paint being either MS (Missouri standard paint) or the CR (chlorinated rubber-alkyd paint).

Columns 4 & 5 indicate the thickness range in which the paint will be evaluated being 10±2, 15±2, or 20±2 mils.

Column 6 indicates the number of the replicate stripes applied being 1 through 4 for test section one and being 5 through 8 for test section two for each pavement type.

A typical identification code, such as WCR10-1 would be identified as White, Chlorinated rubber-alkyd paint, 10±2 mil thickness range and line number 1. This code for stripe identification proved very satisfactory in evaluating all the paints and thicknesses in the statistical analyses.

The random order established for the location of each stripe within each test section on both types of pavements are shown in Table 3. These lines were randomized to eliminate any bias due to line location within a test section.

Each paint was applied in sets of four replicate stripes in wet film thickness ranges of 10±2, 15±2, and 20±2 mils. Stripes not meeting thickness requirements were omitted from the test and relocated at the end of the test section, with the exception of 5 stripes, which, due to time limitations, were accepted for test.

The pavement surface, in the area where the test sections were located, showed considerable wear in the wheel paths. The concrete surface was worn to an uneven exposed aggregate condition. The asphaltic concrete surface although worn to an exposed aggregate condition was relatively smooth. The exposed aggregate in the concrete test section probably had an effect on the life of the paint stripes; however, since all the stripes were subjected to this condition it was felt that no bias was introduced into the experiment. Furthermore, as the two test sections on either pavement type only required an area approximately 300 feet in length by one lane in width, it was felt that the pavement characteristics did not change appreciably throughout the test sections.

FIELD CONTROL TESTS

Weather Conditions:

The weather conditions during the application of pavement markings has a definite effect on the paint characteristics as well as a marked effect on the durability or life of the stripe. To comply with paragraph 5.1 of ASTM D713-66T the temperatures and relative humidities were recorded hourly, as shown in Table 4. The close range in temperature and relative humidity was a good indication that the effect of weather conditions was minimized in this experiment.

Wet Film Thickness:

To insure that each stripe was of a specific wet film thickness and satisfactory for inclusion in the test, a wet film measurement was taken within 5 seconds after the line was placed. To provide a flat smooth surface for film measurements, a metal paving plate (8 inches by 8 inches by 16 mils thick) was placed on the pavement approximately 8 to 12 inches from the shoulder and in the path of the striper. As the stripes were placed by starting at the centerline and moving towards the shoulder, the spray was judged to be most uniform within the latter six feet of the line. The bead stream was broken when the striper passed over the paving plate by catching the beads in a small container. The wet film measurements were taken by the use of an Interchemical Wet Film Thickness Gage (ASTM D1212-54).

The thickness data were separated and regrouped into thickness ranges of 10±2, 15±2, and 20±2 mils (see Table 5). A statistical analysis of this data indicated that there was no significant effect of pavement type on the thickness measurements. This meant that there was no bias with regard to wet film thickness.

Drying Time:

The apparatus used to evaluate all the stripes for dry time is that described in ASTM D711-55. This apparatus is applicable to field use whereas the apparatus described in ASTM D711-67 is designed for laboratory use only.

Since the test for drying time resulted in a delay to the striping operation, only selected lines were tested as shown in Table 6. The results show that the Missouri standard paint required at least 15 to 20 minutes minimum drying time to a no-pick-up condition and ranged up to a maximum of one hour. The chlorinated rubber-alkyd paint required at least 2 to 7 minutes minimum drying time to a no-pick-up condition and ranged up to a maximum of approximately 20 minutes.

The dry time test is only a relative measure of the ability of the paint film to skin over. It does not mean that the paint is completely dry full depth.

Therefore, the data shown here does not necessarily mean that under normal traffic a tire will not cause the dried skin to slip causing fresh paint to be exposed.

Dry Film Thickness

The samples used to measure the wet film thickness of each of the stripes were allowed to air dry for approximately two weeks before taking the dry film thickness measurements. The data were arranged and grouped by wet film thickness (Table 7). A statistical analysis indicated that with one exception there was no significant difference in dry film thickness between pavement type, paint type, or color of the paint. The one exception was between paint types at 20 mil thicknesses. The analysis for the 20 mil thickness data gave a significant difference (0.1%) between the types of paint but no significance between pavement type or color of the paints. By observing Table 7 the thickness of the dry paint film for the chlorinated rubber-alkyd paint is higher in most cases than the Missouri standard paint and is highly significant at the 20 mil application rate.

To show the relative difference in the wet to dry film thicknesses for the paints used in this test, Figures 2 and 3 represent the white Missouri standard and chlorinated rubber-alkyd paints respectively and Figures 4 and 5 represent the yellow Missouri standard and chlorinated rubber-alkyd paints respectively.

For any given wet film thickness, as measured by the Interchemical gage, we obtained a range in dry film as shown in these figures. The chlorinated rubber-alkyd paint did show the largest variation, especially with the yellow formulation.

EVALUATION TEST PROCEDURES

Evaluation of the paint stripes was based on the observation of one or more modes of failure inherent in field conditions. ASTM D713-66T covers basically the general modes of failure which are: (1) appearance, (2) durability, (3) nighttime visibility, and (4) a weighted rating of all three. The appearance and durability ratings were the only modes used to determine the wear resistance of the various paint thicknesses.

General Appearance:

The appearance rating was a measure of the complete impression conveyed when each individual stripe was viewed prior to detailed inspection. This rating took into consideration the degree of wear, discoloration due to yellowing or fading, darkening, and dirt retention. This rating was found to be the most realistic measure of when a stripe should be repainted and was by far the easiest to evaluate.

The observations of abrasion and chipping were used as completely separate measures of durability in an attempt to establish the mode of failure. All of these evaluations were based on a scale of 0 to 10 with 0 being the end point where the stripe is completely worn out and 10 being the initial condition of a newly painted stripe.

Abrasion:

Failure by abrasion, as described in ASTM D821-47, is the condition of a painted stripe caused by gradual surface disappearance or thinning of the film, ultimately exposing the substrate. The degree of failure is estimated by the amount of substrate that is visible. This mode of failure can result from either mechanical abrasion, weathering, or by combination of both. A set of reference photographs are shown in the ASTM Standards publication.

Chipping:

Failure by chipping, as described in ASTM D913-51 is the condition of a painted stripe whereby actual detachment of entire sections of the film, usually in small pieces, has occurred. Failure is usually characterized by sharp distinct edges and definite demarkation of the bare area. The degree of resistance to failure is judged by the amount of substrate that has remained covered. A set of reference photographs are shown in the ASTM Standards publication.

RESULTS AND DISCUSSION

Observations of the concrete test sections began three weeks after placement of the stripes. As the rating system was new to most of the observers, considerable time was spent discussing various paint stripes and acquainting each observer with the various modes of failure being considered in the test. The instruction and observations on the concrete test sections required more time than anticipated; therefore, the asphalt test sections were observed the following week. Thereafter, the observations on the concrete and asphalt test sections were made the same day. Observations were made at periods of 5, 7, 9, 11, 14, 17, 20, and 23 weeks with termination of the concrete test sections at 17 weeks, and termination of the asphalt test sections at 23 weeks.

Observers rated both the inner and outer wheel path portion of each stripe. Each stripe was one of a set of four replicates. The average rating obtained for each mode of failure for each duplicate set of stripes is shown in Tables 8, 9, and 10 for general appearance, abrasion, and chipping respectively. By observation of the original data, the inner and outer wheel path ratings showed little difference in average values; therefore, only the data for the outer wheel path evaluations will be discussed in this report.

The modes of failure evaluated in this field evaluation study, which were explained in detail in the

previous section, were very hard to distinguish at times. The angle at which the sun and the observer made with the stripe was very critical. Some of the deterioration, especially abrasion, could not be detected because of the glare or washout of the finer worn spots. The failure due to chipping was easier to evaluate early in the test, but when the abrasion failures became more predominant, especially when worn full depth causing exposure of the substrate, a considerable amount of interference was encountered in making the evaluation. In the opinion of the panel, the easiest mode of failure to evaluate was general appearance which included both the abrasion and chipping losses as well as the discoloration and dirt retention of the stripe.

The complete statistical evaluations made on each of the modes of failure show the general appearance rating was inclusive and contained basically the same significance levels as did the abrasion and chipping. The best correlation between the modes of failure was between the chipping and general appearance ratings. Data from the chipping and general appearance ratings best predict the actual life expectancy of the stripes with the abrasion enlarging these values by approximately 40 percent. Therefore, the following discussion will be based largely on the general appearance data.

Simplification of the data shown in Tables 8, 9, and 10 for purposes of our discussion was accomplished

by reducing each group of data to its respective regression slope (b') value and recorded in Table 11. These values were obtained by modifying the standard regression equation ($Y = a + bx$) for a straight line by requiring the line of best fit to go through the visual rating (y-axis) of 10.0 at 0 weeks exposure (x-axis). In so doing, the equation of the slope becomes, $b' = -\left(\frac{10-Y}{x}\right)$. Since all new stripes would be given a visual rating of 10.0 and since with the limited number of points available, normal regression analysis would yield random intercepts, the use of 10.0 as a fixed intercept is justified.

Using the slope values for the general appearance rating, Figures 6 and 7 were constructed to show the relative relationships between the Missouri standard and chlorinated rubber-alkyd paints and between the wet film thickness of each paint as rated against age or exposure to traffic. These relationships will be discussed in the following paragraphs and will be evaluated by using analysis of variance techniques. The notation to be used in the analysis of variance is shown in Table 12.

Analyses of variance was run for the durability of the paint stripes with respect to: 2 duplicate test sections, 7 observation periods for concrete and 9 observation periods for asphalt, 3 thicknesses of paint film, and 2 kinds of paint for each visual rating, each pavement type, and each color of paint. The components were calculated from the average of the individual ratings for each stripe which are not shown in this report.

The analysis were made for each of the visual ratings by dividing the data into four groups. Each group of data consisted of either white or yellow paint applied to either asphalt or concrete pavement. Table 13 shows the analyses of variance completed for all four groups of data obtained for the general appearance rating only. Similar analyses were made for the abrasion and chipping ratings but are not shown in this report.

Statistical evaluation by analysis of variance of the raw data yielded probability levels of significance (α) of 0.1% for all of the items being considered. The kind of paint being either Missouri standard or chlorinated rubber-alkyd was significant in all cases. When the general appearance ratings were significant the chipping ratings were also significant except for the kind of white paint on asphalt. This indicates that normally the general appearance and chipping ratings gave similar statistical impressions of the durability of the stripes. This apparent similarity is lost when the life expectancy of each set of duplicate stripes is calculated.

The ASTM method D713-66T for conducting road service tests recommends that the length of time required for a stripe to reach a rating value of 4, on a scale of 0 to 10, for a combined weighted rating of Appearance, Durability, and Night Visibility or a rating value of 3 for any item independent of the others be considered as the useful life of the stripe. The point of useful life or the point at which restriping should be considered for use in this test was a rating of 3 for the

abrasion and chipping ratings evaluated independently and a value of 4 for the general appearance rating based on the definition stated in the previous section.

The life expectancy of each paint type per its color and thickness, with regard to the pavement type where it was placed can be estimated from the previously calculated b' or regression slope values for each group of data. The number of weeks for each set of duplicate stripes to reach a re-stripe condition with respect to each mode of failure are shown in Table 14. The life expectancy or estimated re-stripe age of the stripes show the inability of the chipping rating to maintain its similarity with the general appearance rating.

The effect of age on visual rating was highly significant. The interaction of age on the thickness of the paint film was significant in most cases in the asphalt test sections and not significant in the concrete test sections. This indicates that although thickness had a definite effect over most of the experiment, thickness had little or no effect at an early age. The effects of the interaction of age on the kind of paint used does have a pronounced effect which is to be expected from the fact that the paint type is significant and this significance is a function of age.

The effect of thickness when studied in analyses inclusive of both types of paints is significant at the 0.1% level. This does not give a definite indication as to the relationship between the thicknesses of either of the two paints observed separately. Therefore, by evaluating the two paints separately on each pavement type for the three thickness ranges, Table 15, indicated significance at the 0.1% level for both the Missouri paints. The thickness variables for each paint type for each pavement was subdivided into linear and quadratic components to further evaluate the nature of the thickness relationship. The results for each component calculated for each of the analyses of variance from Table 15 are shown in Table 16.

Generally, there is a linear relationship with both the Missouri standard and chlorinated rubber-alkyd paints. This indicates that as thickness is increased, the life expectancy of the paint stripe increases and is significant per the limits of this test. The Missouri standard paint on concrete does have quadratic tendencies, however, the linear component tends to predominate. This indicates that as thickness is increased the life expectancy of the paint stripe does increase and does so in such a manner that near the end of the expected life of the stripes the 20 mil thickness is significant. However, the advantage of the 20 mil thickness does seem small as indicated by the expected life values shown in Table 14.

The chlorinated rubber-alkyd paint has a linear relationship in all cases. This indicates that as thickness is increased the life expectancy of the paint stripe increases and

is significant. Near the end of the expected life of each thickness group the difference in appearance of the stripes is appreciable. This is shown in Table 14 with the largest difference between the 15 and 20 mil range. The chlorinated rubber-alkyd results may be more pronounced because of the relative increase in percentage of the paint film remaining after drying.

Thickness has been shown to have a highly significant effect on the visual appearance of the painted stripes regardless of paint type, paint color or type of test section and further that this relationship is predominantly linear. To this point, however, no mention has been made of the magnitude of this effect. A study of Table 14 of the relative life expectancy by paint type, paint color and type of test section can be used to evaluate the magnitude of such effect.

The life expectancy of the Missouri standard white and yellow is increased some 6% and 12% respectively on concrete and 12% and 9% respectively on asphalt when the wet film thickness was increased from 10 mils to 20 mils. This is an overall increase of approximately 9% for both colors on both test sections.

The life expectancy of the chlorinated rubber-alkyd white and yellow paints is increased some 40% and 32% respectively on concrete and 18% and 30% respectively on asphalt when the wet film thickness was increased from

10 mils to 20 mils. This is an overall increase of approximately 30% for both colors on both test sections.

A similar comparison can be made reflecting the magnitude of the effect of paint type on visual appearance at each paint thickness. The life expectancy of the chlorinated rubber-alkyd paint at 10 mil, 15 mil, and 20 mil thickness is 16%, 20%, and 38% greater respectively than the Missouri standard paint with a somewhat greater increase in life for the yellow than for the white.

The other rating systems of abrasion and chipping did not offer any additional data nor did they offer any contrary results to those discussed in this report.

APPENDIX A

SPECIFICATIONS AND CHEMICAL ANALYSIS OF MISSOURI DISPERSION RESIN-VARNISH TYPE PAINT

MISSOURI STATE HIGHWAY DEPARTMENT
EQUIPMENT AND PROCUREMENT DIVISION
Jefferson City, Missouri

SPECIFICATIONS FOR WHITE TRAFFIC MARKING PAINT *

1. The specifications cover a ready-mixed white paint suitable for application on concrete and bituminous pavements.

2. The paint shall be homogeneous, well ground, shall not settle badly or cake in the container, and shall be readily broken up with a paddle to a smooth, uniform consistency. It shall be free from water, dirt and other foreign matter and shall dry within the specified period to a good, tough, serviceable film. Any paint which shall have livered or in any way hardened or thickened in the container, or in which the pigment shall have settled out so that it cannot be readily broken up with a paddle to a smooth uniform paint of useable consistency, after six months storage, will be returned to the bidder for full refund or credit. The paint shall be ground in a pebble mill and shall be strained before filling, using natural tubular cloth knitted from 20/1 KP yarn, 26 stitches, 25 wales, weight 3.74 ounces per square yard, and bursting strength 68 pounds or a suitable sieve meeting the approval of the Engineer. Sufficient Prussian blue shall be added to overcome any yellow tint in the paint. Premixing or grinding of the pigments with any portion of the vehicle prior to charging the pebble mill will not be permitted. The dispersion resin shall be added at the time the pebble mill is charged.

3. The Manufacturer shall furnish the Engineer free access to all parts of the plant, and shall furnish every reasonable facility for sampling both the paint and the raw materials during the process of manufacture.

4. All materials used in manufacture shall meet the requirements herein specified. Any materials not specifically covered shall meet the approval of the Engineer.

5. The Manufacturer shall submit samples of raw material in sufficient time that the inspection and testing will not interfere with the production schedule.

* These specifications were in force at the time this investigation was initiated.

6. The ready-mixed paint shall be purchased by volume, one (1) gallon shall mean two hundred thirty-one (231) cubic inches at seventy-seven (77) degrees Fahrenheit.

7. The containers shall be strong, substantial, new, clean, metal drums free from defects or any coating on the inside. One end of the drum shall contain a completely detachable head of uniform size and type, and be securely fastened to the head of the drum by means of any satisfactory air-tight method. No pipe outlets will be permitted. Only gaskets that will insure proper sealing shall be used. Drums that are not satisfactorily sealed and leak when stored upside down will not be accepted. All containers shall be approved by the Engineer as to type and weight.

8. Pigment Constituents

   (a) Titanium Dioxide shall comply with A.S.T.M. Specification D476-66 for Type II.

   (b) Titanium Calcium Pigment shall comply with A.S.T.M. Specification D476-66.

   (c) Magnesium Silicate: This pigment shall consist substantially of natural hydrous magnesium silicate that is white, fibrous, finely ground and is commercially known as pigment quality.

   (d) Aluminum Stearate: This pigment shall be a grit-free, white powder suitable for use in paint.

9. Vehicle Constituents

   (a) Varnish shall have at least a 25 gallon oil length and shall be formulated with a modified phenol formaldehyde resin. The non-volatile oil portion of the varnish shall be composed of not less than seventy-five (75) percent by weight of china wood oil, the balance of the oil portion to be left to the discretion of the manufacturer, except that the use of fish oil will not be permitted. Suitable naphthenate driers shall be incorporated to give the drying time specified. The thinner used in the manufacture of the varnish shall be V. M. and P. naphtha. The varnish shall be thoroughly compatible with the dispersion resin specified under paragraph 9 (b).

When mixed in the ratio of 1/2 to 2 parts varnish to 1 part dispersion resin the mixture shall be smooth, creamy and free from lumps and the mixture of 1/2 varnish to 1 resin shall show no separation when allowed to stand 24 hours in an open container. The varnish shall meet the following requirements:

1. Shall be clear and transparent.

2. Shall set to touch within four (4) hours and dry hard within eight (8) hours.

3. Shall contain not less than fifty (50) percent by weight of non-volatile oils and gums.

4. Shall pass an eighty (80) percent Kauri reduction test.

5. Shall have a viscosity of from B to E (Gardner-Holdt) at 25°C.

6. The dried film shall withstand cold water for eighteen (18) hours, and boiling water for fifteen (15) minutes, without showing any whitening or dulling, after removing from the water and drying at room temperature for ten (10) minutes. Separate films shall be used for each immersion.

(b) Dispersion Resin shall be a highly polymerized, oleoresinous material capable of being dispersed in naphtha or xylol, or mixtures of naphtha and xylol, and drying almost entirely by solvent evaporation. The solid portion shall contain a high percentage of acetone insoluble material. The dispersion resin shall be compatible with all constituents in the paint formulation, and any paint that has separated, livered, or jelled after storage, to such an extent as to render it unuseable will be returned to the bidder for full refund or credit.

The dispersion resin shall have the following properties:

Miscibility with N-Hexane, not less than	70 ml.
Percent Solids (105°C, 3 hrs.)	48 to 56
Percent Zinc Oxide, not less than	7.5
Percent Zinc Oxide in Ash, not less than	98.0
Percent Acetone Insoluble, not less than	45.0
Penetration (Standard cone) 150 gm, 5 sec, 0°C not more than	255

Compatibility Test - The resin shall be compatible.

When tested in the ratio of 1 part dispersion resin and 1 part of rubber solvent naphtha the mixture shall be smooth, creamy and free from lumps and shall show no separation when allowed to stand 72 hours in a closed container.

Skinning Test - No skinning shall be present on the surface when the dispersion resin is allowed to stand in a partly filled closed container for 72 hours.

Color - A light transmittance of not less than 30 percent.

When the dispersion resin is extracted with rubber solvent naphtha in the ratio of 3 parts naphtha to 1 part resin the extracted liquid shall be clear and show a light transmittance of not less than 30 percent at a wave length of 475 millimicrons measured on Bausch and Lomb Spectronic 20.

Plastic Flow - The dispersion resin shall retain its plastic flow characteristics when allowed to stand in an open container for 24 hours.

(c) Butyl Alcohol shall comply with A.S.T.M. Specification D304-58 for normal Butyl Alcohol.

(d) Naphtha Solvent shall be a petroleum distillate commonly known as "rubber solvent", having the following characteristics:

A.P.I. Gravity at 60°F	68-74
Initial Boiling Point	100-120°F
End Point	Not over 285°F.
Color	Water white
Corrosion	It shall not blacken or corrode a clean, metallic copper strip in thirty (30) minutes, at the boiling point of the naphtha.

(e) China Wood Oil shall comply with A.S.T.M. Specification D12-64 for Raw Tung Oil. Beta Tung Oil will not be approved.

10. Pigment Formulation — Percent by Weight

Rutile Titanium Dioxide	10.0
Titanium Calcium Pigment	62.0
Magnesium Silicate	27.0
Aluminum Stearate	1.0

11. Vehicle Formulation — Percent by Weight

Varnish	43.0
Dispersion Resin	28.7
Butyl Alcohol	4.5
Naphtha Solvent	23.8
Toluene	*

* Five gallons of toluene per 1000 gallons of finished paint.

12. Mixed Paint — Percent by Weight

Pigment	48.0 - 51.0
Vehicle	49.0 - 52.0
Minimum Grind (Hegman Gage)	3

Skinning Test - No skinning shall be present on the surface when the paint is allowed to stand in a partly filled closed container for 72 hours. The paint shall be free of lumps and skins when strained through a No. 100 mesh sieve.

Freezing and Thawing - The physical characteristics of the paint shall not be affected when the paint is subjected to 5 cycles of freezing and thawing (18 hours at 0°F, 6 hours at 100°F.)

The finished paint, when manufactured, shall have a consistency of not less than 60 nor more than 80 seconds at 80°F. as measured with a number 4 Ford Cup. The Engineer may increase or decrease the viscosity requirements as much as 10 seconds.

When flowed on a tinned panel and set at an angle of 45°, the paint shall dry within ten (10) minutes at a temperature of 77°F.

MISSOURI STATE HIGHWAY DEPARTMENT
EQUIPMENT AND PROCUREMENT DIVISION
Jefferson City, Missouri

SPECIFICATIONS FOR YELLOW
TRAFFIC MARKING PAINT*

1. These Specifications cover a ready-mixed yellow paint suitable for application on concrete and bituminous pavements. The color of the finished paint shall be standard Federal Yellow. No other pigments, lakes or tinting colors, other than specified shall be used, but two or more shades of chrome yellow may be used if necessary to obtain the specified standard color.

2. The paint shall be homogeneous, well ground, shall not settle badly or cake in the container, and shall be readily broken up with a paddle to a smooth uniform consistency. It shall be free from water, dirt, and other foreign matter and shall dry within the specified period to a good, tough, servicable film. Any paint which shall have livered or in any way hardened or thickened in the container, or in which the pigment shall have settled out so that it cannot be readily broken up with a paddle to a smooth uniform paint or useable consistency, after 6 months storage, will be returned to the bidder for full refund or credit. The paint shall be ground in a pebble mill and shall be strained before filling, using natural tubular cloth knitted from 20/1 KP yarn, 26 stitches, 25 wales, weight 3.74 ounces per square yard, and bursting strength 68 pounds or a suitable sieve meeting the approval of the Engineer. Premixing or grinding of the pigments with any portion of the vehicle prior to charging the pebble mill will not be permitted. The dispersion resin shall be added at the time the pebble mill is charged.

3. The Manufacturer shall furnish the Engineer free access to all parts of the plant, and shall furnish every reasonable facility for sampling both the paint and raw materials during the process of manufacture.

4. All materials used in manufacture shall meet the requirements herein specified. Any materials not specifically covered shall meet the approval of the Engineer.

5. The Manufacturer shall submit samples of raw materials in sufficient time that the inspection and testing will not interfere with the production schedule.

* These specifications were in force at the time this investigation was initiated.

6. The ready-mixed paint shall be purchased by volume, one (1) gallon shall mean two hundred thirty-one (231) cubic inches at seventy-seven (77) degrees Fahrenheit.

7. The containers shall be strong, substantial, new, clean, metal drums, free from defects or any coating on the inside. One end of the drum shall contain a completely detachable head of uniform size and type, and be securely fastened to the head of the drum by means of any satisfactory air-tight method. No pipe outlets will be permitted. Only gaskets that will insure proper sealing shall be used. Drums that are not satisfactorily sealed and leak when stored upside down will not be accepted. All containers shall be approved by the Engineer as to type and weight.

8. Pigment Constituents

   (a) Medium Chrome Yellow shall comply with A.S.T.M. Specification D211-67 Type III.

   (b) Magnesium Silicate: This pigment shall consist substantially of natural hydrous magnesium silicate that is white, fibrous, finely ground and is commercially known as pigment quality.

   (c) Aluminum Stearate - This pigment shall be a grit-free, white powder suitable for use in paint.

9. Vehicle Constituents

   (a) Varnish shall have at least a 25 gallon oil length and shall be formulated with a modified phenol formaldehyde resin. The non-volatile oil portion of the varnish shall be composed of not less than seventy-five (75) percent by weight of china wood oil, the balance of the oil portion to be left to the discretion of the manufacturer, except that the use of fish oil will not be permitted. Suitable naphthenate driers shall be incorporated to give the drying time specified. The thinner used in the manufacture of the varnish shall be V. M. and P. naphtha. The varnish shall be thoroughly compatible with the dispersion resin specified under paragraph 9 (b). When mixed in the ratio of 1/2 to 2 parts varnish to 1 part dispersion resin the mixture shall be smooth,

creamy and free from lumps and the mixture of 1/2 varnish to 1 resin shall show no separation when allowed to stand 24 hours in an open container. The varnish shall meet the following requirements.

1. Shall be clear and transparent.

2. Shall set to touch within four (4) hours and dry hard within eight (8) hours.

3. Shall contain not less than fifty (50) percent by weight of non-volatile oils and gums.

4. Shall pass an eighty (80) percent Kauri reduction test.

5. Shall have a viscosity of from B to E (Gardner-Holdt) at 25°C.

6. The dried film shall withstand cold water for eighteen (18) hours and boiling water for fifteen (15) minutes, without showing any whitening or dulling, after removing from the water and drying at room temperature for ten (10) minutes. Separate films shall be used for each immersion.

(b) Dispersion Resin shall be a highly polymerized, oleoresinous material, capable of being dispersed in naphtha or xylol, or mixtures of naphtha and xylol and drying almost entirely by solvent evaporation. The solid portion shall contain a high percentage of acetone insoluble material. The dispersion resin shall be compatible with all constituents in the paint formulation and any paint that has separated, livered, or jelled, after storage, to such an extent as to render it unusable, will be returned to the bidder for full refund or credit.

The dispersion resin shall have the following properties:

Miscibility with N-Hexane,
not less than . . . . . 70 ml.
Percent Solids (105°C, 3 hrs.) . . . 48 to 56
Percent Zinc Oxide,
not less than 7.5
Percent Zinc Oxide in Ash,
not less than 98.0
Percent Acetone Insoluble,
not less than 45.0
Penetration (Standard cone)
150 gm, 5 sec, 0°C, not more
than 255

Compatibility Test - The resin shall be compatible.

When tested in the ratio of 1 part dispersion resin and 1 part of rubber solvent naphtha the mixture shall be smooth, creamy and free from lumps and shall show no separation when allowed to stand 72 hours in a closed container.

Skinning Test. No skinning shall be present on the surface when the dispersion resin is allowed to stand in a partly filled closed container for 72 hours.

Color - A light transmittance of not less than 30 percent.

When the dispersion resin is extracted with rubber solvent naphtha in the ratio of 3 parts naphtha to 1 part resin the extracted liquid shall be clear and show a light transmittance of not less than 30 percent at a wave length of 475 millimicrons measured on Bausch and Lomb Spectronic 20.

Plastic Flow - The dispersion resin shall retain its plastic flow characteristics when allowed to stand in an open container for 24 hours.

(c) Butyl Alcohol shall comply with A.S.T.M. Specification D304-58 for normal Butyl Alcohol.

(d) Naphtha Solvent shall be a petroleum distillate commonly known as "rubber solvent", having the following characteristics:

A.P.I. Gravity at 60°F 68-74
Initial Boiling Point . . . . . 100-120°F
End Point . . . . . Not over 285°F
Color . . . . . Water White
Corrosion . . . . . It shall not blacken or corrode a clean, metallic copper strip in thirty (30) minutes, at the boiling point of the naphtha.

(e) China Wood Oil shall comply with A.S.T.M. Specification D12-64 for Raw Tung Oil. Beta Tung Oil will not be approved.

10. Pigment Formulation — Percent by Weight

Medium Chrome Yellow	60.0
Magnesium Silicate	39.0
Aluminum Stearate	1.0

11. Vehicle Formulation — Percent by Weight

Varnish	43.0
Dispersion Resin	28.7
Butyl Alcohol	4.5
Naphtha Solvent	23.8
Toluene	*

* Five gallons of toluene per 1000 gallons of finished paint.

12. Mixed Paint — Percent by Weight

Pigment	48.0 - 51.0
Vehicle	49.0 - 52.0
Minimum Grind (Hegman Gage)	2

Skinning Test - No skinning shall be present on the surface when the paint is allowed to stand in a partly filled closed container for 72 hours. The paint shall be free of lumps and skins when strained through a No. 100 mesh sieve.

Freezing and Thawing - The physical characteristics of the paint shall not be affected when the paint is subjected to 5 cycles of freezing and thawing. (18 hours at 0°F, 6 hours at 100°F.)

The finished paint, when manufactured, shall have a consistency of not less than 60 nor more than 80 seconds at 80°F. as measured with a number 4 Ford Cup. The Engineer may increase or decrease the viscosity requirements as much as 10 seconds.

When flowed on a tinned panel and set at an angle of 45°, the paint shall dry within ten (10) minutes at a temperature of 77°F.

13. The attention of all bidders is invited to the fact that traffic paints are and have been under continuous study and testing by the Materials Laboratory of the State Highway Commission, located on Highway 50 West, Jefferson City, Missouri. Many of these tests have been developed by the State Highway Commission in order to secure the best possible final product, and bidders and their representatives are invited to said laboratory, at which time the various tests employed will be explained to the bidder.

    In addition to the above stipulation the Commission reserves the right to reject any and all bids, to select the paint which will in the opinion of the Commission and as shown by tests in the Commission's laboratory, produce the most satisfactory final product.

TABLE 1

PROPERTIES OF MISSOURI
DISPERSION RESIN-VARNISH TYPE PAINTS

White:	Lab. No. 69-4509	
	Percent Pigment	51.0
	Percent Vehicle	49.0
	Percent Non-Volatile in Vehicle	33.7
	Weight per Gallon, lbs.	10.81
	Viscosity @ 80°F (Ford Cup #4) Seconds	76
	Drying Time, Minutes	5
	Minimum Grind (Hegman Gage)	3
Yellow:	Lab. No. 69-3266	
	Percent Pigment	51.0
	Percent Vehicle	49.0
	Percent Non-Volatile in Vehicle	34.4
	Weight per Gallon, lbs.	11.35
	Viscosity @ 80°F (Ford Cup #4) Seconds	99
	Drying Time, Minutes	6
	Minimum Grind (Hegman Gage)	2

APPENDIX B

SPECIFICATIONS AND CHEMICAL ANALYSIS OF CHLORINATED RUBBER-ALKYD PAINT

MISSOURI STATE HIGHWAY DEPARTMENT
EQUIPMENT AND PROCUREMENT DIVISION

Experimental White Traffic Marking Paint

Specification A*

A. Pigment Constituents

(a) Titanium Dioxide. This pigment shall comply with A.S.T.M. Specification D476-66, Type I, Anatase.

(b) Magnesium Silicate. This pigment shall consist substantially of natural hydrous magnesium silicate that is white, fibrous, finely ground, and is commercially known as paint pigment quality.

(c) Zinc Oxide. This pigment shall comply with A.S.T.M. Specification D79-44, American Process Type.

(d) Calcium Carbonate. This pigment shall comply with A.S.T.M. Specification D1199-66T, Type PC, Grade 1.

(e) Montmorillonite. (Bentone 38 prewet) This pigment shall be finely divided hydrous aluminum silicate powder suitable for use in paints.

B. Vehicle Constituents

(a) Chlorinated Rubber. The chlorinated rubber shall have the following properties:

Chlorine	64 to 67%
Color (Gardner, 20% by weight in toluene)	4 maximum
Viscosity (20% by weight in toluene)	17 to 25 centipoises

(b) Alkyd Resin. The alkyd resin solution shall be a medium length soya or linseed oil modified type alkyd that has been reduced in VM and P Naphtha to a minimum 60% Solids Content. The solution shall contain a minimum of 33% phthalic anhydride based on the alkyds solids. The alkyd resin solution shall be compatible when tested as shown below:

(1) A solution containing 100 grams of chlorinated rubber, 130 grams of the alkyd resin solution, and 290 grams of methyl ethyl ketone shall be clear, transparent and show no separation after 24 hours storage at 80 ± 5°F.

* These specifications were in force at the time this investigation was initiated.

(c) Chlorinated Paraffin. This material shall meet Federal Specification MIL-C-429A, Type I.

(d) Methyl Ethyl Ketone. This material shall meet Federal Specification TT-M-00261C.

(e) Aromatic Naphtha. This material shall meet the following requirements:

Appearance	clear and free of sediment
Color	Water white
Specific Gravity @ 60°F	0.873 to 0.876
Boiling Range	320° to 355°F

(f) Methyl Alcohol. This material shall be commercial Methyl Alcohol suitable for use in paints.

(g) Drier. This material shall be lead and cobalt driers suitable for use in paints.

(h) Anti-Skinning Agent. This material shall be an anti-skinning agent for use in paints.

C. Pigment Formulation

	Percent by Weight
Titanium Dioxide Pigment	34.7
Magnesium Silicate Pigment	30.3
Zinc Oxide Pigment	8.7
Calcium Carbonate Pigment	26.0
Bentone 38	0.3

D. Vehicle Formulation

	Percent by Weight
Alkyd Resin	21.2
Chlorinated Rubber	16.3
Chlorinated Paraffin	12.2
Methyl Ethyl Ketone	47.2
Aromatic Naphtha	0.8
Methyl Alcohol	0.8
*Epichlorohydrin	0.5
Lead Driers (24%)	0.3
Cobalt Drier (6%)	0.2
Anti-Skinning Agent	0.5

*Epichlorohydrin is added as a stabilizer.

E. Mixed Paint

Grind (Hegman Gage) minimum	2 1/2
Viscosity , K. U. at 77°F (Stormer)	70 to 80

MISSOURI STATE HIGHWAY DEPARTMENT
EQUIPMENT AND PROCUREMENT DIVISION

Experimental Yellow Traffic Marking Paint

Specification B*

A. Pigment Constituents

(a) Medium Chrome Yellow. This pigment shall comply with A.S.T.M. Specification D211-67, Type III.

(b) Titanium Dioxide. This pigment shall comply with A.S.T.M. Specification D476-66, Type I, Anatase.

(c) Magnesium Silicate. This pigment shall consist substantially of natural hydrous magnesium silicate that is white, fibrous, finely ground, and is commercially known as paint pigment quality.

(d) Zinc Oxide. This pigment shall comply with A.S.T.M. Specification D79-44, American Process Type.

(e) Calcium Carbonate. This pigment shall comply with A.S.T.M. Specification D1199-66T, Type PC, Grade I.

(f) Montmorillonite. (Bentone 38-prewet) This pigment shall be a finely divided hydrous aluminum silicate powder suitable for use in paints.

B. Vehicle Constituents

(a) Chlorinated Rubber. The chlorinated rubber shall have the following properties:
Chlorine . . . . . 64 to 67%
Color (Gardner, 20% by weight in toluene) . . . . . 4 maximum
Viscosity (20% by weight in toluene) . . . . . 17 to 25 centipoises

(b) Alkyd Resin. The alkyd resin solution shall be a medium length soya or linseed oil modified type alkyd that has been reduced in VM and P Naphtha to a minimum 60% Solids Content. The solution shall contain a minimum of 33% phthalic anhydride based on the alkyds solids. The alkyd resin solution shall be compatible when tested as shown below:

* These specifications were in force at the time this investigation was initiated.

(1) A solution containing 100 grams of chlorinated rubber, 130 grams of the alkyd resin solution, and 290 grams of methyl ethyl ketone shall be clear, transparent and show no separation after 24 hours storage at 80 ± 5°F.

(c) Chlorinated Paraffin. This material shall meet Federal Specification MIL-C-429A, Type I.

(d) Methyl Ethyl Ketone. This material shall meet Federal Specification TT-M-00261C.

(e) Aromatic Naphtha. This material shall meet the following requirements:

Appearance	clear and free of sediment
Color	Water white
Specific Gravity @ 60°F	0.873 to 0.876
Boiling Range	320° to 355°F

(f) Methyl Alcohol. This material shall be commercial Methyl Alcohol suitable for use in paints.

(g) Drier. This material shall be lead and cobalt driers suitable for use in paints.

(h) Anti-skinning Agent. This material shall be an anti-skinning agent suitable for use in paints.

C. Pigment Formulation

	Percent by Weight
Medium Chrome Yellow Pigment	30.7
Titanium Dioxide Pigment	3.8
Magnesium Silicate Pigment	26.8
Zinc Oxide Pigment	7.7
Calcium Carbonate Pigment	30.7
Bentone 38	0.3

D. Vehicle Formulation

	Percent by Weight
Alkyd Resin	20.8
Chlorinated Rubber	16.0
Chlorinated Paraffin	12.0
Methyl Ethyl Ketone	48.1
Aromatic Naphtha	0.8
Methyl Alcohol	0.8
*Epichlorohydrin	0.5
Lead Driers (24%)	0.3
Cobalt Driers (6%)	0.2
Anti-Skinning Agent	0.5

*Epichlorohydrin is added as a stabilizer.

E. Mixed Paint

Grind (Hegman Gage) minimum 2 1/2
Viscosity, K. U. at 77°F (Stormer) . . . . . 72 to 82

TABLE 2

PROPERTIES OF
CHLORINATED RUBBER-ALKYD PAINT

White:	Lab. No. 69-4987	
	Percent Pigment	49.2
	Percent Vehicle	50.8
	Percent Non-Volatile in Vehicle	36.9
	Weight per Gallon, lbs.	12.00
	Viscosity K. U. at 77°F.	80
	Drying Time, Minutes	2
	Minimum Grind (Hegman Gage)	3
Yellow:	Lab. No. 69-5019	
	Percent Pigment	48.2
	Percent Vehicle	51.8
	Percent Non-Volatile in Vehicle	37.2
	Weight per Gallon, lbs.	12.15
	Viscosity K. U. at 77°F.	82
	Drying Time, Minutes	2
	Minimum Grind (Hegman Gage)	3½

APPENDIX C

SPECIFICATIONS FOR GLASS BEADS

MISSOURI STATE HIGHWAY DEPARTMENT
EQUIPMENT AND PROCUREMENT DIVISION

Jefferson City, Missouri

Type I

SPECIFICATION FOR FREE FLOW REFLECTORIZING SPHERES*

For Application on Traffic Marking Paint

GENERAL

1. These specifications cover free flow reflectorizing spheres for application on traffic paint for the production of a reflective surface to improve the night visibility of the paint film.

2. The spheres shall be manufactured from glass of a composition designed to be highly resistant to traffic wear and to the effects of weathering.

MATERIAL

The spheres shall conform to the following requirements:

1. The material shall be essentially free of sharp angular particles and beads showing milkiness, surface scoring, scratching, air inclusions, or similar defects. The beads shall be spherical in shape, containing not more than thirty (30) per cent of irregularly shaped particles. Mechanically controlled vibration on a glass plate at a predetermined slope shall be used to separate the true spheres from the irregularly shaped particles.

2. Gradation: The spheres shall meet the following gradation requirements:

Opening - U. S. Standard Sieves	Per Cent Passing
# 16 Sieve	100
# 20 Sieve	99.5-100
# 30 Sieve	80-95
# 50 Sieve	18-35
#100 Sieve	0-10
#200 Sieve	0-2

3. The spheres when tested by the liquid immersion method at 25°C shall show an index of refraction within the range of 1.50 to 1.65.

* These specifications were in force at the time this investigation was initiated.

4. Reflectance: Brightness, expressed as candle power per foot candle per square foot, not less than 3.25 (entrance angle 0° and observation angle 0.2°).

Method of Testing for Reflectance:

Optical testing shall consist of measuring the brightness by the following procedure: A 5 inch diameter test panel shall be prepared by applying the beads to a wet paint film of Sherwin Williams Super Ken-Tone Ceiling Flat White Paint or equal. The paint film shall have a minimum thickness of 6 mils and the beads applied at a minimum rate of 6 pounds per gallon. The excess beads that do not adhere to the paint film shall be removed after the paint film has dried by lightly tapping the panel when in a vertical position.

The panel to be tested shall be located at a distance of 100 feet from a single uniformly bright light source having an effective diameter of 2 inches; the light source shall be operated at approximately normal efficiency. The return light from the reflector shall be measured by means of a photoelectric photometer having a minimum sensitivity of 1×10^{-7} footcandle per millimeter scale division. The photometer shall have a receiver aperture 0.5 inch in diameter, shielded to eliminate stray light. The distance from light source center to aperture center shall be 4.2 inches for 0.2° observation angle.

5. Chemical Stability: Beads which show any tendency toward decomposition, including surface etching, when exposed to atmospheric conditions, moisture, dilute acids, or alkalies or paint film constituents, may, prior to acceptance, be required to demonstrate satisfactory behavior under such tests as may be prescribed.

6. Beads shall be free of waxes and oils.

7. The beads shall be free of clusters and hard lumps and shall flow uniformly through dispensing equipment under any weather conditions suitable for striping including atmospheric humidity to 90 percent.

Method of determining free flowing properties:

Weigh 100 grams of dry beads in a glass crystallizing dish 100 mm diameter and 50 mm depth. Place the dish containing the beads on a perforated shelf one inch above the bottom of a 215 mm diameter, 140 mm depth specimen jar containing sufficient water to cover the bottom of the jar to a depth of 1/4 inch. The specimen shall remain in the test jar at 25°C for four (4) hours. When the sample is removed from the test jar the beads are transferred to a metal pan and inspected for lumps and clusters. The beads shall be essentially free of lumps or clusters and shall flow through a standard pyrex funnel 125 mm diameter at top.

8. The attention of all bidders is invited to the fact that glass beads are and have been under continuous study and testing by the Materials Laboratory of the State Highway Commission, located on Highway 50 West, Jefferson City, Missouri. Many of these tests have been developed by the State Highway Commission in order to secure the best possible final product, and bidders and their representatives are invited to said laboratory at which time the various tests employed will be explained to the bidder.

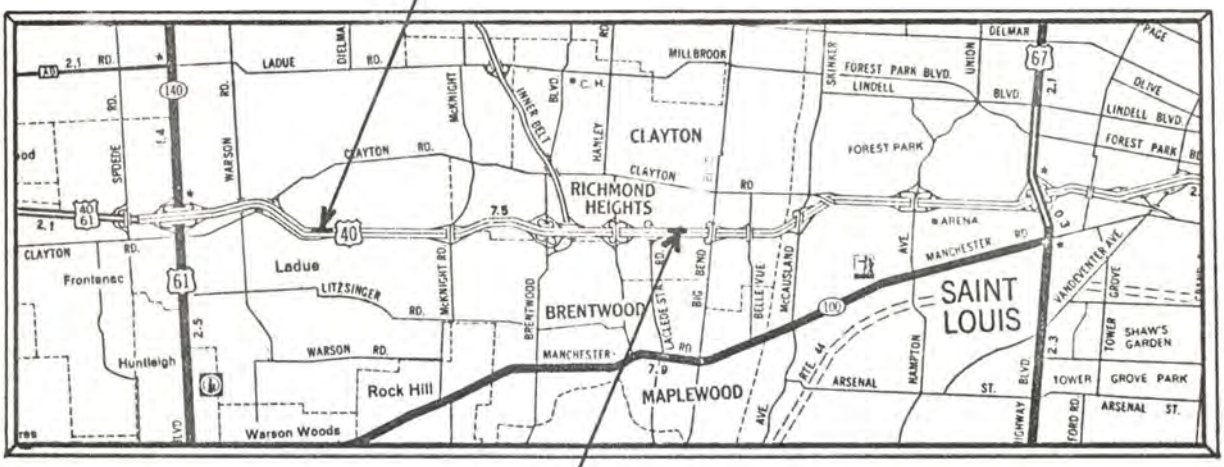
   In addition to the above stipulation, the Commission reserves the right to reject any and all bids, to select the beads which will, in the opinion of the Commission and as shown by tests in the Commission's Laboratory, produce the most satisfactory final product.

APPENDIX D

TEST SECTION DESIGN AND FIELD DATA

Figure 1 - Location and Description of Test Sites

Asphalt Test Sections
West Bound Lane



Concrete Test Sections
West Bound Lane

Asphalt Test Sections: Asphaltic concrete surface on an 8" reinforced PCC pavement, two 12' lanes, testing in outer lane only.

Concrete Test Sections: 9" reinforced PCC pavement, three 12' lanes, testing in outer lane only.

TABLE 3

TEST SECTION LAYOUT FOR THE
ASPHALT AND CONCRETE PAVEMENTS

Line Index No.	Line Ident. No.	Random Ordering* of Index Numbers			
		Asphalt		Concrete	
		TS 1	TS 2	TS 1	TS 2
1	WCR10-1	23	20	2	25
2	-2	5	22	47	5
3	-3	14	45	6	44
4	-4	38	44	27	41
5	WCR15-1	11	16	31	6
6	-2	43	4	43	29
7	-3	36	32	4	42
8	-4	7	3	13	33
9	WCR20-1	31	1	37	9
10	-2	9	27	22	27
11	-3	25	48	38	22
12	-4	10	8	25	21
13	YCR10-1	37	37	33	31
14	-2	47	5	48	46
15	-3	32	40	17	7
16	-4	16	11	29	48
17	YCR15-1	48	33	36	23
18	-2	17	19	46	18
19	-3	8	18	10	20
20	-4	4	7	18	35
21	YCR20-1	41	29	39	30
22	-2	28	10	16	1
23	-3	39	14	20	12
24	-4	33	35	14	16
25	WMS10-1	29	12	23	14
26	-2	2	2	9	24
27	-3	27	23	8	32
28	-4	40	13	11	10
29	WMS15-1	26	42	32	3
30	-2	15	24	34	28
31	-3	3	6	3	39
32	-4	30	36	42	2
33	WMS20-1	13	28	21	19
34	-2	19	9	7	36
35	-3	18	39	5	40
36	-4	6	17	40	34
37	YMS10-1	12	43	12	13
38	-2	22	41	44	43
39	-3	42	34	24	15
40	-4	1	26	30	11
41	YMS15-1	24	38	28	17
42	-2	34	15	41	4
43	-3	35	31	45	37
44	-4	44	30	35	45
45	YMS20-1	46	25	15	47
46	-2	21	46	19	38
47	-3	45	21	26	26
48	-4	20	47	1	8

*Series obtained from "Tables of Random Sampling Numbers", by M. G. Kendal and B. Babington Smith, Cambridge Univ. Press, 1951.

TABLE 4

HOURLY TEMPERATURE AND RELATIVE HUMIDITY READINGS DURING PLACEMENT OF THE STRIPES

Date	Time	Temp. Deg. F	R.H. (%)
August 29	9:00 AM	72	72
	10:00 AM	79	77
	11:00 AM	79	79
	12:00 AM	82	65
	1:00 PM	83	59
	2:00 PM	84	53
	3:00 PM	85	51
	4:00 PM	84	49
August 30	9:00 AM	75	69
	10:00 AM	80	53
	11:00 AM	81	61
	12:00 AM	82	53
	1:00 PM	83	44
	2:00 PM	84	42
	3:00 PM	85	47
	4:00 PM	85	47
August 31	9:00 AM	75	69
	10:00 AM	77	63
	11:00 AM	78	60
	12:00 AM	80	61
	1:00 PM	82	60
	2:00 PM	85	57

TABLE 5

WET FILM THICKNESS MEASUREMENTS OF STRIPES AT TIME OF PLACEMENT

Line Ident. No.	Thickness (Mils.) Asphalt TS 1	Asphalt TS 2	Concrete TS 1	Concrete TS 2	Line Ident. No.	Thickness (Mils.) Asphalt TS 1	Asphalt TS 2	Concrete TS 1	Concrete TS 2
WMS10	12	11	11	10	WCR10	11	8	10	8
	11	10	10	9		8	11	11	10
	12	10	10	10		9	10	9	9
	11	11	11	10		10	9	11	10
WMS15	14	16	15	17	WCR15	13	17	14	15
	13	16	15	17		15	17	13	15
	13	17	15	15		15	16	13	15
	14	15	13	15		13	16	13	15
WMS20	19	18	18	18		21	22	21	21
	17	19	21	22		21	19	19	19
	17	20	19	19		18	20	20	19
	18	19	20	20		19	19	20	18
YMS10	11	8	12	9	YCR10	11	11	10	11
	10	11	9	11		10	10	9	9
	12	11	9	11		11	12	11	11
	12	11	10	11		11	12	10	11
YMS15	13	13	15	15	YCR15	15	15	15	15
	16	13	16	17		14	15	15	13
	16	13	17	14		15	15	15	15
	15	17	16	16		15	16	16	17
YMS20	19	22	20	19	YCR20	19	22	18	20
	18	21	20	19		20	21	20	18
	20	21	19	18		20	22	20	18
	23	23	19	18		20	21	20	23

TABLE 6

DRY TIME TO NO-TRACK AND NO-PICK-UP

Line Ident	No-Track Time Min-Sec	No-Pick-Up Time Min-Sec	Line Ident	No-Track Time Min-Sec	No-Pick-Up Time Min-Sec
Asphalt Pavement - Test Section #1					
WMS10-4	---	15-25	WCR15-3	---	05-03
WMS15-2	---	22-15	WCR15-4	---	01-55
WMS15-3	---	22-17	WCR20-1	---	06-55
WMS20-1	21-24	23-39	WCR20-2	02-42	05-08
YMS10-4	---	45-02	WCR20-3	---	06-21
YMS20-1	---	60-00	WCR20-4	05-50	08-21
WCR15-1	---	03-37	YCR10-3	---	08-32
WCR15-2	06-07	06-54			
Asphalt Pavement - Test Section #2					
WMS10-8	19-04	22-32	WCR10-5	05-30	06-30
WMS15-5	---	18-56	WCR10-7	---	06-25
WMS15-6	19-10	29-45	WCR15-5	---	06-20
WMS15-7	---	26-58	WCR15-7	10-00	11-53
WMS15-8	---	27-35	WCR20-8	---	05-05
WMS20-5	---	22-40	YCR10-5	04-17	07-16
YMS10-8	---	20-24	YCR15-5	---	04-53
YMS15-8	---	48-07	YCR20-6	---	05-56
YMS20-7	---	38-27	YCR20-8	---	10-00
Concrete Pavement - Test Section #1					
WMS10-2	---	48-40	WCR15-3	---	06-00
WMS15-4	---	40-20	YCR10-3	---	05-20
YMS10-1	---	29-30	YCR20-3	18-10	19-40
YMS10-3	---	46-00			
Concrete Pavement - Test Section #2					
WMS10-8	---	56-00	WCR20-7	---	13-45
WMS15-8	---	51-45	YCR10-8	---	10-36
WCR10-8	05-35	08-32	YCR15-8	---	04-18
WCR15-7	---	16-00	YCR20-6	---	11-10

TABLE 7

DRY FILM THICKNESS MEASUREMENTS OF STRIPES

Line Ident No.	Thickness (Mils.) Asphalt TS 1	Asphalt TS 2	Concrete TS 1	Concrete TS 2	Line Ident No.	Thickness (Mils.) Asphalt TS 1	Asphalt TS 2	Concrete TS 1	Concrete TS 2
WMS10	8.80	6.63	5.43	6.88	WCR10	6.00	7.00	4.75	7.85*
	7.45	6.27	6.72	7.05		7.50*	8.00	7.68	7.00
	9.00	7.00*	7.47	7.65		7.00	8.00	6.55	5.68
	6.78	7.58	8.00*	6.80		7.50*	7.00	6.00	6.52
WMS15	8.00*	7.12	6.50	10.87	WCR15	7.08	9.00	5.57	9.37
	7.00*	8.45	8.82	9.87		11.82	6.00	5.45	8.82
	7.25	9.18	10.55	10.45		10.00*	11.00	6.85	11.40
	7.25	8.00*	6.68	8.65		9.63*	9.00	8.35	10.20
WMS20	9.88	7.75	8.80	7.20	WCR20	10.75	12.42	15.40	11.63
	9.30	11.00*	10.97	9.48		6.07	13.50	12.52	14.00
	10.72	9.93	11.10	8.90		12.00*	10.00	14.31*	10.02
	9.10	12.08	10.28	10.27		10.47	10.40	15.00	13.25
YMS10	5.32	4.63	3.78	5.57	YCR10	4.85	9.00	6.58	6.38
	3.50	6.00	5.08	6.18		6.00	8.00	4.63	6.13
	4.70	6.63	5.98	5.98		10.00	10.00	5.33	7.00
	3.32	6.13	5.43	6.73		9.00	12.00	6.47	8.00
YMS15	5.18	6.58	5.63	6.87	YCR15	9.00	9.00	4.37	6.03
	7.05	7.50	7.22	6.48		6.87	12.12	9.93	4.35
	8.05	7.23	6.10	5.30		8.87	9.95	9.78	5.33
	6.40	7.18	6.20	5.60		10.00*	8.97	11.52	4.75
YMS20	6.87	8.32	7.82	8.08	YCR20	16.88	15.25	11.30	10.95
	8.43	7.60	7.32	8.73		12.08	13.20	11.92	9.25
	7.93	7.38	7.78	7.63		16.95	13.32	10.73	10.05
	7.95	8.38	7.50	7.12		15.32	14.90	14.33	13.70

* Estimated values.

Figure 2 - Wet vs. Dry Film Thickness of the White Missouri Standard Paint.

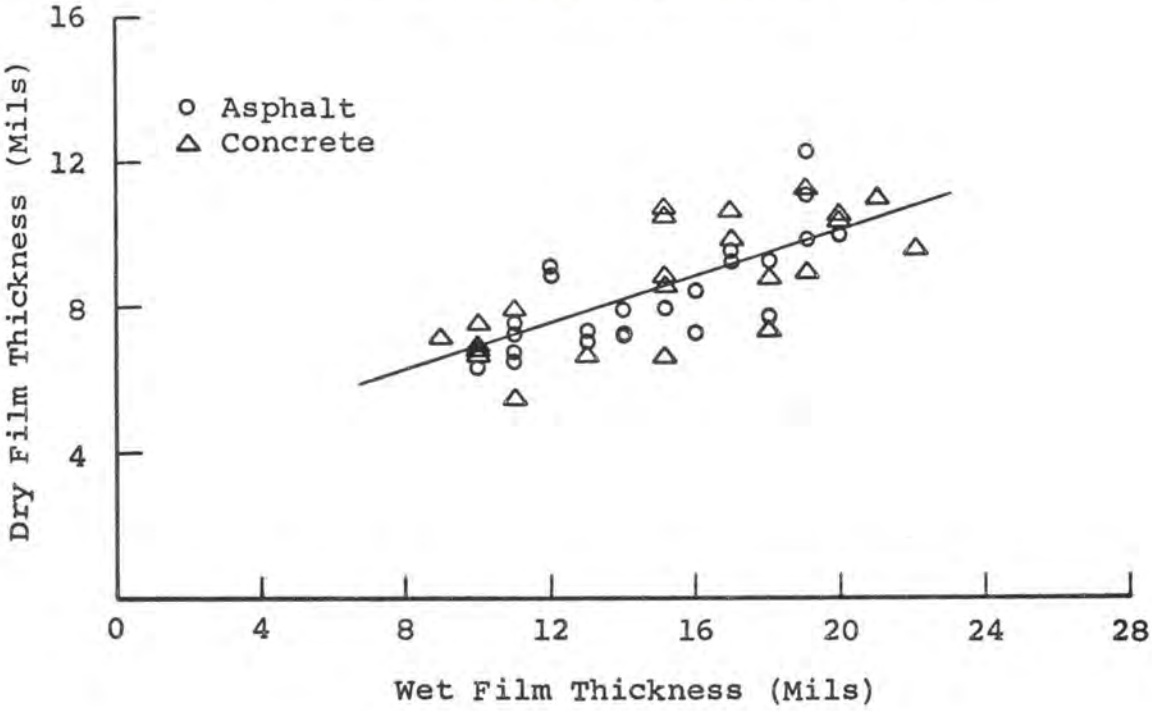


Figure 3 - Wet vs. Dry Film Thickness of the White Chlorinated Rubber-Alkyd Paint.

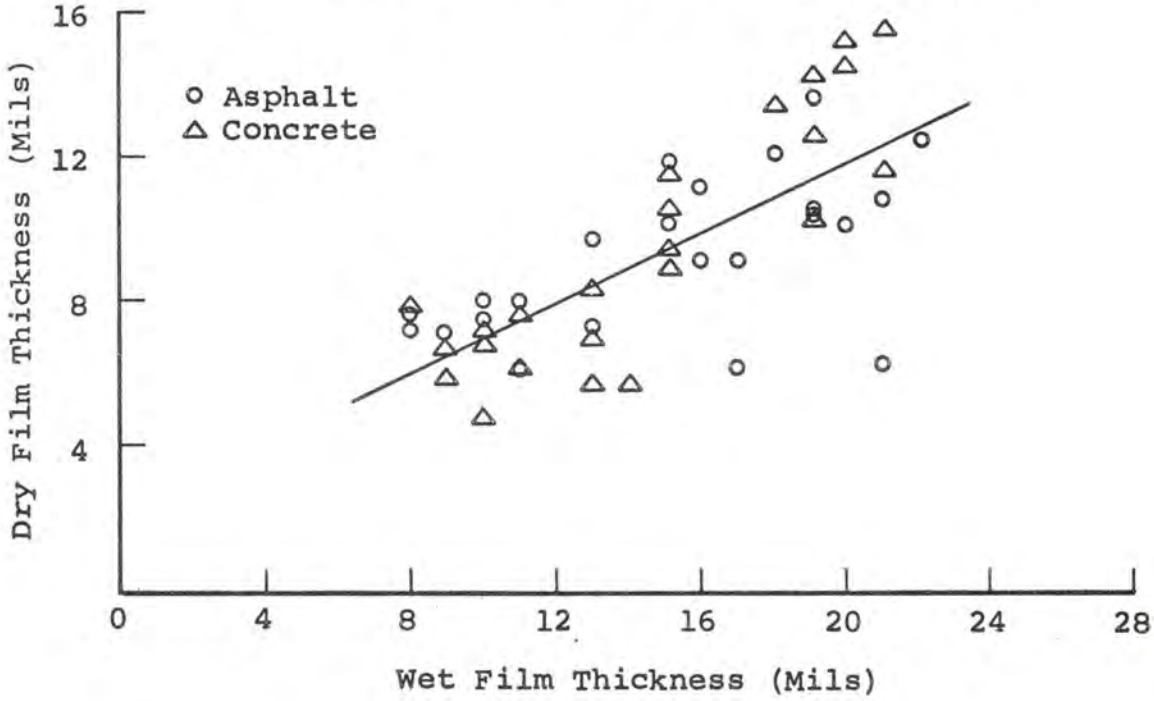


Figure 4 - Wet vs. Dry Film Thickness of the Yellow Missouri Standard Paint.

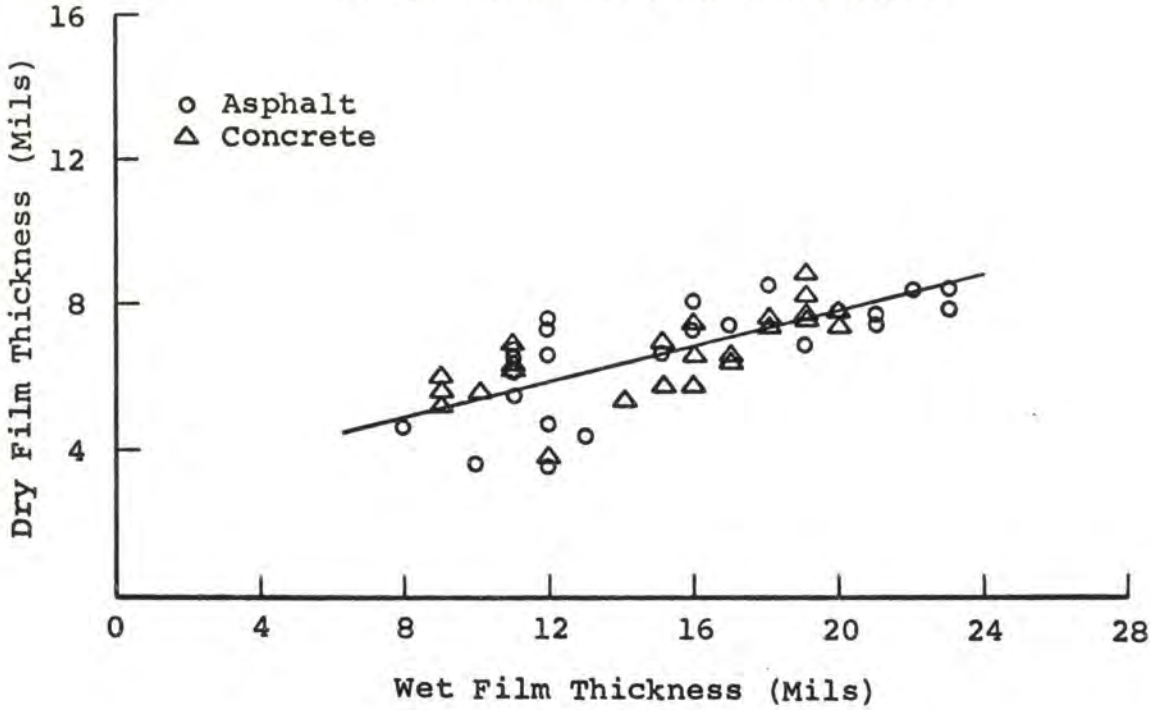
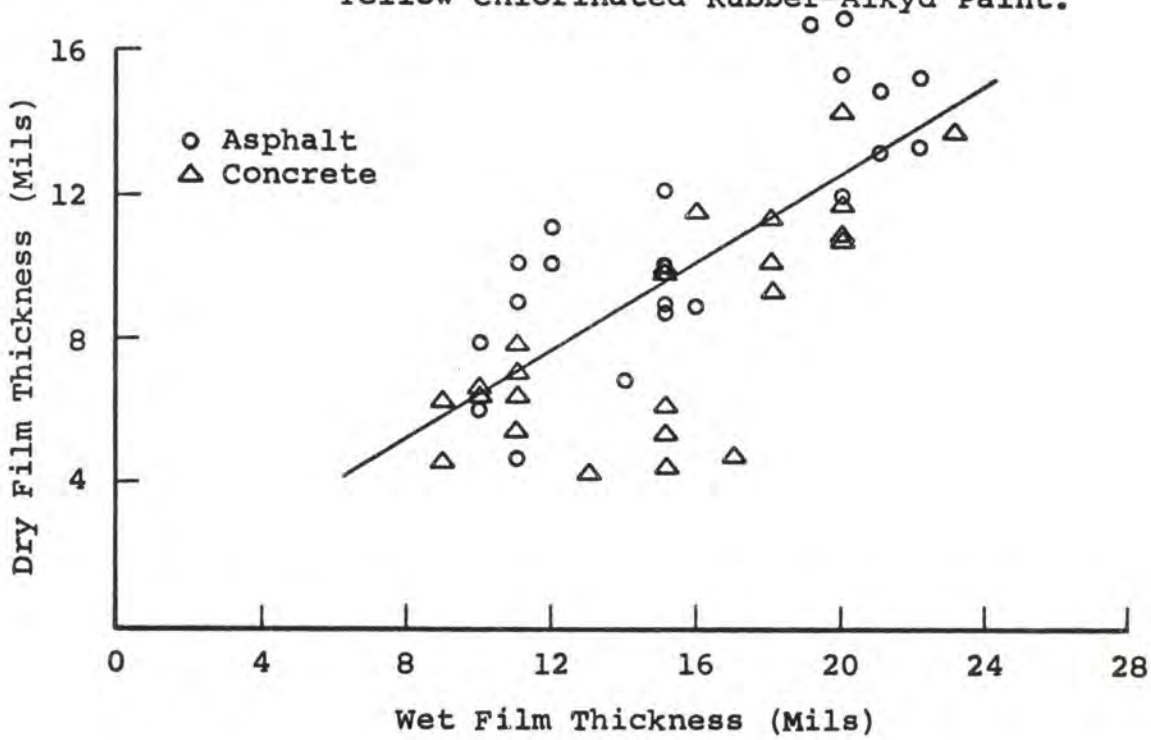


Figure 5 - Wet vs. Dry Film Thickness of the Yellow Chlorinated Rubber-Alkyd Paint.



APPENDIX E

STATISTICAL ANALYSES AND EVALUATION DATA

TABLE 8

AVERAGE RATING FOR GENERAL APPEARANCE
FOR EACH PAINT BY WET FILM THICKNESS AND PAVEMENT TYPE
(Outer Wheel Path Only)

Obs. No.	Paint Type	Age (Wks)	Asphalt Thickness (Mils) 10	15	20	Concrete Thickness (Mils) 10	15	20
			Color - White					
1	Mo.	4	8.6	8.6	8.8	9.2*	9.2*	9.4*
	CR.		9.0	8.8	8.7	8.3*	8.4*	8.6*
2	Mo.	5	7.4	7.0	7.4	7.8	8.1	8.1
	CR.		8.5	7.9	7.4	8.2	8.6	9.0
3	Mo.	7	7.8	7.9	7.8	5.1	5.0	5.9
	CR.		7.2	7.3	7.4	6.3	6.8	7.7
4	Mo.	9	6.4	6.7	6.8	3.7	3.7	4.3
	CR.		5.6	6.5	6.8	4.6	5.4	5.8
5	Mo.	11	5.1	5.7	5.6	2.1	2.0	2.6
	CR.		4.8	4.8	5.2	2.1	3.6	4.8
6	Mo.	14	3.2	4.2	4.7	1.0	1.2	1.4
	CR.		3.6	4.7	5.6	1.8	3.2	4.6
7	Mo.	17	1.3	2.2	3.3	0.6	0.5	0.8
	CR.		2.8	3.1	4.3	1.2	2.1	3.0
8	Mo.	20	0.8	1.0	1.9	-	-	-
	CR.		1.2	2.0	3.1	-	-	-
9	Mo.	23	0	0	0	-	-	-
	CR.		0	0.2	0.4	-	-	-
			Color - Yellow					
1	Mo.	4	8.7	9.2	8.8	8.9*	8.8*	9.2*
	CR.		9.5	9.5	9.4	8.8*	8.7*	9.5*
2	Mo.	5	8.2	8.5	8.6	7.5	7.4	8.4
	CR.		9.0	9.0	9.1	7.8	8.3	8.6
3	Mo.	7	7.3	7.6	7.2	5.0	4.6	5.8
	CR.		8.0	8.1	8.9	6.5	7.1	7.9
4	Mo.	9	5.9	6.6	6.3	3.6	3.0	4.6
	CR.		7.4	7.2	8.3	5.2	5.6	6.8
5	Mo.	11	5.1	5.9	5.5	1.3	1.4	2.2
	CR.		6.4	6.7	7.4	3.2	3.8	5.0
6	Mo.	14	4.3	5.6	5.4	0.8	0.6	1.4
	CR.		6.8	6.3	7.7	3.1	3.4	4.9
7	Mo.	17	2.3	3.6	3.4	0	0.2	0.3
	CR.		4.3	4.8	6.0	1.8	2.0	3.1
8	Mo.	20	1.0	1.4	1.8	-	-	-
	CR.		2.6	3.1	4.7	-	-	-
9	Mo.	23	0	0	0	-	-	-
	CR.		0.5	0.8	1.6	-	-	-

* These observations were made at 3 weeks.

TABLE 9

AVERAGE RATING FOR ABRASION FOR EACH
PAINT BY WET FILM THICKNESS AND PAVEMENT TYPE
(Outer Wheel Path Only)

Obs. No.	Paint Type	Age Wks.	Asphalt 10 mil.	Asphalt 15 mil.	Asphalt 20 mil.	Concrete 10 mil.	Concrete 15 mil.	Concrete 20 mil.
				Color: White				
1	Mo.	4	9.0	9.1	9.1	9.6*	9.6*	9.6*
	CR.		9.4	9.2	9.2	9.1*	9.0*	9.2*
3	Mo.	7	8.1	8.2	8.1	7.8	7.5	8.3
	CR.		7.8	7.8	7.9	7.8	8.4	8.5
4	Mo.	9	7.5	8.1	8.2	7.1	7.2	7.4
	CR.		7.6	7.9	8.1	6.3	7.4	7.8
6	Mo.	14	5.0	6.0	6.5	4.6	4.4	5.2
	CR.		6.4	6.6	7.2	5.0	6.1	6.5
8	Mo.	20	2.0	2.1	3.4	-	-	-
	CR.		1.8	2.4	4.6	-	-	-
				Color: Yellow				
1	Mo.	4	9.1	9.4	9.4	9.6*	9.7*	9.8*
	CR.		9.5	9.6	9.6	9.4*	9.1*	9.6*
3	Mo.	7	8.2	8.4	8.3	7.9	7.5	8.4
	CR.		8.5	8.6	8.8	8.1	8.4	8.9
4	Mo.	9	7.6	8.2	8.1	6.2	6.2	7.6
	CR.		8.2	8.2	8.7	7.5	7.5	8.4
6	Mo.	14	6.7	7.2	7.2	3.6	4.7	5.8
	CR.		6.6	7.4	8.1	6.0	5.6	7.0
8	Mo.	20	2.2	2.8	3.2	-	-	-
	CR.		3.8	5.4	5.4	-	-	-

* These observations were made at 3 weeks.

TABLE 10

AVERAGE RATING FOR CHIPPING FOR EACH PAINT BY WET FILM THICKNESS AND PAVEMENT TYPE (Outer Wheel Path Only)

Obs. No.	Paint Type	Age Wks	Asphalt 10 mil	Asphalt 15 mil	Asphalt 20 mil	Concrete 10 mil	Concrete 15 mil	Concrete 20 mil
				Color: White				
1	Mo.	4	9.8	9.7	9.8	9.8*	9.5*	10.0*
	CR.		10.0	10.0	10.0	9.3*	9.8*	9.9*
3	Mo.	7	8.3	8.5	8.5	5.2	5.0	5.5
	CR.		7.6	8.1	8.6	6.2	6.7	7.4
4	Mo.	9	7.4	7.4	7.8	3.8	3.5	4.2
	CR.		6.4	7.3	8.0	4.6	5.8	6.0
6	Mo.	14	3.8	4.6	5.1	1.4	1.8	1.9
	CR.		4.4	5.4	6.4	2.2	3.5	4.5
8	Mo.	20	1.4	1.8	2.4	-	-	-
	CR.		1.7	1.8	3.0	-	-	-
				Color: Yellow				
1	Mo.	4	9.4	9.6	9.6	9.5*	9.1*	9.6*
	CR.		10.0	10.0	10.0	9.5*	9.9*	10.0*
3	Mo.	7	7.0	7.3	7.1	4.3	4.2	5.5
	CR.		8.2	8.1	8.8	6.7	7.2	7.8
4	Mo.	9	6.1	6.6	6.2	3.7	3.1	4.4
	CR.		7.7	7.6	8.4	5.2	5.8	6.9
6	Mo.	14	4.5	5.4	5.0	1.1	1.1	1.9
	CR.		6.8	6.6	7.7	3.5	3.6	4.8
8	Mo.	20	1.9	2.0	2.3	-	-	-
	CR.		2.9	4.4	4.8	-	-	-

* These observations were made at 3 weeks.

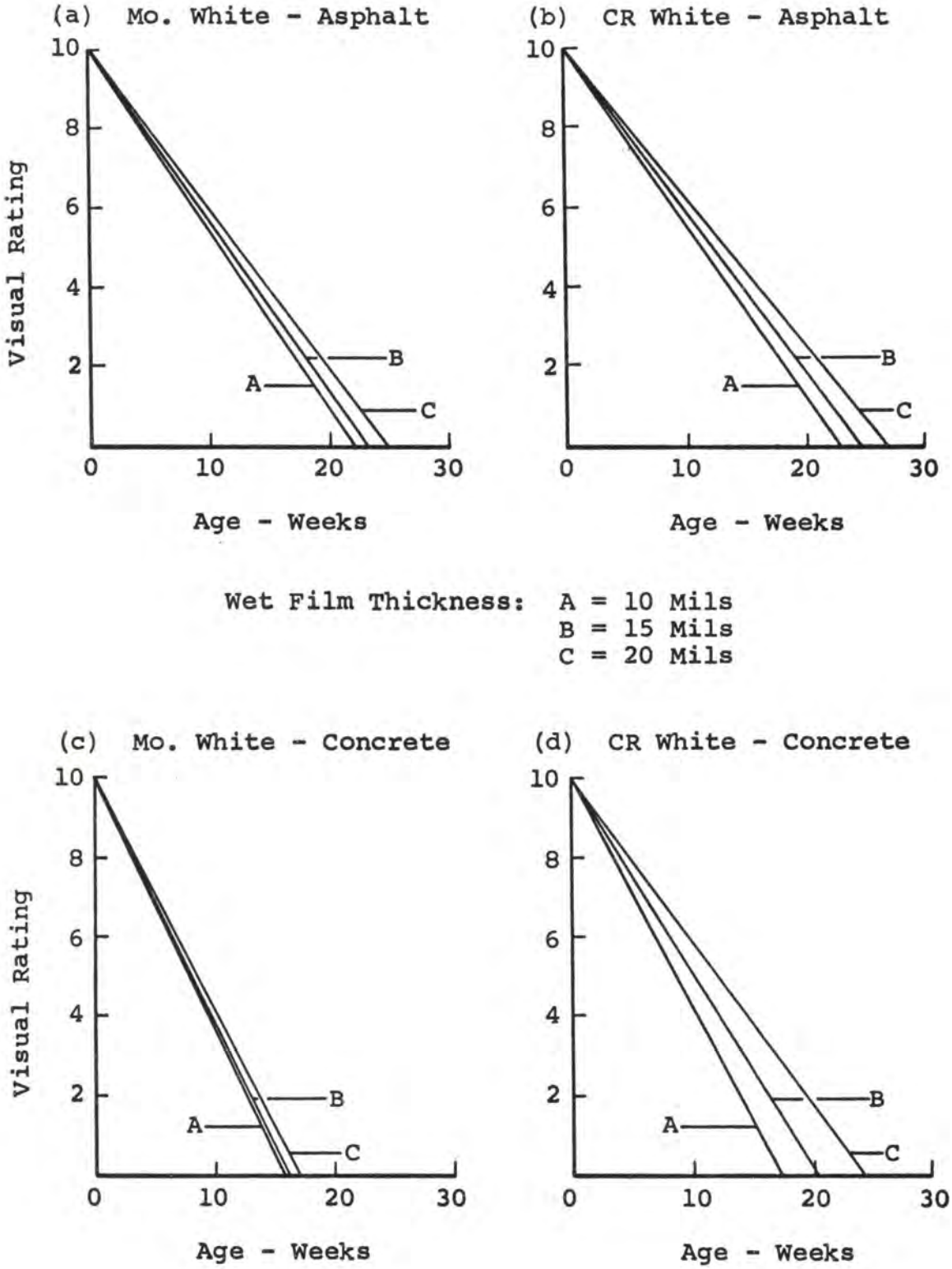
TABLE 11

SLOPE (b') VALUES* FOR DATA IN TABLES 8, 9, and 10

Paint Type	Paint Color	Asphalt 10 mil.	Asphalt 15 mil.	Asphalt 20 mil.	Concrete 10 mil.	Concrete 15 mil.	Concrete 20 mil.
				General Appearance			
Mo.	White	0.4556	0.4314	0.4047	0.6196	0.6185	0.5837
CR.	White	0.4372	0.4101	0.3723	0.5712	0.4876	0.4089
Mo.	Yellow	0.4364	0.3960	0.4014	0.6531	0.6625	0.5967
CR.	Yellow	0.3471	0.3350	0.2684	0.5105	0.4790	0.3840
				Abrasion			
Mo.	White	0.3636	0.3332	0.2885	0.3531	0.3650	0.3095
CR.	White	0.3420	0.3195	0.2455	0.3623	0.2752	0.2438
Mo.	Yellow	0.3234	0.2870	0.2784	0.4170	0.3785	0.2752
CR.	Yellow	0.2699	0.2102	0.1890	0.2794	0.2925	0.1949
				Chipping			
Mo.	White	0.3974	0.3702	0.3392	0.6280	0.6262	0.5883
CR.	White	0.3956	0.3584	0.2940	0.5567	0.4552	0.3925
Mo.	Yellow	0.4009	0.3712	0.3774	0.6647	0.6865	0.5865
CR.	Yellow	0.2966	0.2621	0.2142	0.4740	0.4397	0.3465

* The values shown in this table are numerically negative.

Figure 6 - Regression Lines for the General Appearance Ratings for the White Paints.



Wet Film Thickness: A = 10 Mils
B = 15 Mils
C = 20 Mils

Figure 7 - Regression Lines for the General Appearance Ratings for the Yellow Paints.

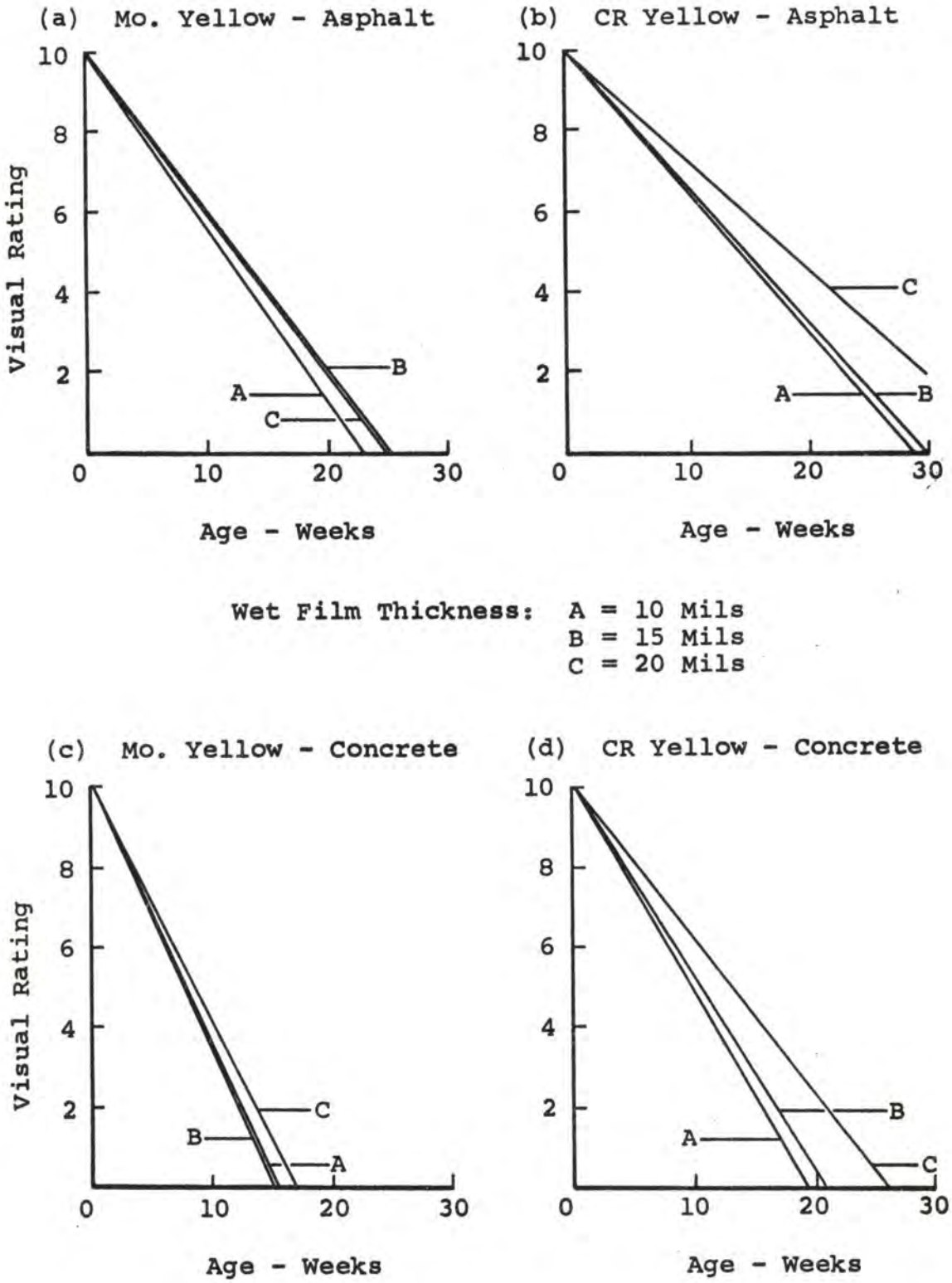


TABLE 12

NOTATION

These symbols will be used in the following tables:

DF = Degrees of freedom
SS = Sum of squares of residuals
MS = Average mean square (SS/DF)
F = Ratio of two mean squares (two variances)
α = Probability level of significance of the test
K = Kind of paint
T = Thickness of wet paint film
A = Age
R = Residual or pooled effects of the individuals and duplicates
T_L = Function of thickness for linear regression component
T_Q = Function of thickness for quadratic regression components
S = Significant
HS = Highly Significant
NS = Not Significant

Significant = In testing significance a value below the 5% level will be considered not significant, a value between the 5% and 1% level of questionable significance, a value between 1% and 0.1% level as significant, and a value above 0.1% as being highly significant.

TABLE 13

ANALYSIS OF VARIANCE FOR THE GENERAL APPEARANCE RATING

Item	DF	SS	MS	F	∝	S
a. Analysis of the White Paints on Asphalt Pavement.						
K	1	6.98	6.98	14.24	0.001	HS
T	2	31.65	15.82	32.28	0.001	HS
A	8	3356.55	419.57	856.26	0.001	HS
KT	2	0.10	0.05	0.10	- -	NS
TA	16	45.94	2.87	5.86	0.001	HS
KA	8	35.05	4.38	8.94	0.001	HS
KTA	16	8.71	0.54	1.10	- -	NS
R	378	186.38	0.49			
Total	431	3671.36				
b. Analysis of the Yellow Paints on Asphalt Pavement.						
K	1	181.31	181.31	370.02	0.001	HS
T	2	35.65	17.82	36.37	0.001	HS
A	8	3285.71	410.71	838.18	0.001	HS
KT	2	16.82	8.41	17.16	0.001	HS
TA	16	16.95	1.06	2.16	0.01	S
KA	8	30.72	3.84	7.84	0.001	HS
KTA	16	10.54	0.66	1.35	- -	NS
R	378	184.39	0.49			
Total	431	3762.09				
c. Analysis of the White Paints on Concrete Pavement.						
K	1	95.20	95.20	89.81	0.001	HS
T	2	58.85	29.42	27.75	0.001	HS
A	6	2542.09	423.68	399.70	0.001	HS
KT	2	19.24	9.62	9.08	0.001	HS
TA	12	14.83	1.24	1.17	- -	NS
KA	6	63.89	10.65	10.05	0.001	HS
KTA	12	11.79	0.98	0.92	- -	NS
R	294	311.00	1.06			
Total	335	3116.89				
d. Analysis of the Yellow Paints on Concrete Pavement.						
K	1	250.04	250.04	181.19	0.001	HS
T	2	67.29	33.64	24.38	0.001	HS
A	6	2497.28	416.21	301.60	0.001	HS
KT	2	6.03	3.02	2.19	- -	NS
TA	12	7.56	0.63	0.46	- -	NS
KA	6	79.84	13.31	9.64	0.001	HS
KTA	12	6.53	0.54	0.39	- -	NS
R	294	406.26	1.38			
Total	335	3320.83				

TABLE 14

LIFE EXPECTANCY OF EACH GROUP OF STRIPES CALCULATED FROM THE REGRESSION SLOPE (b') VALUES

Paint Type	Asphalt 10 mil	Asphalt 15 mil	Asphalt 20 mil	Concrete 10 mil	Concrete 15 mil	Concrete 20 mil
General Appearance						
Mo. White	13.2	13.9	14.8	9.7	9.7	10.3
CR. White	13.7	14.6	16.1	10.5	12.3	14.7
Mo. Yellow	13.7	15.2	14.9	9.2	9.0	10.0
CR. Yellow	17.3	17.9	22.4	11.8	12.5	15.6
Abrasion						
Mo. White	19.2	21.0	24.3	19.8	19.2	22.6
CR. White	20.5	21.9	28.5	19.3	25.4	28.7
Mo. Yellow	21.6	24.4	25.1	16.8	18.5	25.4
CR. Yellow	25.9	33.3	37.0	25.0	23.9	35.9
Chipping						
Mo. White	17.6	18.9	20.6	11.1	11.2	11.9
CR. White	17.7	19.5	23.8	12.6	15.4	17.8
Mo. Yellow	17.5	18.8	18.5	10.5	10.2	11.9
CR. Yellow	23.6	26.7	32.7	14.8	15.9	20.2

TABLE 15
ANALYSIS OF VARIANCE FOR THICKNESS
PER PAINT TYPE, PER PAVEMENT TYPE FOR
GENERAL APPEARANCE RATING

Item	DF	SS	MS	F	α	S
Missouri Standard White on Asphalt						
T	2	14.77	7.38	22.36	0.001	HS
A	8	1841.66	230.21	697.61	0.001	HS
TA	16	18.69	1.17	3.54	0.001	HS
R	189	62.46	0.33			
Total	215	1937.58				
Missouri Standard Yellow on Asphalt						
T	2	15.21	7.60	28.15	0.001	HS
A	8	1825.03	228.13	844.92	0.001	HS
TA	16	9.97	0.62	2.30	0.01	S
R	189	51.68	0.27			
Total	215	1901.89				
Missouri Standard White on Concrete						
T	2	6.77	3.38	33.80	0.001	HS
A	6	1617.02	269.50	2695.00	0.001	HS
TA	12	3.34	0.27	2.70	0.01	S
R	147	14.30	0.10			
Total	167	1641.43				
Missouri Standard Yellow on Concrete						
T	2	21.71	10.85	18.39	0.001	HS
A	6	1678.16	279.69	474.05	0.001	HS
TA	12	7.26	0.60	1.02	- -	NS
R	147	87.39	0.59			
Total	167	1794.52				
Chlorinated Rubber-alkyd White on Asphalt						
T	2	16.98	8.49	12.86	0.001	HS
A	8	1549.94	193.74	293.54	0.001	HS
TA	16	35.96	2.25	3.41	0.001	HS
R	189	123.92	0.66			
Total	215	1726.80				
Chlorinated Rubber-alkyd Yellow on Asphalt						
T	2	37.26	18.63	26.61	0.001	HS
A	8	1491.40	186.42	266.31	0.001	HS
TA	16	17.52	1.10	1.57	- -	NS
R	189	132.71	0.70			
Total	215	1678.89				
Chlorinated Rubber-alkyd White on Concrete						
T	2	71.32	35.66	17.74	0.001	HS
A	6	988.96	164.83	82.00	0.001	HS
TA	12	23.28	1.94	0.96	- -	NS
R	147	296.70	2.01			
Total	167	1380.26				
Chlorinated Rubber-alkyd Yellow on Concrete						
T	2	51.61	25.80	11.89	0.001	HS
A	6	898.96	149.83	69.05	0.001	HS
TA	12	6.83	0.57	0.26	- -	NS
R	147	318.87	2.17			
Total	167	1276.27				

TABLE 16

LINEAR AND QUADRATIC COMPONENTS OF THICKNESS IN ANALYSIS OF VARIANCE FROM TABLE 15.

Item	SS=MS*	F	α	Significance
Missouri Standard White on Asphalt				
T_L	14.76	44.72	0.001	Highly Significant
T_Q	0.01	0.03	- -	Not Significant
Missouri Standard Yellow on Asphalt				
T_L	8.31	30.77	0.001	Highly Significant
T_Q	0.13	0.48	- -	Not Significant
Missouri Standard White on Concrete				
T_L	5.60	56.00	0.001	Highly Significant
T_Q	1.17	11.70	0.001	Highly Significant
Missouri Standard Yellow on Concrete				
T_L	13.03	22.08	0.001	Highly Significant
T_Q	8.68	14.71	0.001	Highly Significant
Chlorinated Rubber-alkyd White on Asphalt				
T_L	16.74	25.36	0.001	Highly Significant
T_Q	0.02	0.03	- -	Not Significant
Chlorinated Rubber-alkyd Yellow on Asphalt				
T_L	30.91	44.15	0.001	Highly Significant
T_Q	0.13	0.18	- -	Not Significant
Chlorinated Rubber-alkyd White on Concrete				
T_L	71.28	35.46	0.001	Highly Significant
T_Q	0.03	0.01	- -	Not Significant
Chlorinated Rubber-alkyd Yellow on Concrete				
T_L	47.97	22.10	0.001	Highly Significant
T_Q	3.64	1.67	- -	Not Significant

* SS=MS because the DF = 1 in both the linear and quadratic components.

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