HIGHWAY RESEARCH BOARD

Bulletin No. 36

Pavement Marking

1951

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1951

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HIGHWAY RESEARCH BOARD

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PAVEMENT MARKING

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1951

HIGHWAY RESEARCH BOARD
DIVISION OF ENGINEERING AND INDUSTRIAL RESEARCH
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Washington 25, D. C. May 1951

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*This Committee has sponsored the paper "Methods and Application Procedures for Pavement Marking".

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*This Committee sponsored the paper "Present Preferences for Traffic Paint".

CONTENTS

REPORT OF THE COMMITTEE ON ROADWAY PAVEMENT MARKINGS

A. R. Lauer, Chairman
Professor of Psychology, Iowa State College

During the past year efforts have been made in four general directions; (1) verifying and publicizing the results of a survey made last year on line-striping practices in the various states, (2) analysis of methods and equipment used in applying center and barrier lines, (3) collecting information on researches being carried out in this area, and (4) encouraging highway departments, experiment stations as well as colleges and universities to pursue research on various problems in this area.

The major effort of the Committee was focused on securing specific information on methods of striping from every state in the Union, a project in which every member took part and which was presented in an open meeting of the Committee by Mr. Charles R. Waters of New York. Splendid cooperation was obtained from every state and it is the feeling of the Committee that some very worthwhile information has been assembled.

Any study or compilation of facts or information must be considered as being relative in its application. For example, our study shows that 39 states use plain unreflectorized paint for striping. The necessity for repainting varies from four months to three years with a median value around 12 months. This type of information must be tempered by judgment of the reader considering the amount of traffic, climatic effects on paint, type of paint used, type of surface painted and even by the pressure of public opinion.

METHODS AND APPLICATION PROCEDURES FOR PAVEMENT MARKING

Charles R. Waters
District Engineer, State Department of Public Works, Buffalo, N. Y.

SYNOPSIS

Contact was made with every highway department in the country, in addition to several foreign provinces and countries, with the request that a form containing 70 or more items relating to types of paint, costs, methods of application, methods of protecting green paint, drying time, mixing of beads, when used, and other important aspects of pavement striping. The data are being put up in tabular and graphic form and will be presented as reported by the respective states.

Data on types, weight, cost and features of striping equipment will be presented. Reports were obtained from every state in the Union and some foreign countries.

Analysis of questionnaires indicates a growing interest in marking traffic lines on pavements as a means of safety on highways. Steps toward uniformity throughout the United States are indicated.

From 48 states reporting, 18 report that the stripers were designed and built in their own shops, 29 report that stripers were purchased from commercial sources and one state reports that their markings are placed by a contractor. The Provinces of Manitoba and Nova Scotia in Canada also contract for the placing of markings while Ontario, British Columbia and the Territory of Hawaii use purchased stripers.

Thirty states report using self-propelled units, nine trail the unit, eight use the push-mobile type and one did not report. Forty-four states use pressure nozzles while four

use the flow type. Thirty-eight states place preliminary markings for the equipment to follow while ten states do not.

Thirty-seven states plus four provinces reporting from Canada use reflectorized markings for increased night safety. Six states use non-reflectorized markings and five did not furnish definite information. Hawaii uses reflectorized markings. While a number of states place only reflectorized markings, the greater percentage also use plain paint, with the reflectorized markings used on main touring routes, No-Passing zones, troublesome intersections and railroad crossings at grade. The drying time of the paint is reported as varying from 15 minutes up to 2 hours.

Of the 43 states using dash lines, the length of the paint mark and the space between varies from a minimum of 9 - 15 ft. to a maximum of 70 - 70 ft. with 20 states using a 15 - 25 ft pattern. Most of the states have standardized on a four inch width marking although three report using a three inch line and one a six inch line. By reason of using a dash line, a saving in paint of from 50 to 80 percent is accomplished.

The cost of providing markings varies greatly according to quality of paint and application methods. Currently it is reported as varying between $13.00 and $63.00 for an unreflectorized line and between $25.00 and $80.00 for a reflectorized line Operational costs are greatly responsible for this variance, it being reported that a low of 5 miles and a high of 100 miles of pavement is painted a day.

The most recent study by members of Project Committee No. 11 - Roadway Pavement Markings, Highway Research Board, has been completed. The Committee considered it would be advantageous to assemble information from all states regarding pavement marking procedures. Accordingly, a questionnaire prepared by the Committee was forwarded to officials of the State Highway Departments to be completed and returned for tabulation. Contact was made with every State Highway Department, in addition to several foreign countries and a number of the provinces in Canada. The questionnaire contained over 70 items relating to the types of equipment used, methods of application, drying time of paint, use of glass spheres for night reflectance together with other pertinent and important aspects of pavement marking.

This report, prepared from the data obtained, is purely factual and is based on the points covered in the questionnaire. The work of the present writer is that of compiling and tabulating the information collected by the regional sub-chairmen. No attempt is made in this report to evaluate the methods used in the various states, nor to make a judgment of evaluation on types or methods.

Some 36 states gave written statements that they are using the geometry or pattern of the system recommended in the Federal Manual on Uniform Traffic Control Devices for Streets and Highways.

The data obtained from the questionnaires have been tabulated in chart form for detailed study. Pertinent information which is of principal interest follows in the order indicated on the charts. [1]

EQUIPMENT USED FOR STRIPING

From 48 states reporting, 17 advise that stripers were designed and built in their own shops and 31 report that machines were purchased from commercial sources. The oldest of the stripers dates back to 1934, although 37 states or 77 percent report using equipment purchased or built subsequent to 1946, and 16 states report using equipment which is not older than one year. It is assumed that new devices and improvements have been added to the old equipment from time to time.

There is a great variance in the weight and the cost of equipment. The minimum weight of any unit as reported is 175 lb. which is only the weight of striping device. It does not include truck, paint tanks and miscellaneous equipment. The maximum weight of any one unit which includes the truck attached striper, tanks and all equipment is

[1]The charts are folded in at the end of this bulletin.

22,000 lb. From the reports, it is found that weights vary greatly according to type of equipment and the mileage to be painted. In some states, one or two large units cover the entire mileage while in others a number of small machines are employed.

While the cost of a shop-constructed striper whether pushed, pulled or mounted on the truck, may be relatively small, the cost of a commercial self-propelled unit, or truck mounted unit in which the truck cost is included, may seem to be exceedingly high.

COST OF PAINT AND PAINTING

The cost of pavement marking equipment is reported as varying from a minimum of $700 to a maximum of $16,000. Small self-propelled units capable of placing only 5 to 10 miles of line per day are in the lower range, while the fully equipped heavy duty equipment capable of placing up to 60 to 70 per day costs in the upper brackets. The total cost of all equipment as reported in the questionnaires is $280,069.00, or an average of $5,600 per unit.

In analyzing the information furnished regarding the number of vehicles required in placing the markings, it is found that, in general, the complete unit consists of either a self-propelled paint striper or a truck mounted striper and a service truck. The service truck in addition to carrying extra paint and supplies, picks up and returns to the paint striper the flags, blocks or other devices previously placed on the wet paint line to protect it while drying.

WIDTH OF ROAD EQUIPMENT USED

The overall width of the stripers varies according to type. The minimum width is 2 ft. 8 in. for a self-propelled unit, the maximum width 9 ft. 6 in. for a striper attached to the side of a truck. An average of all reporting is between 6 and 7 ft., which is standard width for a truck of medium size. Only two states report widths exceeding 8 ft., one 9 ft. and one 9 ft. 6 in. It appears that passing difficulty might be encountered when placing markings on a 16 or 18 ft. pavement when using a unit of excess width. In New York the Vehicle and Traffic Law prohibits the movement of vehicles having a width greater than 8 ft. over public highways unless a special permit is issued.

The data show that 31 states use a self-propelled unit, 9 trail the unit and 8 use the Pushmobile type. The self-propelled units include both commercial stripers operating under their own power and those mounted on trucks. The trailer type are those mounted in a framework running on low pneumatic tires towed immediately at the rear of the truck, and the Pushmobile types are those units built into a frame having both front and rear axles, pushed ahead of the paint truck.

PAINT CAPACITY OF STRIPERS USED AND PERSONNEL REQUIRED IN LAYING

The number of paint tanks in use varies from 1 to 4 having a capacity as low as 12 gallons and as high as 700 gallons. The 12-gallon tank is contained on the small self-propelled unit with the 700 gallon tank mounted on a large self-propelled unit. Fourteen states report using one paint tank, 14 states use 2 tanks, 15 states use 3 tanks and 5 states use 4 tanks. Twenty-one states or nearly 44 percent use a 60-gallon tank apparently for ease in filling, cleaning and space requirements. From the 48 states, 26 transfer the paint to the tank by hand using a pail or the original 5-gallon container while the remaining 22 states transfer it by either air pressure or mechanical pump. It appears that hand methods enter into the transferring of paint, and it is probable that if the paint is purchased in standard 5-gallon pails, it is emptied directly into the paint tank; if furnished in 30 or 60 gallon drums, the pump or air pressure method is used.

Pressure nozzles are used by 92 percent of the states, only 4 reporting the use of flow nozzles.

The personnel required to operate the stripers varies from one with the small self-propelled unit up to 11 on the large self-propelled units. In most cases, the questionnaire did not definitely state whether or not the personnel included men for operating the service truck. From the average of all 48 states, 4.5 men are required for a complete marking crew.

COST OF PRELIMINARY MARKING

Thirty-six states place preliminary markings for the guidance of the paint striper at a cost varying from 75 cents for center line and 70 cents for barrier line to $35 for center line and $15 for barrier line. Ten states do no preliminary marking and two states place preliminary markings only at certain locations. Replies were lacking from a number of states as to the cost of preliminary markings and 4 states reported no additional cost for placing the barrier line marks.

PROTECTION OF THE UNIT, DRYING, ETC.

For the protection and safety of the painting unit, 20 states report using a police escort while 27 do not; one state did not report on this question. Other means of protecting the unit include a car ahead to warn approaching traffic used by 9 states; signs or flagmen used by 22 states; and siren and flasher used by 5 states.

From 46 states reporting, 39 state that gaps are left in the markings at cross streets, 7 report in the negative; 27 report gaps left at cross roads while 20 report that markings are carried through the intersection.

The speed of travel of the marking equipment in miles per hour is reported to be from a low of 2 m. p. h. to a high of 20 m. p. h. The data show that 35 states, or 73 percent, traveled at a rate of from 5 to 10 m. p. h. Reports regarding the number of miles marked per day varies from 5 to 100. Thirty-six states, or 75 percent, report their equipment marks between 20 and 40 miles per day. A great many variables such as type of equipment and drying time of paint enter into the number of miles which can be painted in a specified number of hours.

ADDITIONAL COST IN TWO COLORS

In reply to the question on the additional cost by reason of using two colors, one state reported 25 cents per mile, one $1.65, one $5.10, one $9.30 and one $11.34. Six reported no additional cost, two reported the additional cost to be negligible and the remaining states made no reply or do not use two colors.

From 42 states reporting on the question, "How many strips are required to mark a two-lane highway?", 37 stated the marking is completed in one trip, one state reported one to two trips, two states reported two trips and two states reported three trips.

TIME BETWEEN PAINTING

From 39 states using plain unreflectorized paint, one state reports the necessity for repainting every 4 to 6 months, four states repaint every 6 months, five states repaint every 6 to 12 months, one state repaints every 8 to 12 months, 18 repaint once a year, two repaint every 12 to 18 months, one repaints every 18 months, three repaint from 1 to 2 years, one repaints from 1 to 3 years, two repaint every 2 years, and one state reports that the time between repainting is variable. Traffic density, quality of paint and weather conditions dictate to a large degree the necessity for remarking the lines.

A variety of answers were received from 41 states reporting on the life of reflectorized markings either as a regular program or on an experimental basis. The most frequent repainting is reported as being every 6 months (only one state), the longest span between paintings, 3 years. A number of states report they are placed yearly but ten states definitely indicate an increase in the life of the marking by the use of reflectorized paint.

METHOD OF APPLYING REFLECTORIZED PAINTS

Regarding the method of placing reflectorized markings, 24 states report using the pre-mix method, 39 use the beads on wet paint method and five use a combination of the two known as overlay. Sixteen states use both the premix and the beads on wet paint methods as a regular practice.

All except four states use either signs or protective devices to guard the wet paint markings against tracking by vehicles during the drying period. The devices vary from simple home-made wooden blocks to cones, Z guards, and pyramids manufactured commercially. In 21 states, police patrol the wet paint line during the drying period. In 15 states motorists are liable to arrest for driving on wet paint.

DRYING TIME

The reported drying time for reflectorized paint varies between ten and 120 minutes depending upon the formulation, pavement conditions, temperature, humidity and wind velocity. The greater percentage report the time as being between 20 and 40 minutes. Only two states report clogging trouble at the spray gun, all others stated they experienced no clogging or only minor difficulties.

Thirty-one states report good visibility of reflectorized paint before wear and 14 average visibility. The wearing quality is reported as good by 24 states, 16 report average wear, one reports variable wear, one average to poor and two poor.

LENGTH OF SEGMENTS PAINTED

Of the 43 states using dash lines, the length of the paint mark and the space between varies from a minimum of 9 ft. dash with 15 ft. gap to a maximum of 70 ft. dash with 70 ft. gap. From this number, 21 states or nearly 49 percent use a 15 ft. dash with a 25 ft. gap. Most of the states have standardized on a 4 in. width marking although one uses a 3 in., one a 4-1/2 in., two use 5 in., and one uses a 6 in. width of line.

AMOUNT AND COST OF BEADS USED

Three states report using 4 lb. of glass spheres per gallon of paint, one state uses 4-1/4 lb., two states 4-1/2 lb., six states 5 lb., one state 4 to 6 lb., one state 5-1/4 lb., three states 5 to 6 lb., and 26 states or over 60 percent use 6 lb. per gallon of paint. A number of states purchase reflectorized paint as a packaged product; about 6 lb. of beads furnished with each gallon of paint.

The cost of the glass spheres per gallon of paint is reported as low as 64 cents when used at the rate of 4 lb. per gallon up to $1.62 when used at the rate of 6 lb. per gallon. It is now generally known that beads may be purchased in carload lots for as little as 12 cents per pound.

By reason of using a dashed rather than a solid line, a saving varying from 50 to 80 percent is reported. States using a 20 ft. paint line with a 20 ft. gap or any pattern using the same length paint line and gap between, accomplish a 50 percent saving in paint. Three states reported using a 15 to 35 ft. pattern with a saving of 70 percent and one state saves 80 percent by using a 10 to 40 ft. marking.

COST OF VARIOUS PAINTS

Information regarding purchase cost and application cost of plain paint, asphalt paint, reflectorized white and reflectorized yellow paints was insufficient on a number of the returned questionnaires and it is therefore impracticable to arrive at any definite comparisons. Some states furnished the name of the manufacturer, others stated that the paint is purchased on bid while the paint for one state is manufactured at the State Prison.

Factors entering into the cost of paint include quality, freight rate, and whether or not the purchase is made on a competitive basis. Currently it is reported that plain white paint is purchased for as low as $1.19 per

gallon and as high as $3.00 per gallon. The average cost per gallon from 36 states reporting is $1.69 per gallon.

Analysis of the information on the returned questionnaires indicates that while some states reported total cost per mile on the basis of using a dashed line, others reported on the basis of using a single solid line. For this reason, we are unable to furnish a comparison of cost per mile figures. However, all information obtained has been indicated on the tabulation chart and may be studied by the individual for detailed costs in any particular state. It is reasonably safe to assume that any figure indicating under 9 gallons of paint used per mile is for a dashed line and any figure over 12 refers to the single solid line. The cost as reported varies between $13.00 and $63.00 per mile for a plain unreflectorized marking. Application methods are largely responsible for this variance as between 5 and 100 miles of pavement are reported to be painted a day.

Fifteen gallons of paint per mile for a solid line 4 in. in width and 6 gallons per mile for a 15 ft. dash with a 25 ft. gap line are practical to use for estimating purposes.

Ten states furnished limited information on the use of asphaltic type of paint. The cost varies between 17 cents and 46 cents per gallon for purchased paint. One state reports a cost of $1.00 per gallon for asphaltic paint.

Thirty-two states furnished current prices on reflectorized white paint, the low being $1.94 - the high $4.50 per gallon. The average cost per gallon is indicated at $3.14. As high as 23 gallons per mile and as low as 12 gallons per mile is reported as being used. It is assumed that these figures are based on a single solid line.

In nearly all states the additional cost of providing a reflectorized marking may be attributed to the increase in the cost of the painting material, as cost of application is practically the same in either case.

Twenty-three states furnished limited information regarding reflectorized yellow paint. From 16 states using both white and yellow reflectorized paint, it is found that the average cost of white is $3.28 and the average cost of yellow is $3.47 per gallon. This is an increase of 19 cents per gallon or 5.8 percent when using yellow reflectorized paint.

REPORTS FROM OUTSIDE THE UNITED STATES

In addition to receiving completed questionnaires from all 48 states, replies were received from the provinces of British Columbia, Manitoba, Nova Scotia, Ontario and New Brunswick in Canada and the Territory of Hawaii. Two of the provinces contract for the placing of their markings, two use commercially manufactured equipment and one has constructed its own striper. Hawaii uses a purchased unit.

The length of the paint cycle in the Canadian Provinces is reported as varying between 30 and 120 ft. The length of the dash line varies from 10 to 20 ft. with a 20 to 100 ft. gap. Three place a 4 in. width marking, one a 4-1/2 in. and one a 5 in. width. Hawaii places a 6 ft. dash line with a 9 ft. gap, using a 4 in. width line.

SUMMARY

The foregoing information is based purely on the data reported by the respective states and provinces. The information has been tabulated by states alphabetically in the charts, which are folded in at the end of this bulletin.

It is the thought of the Committee that the results of this project should prove of value to the several states in securing greater effectiveness and economy in pavement marking methods and procedures; also that this report together with future studies will contribute greatly toward establishing greater uniformity in marking practices, ultimately leading to the evolution of a form of markings which will be best from a standpoint of safety as well as from other points of view.

PRESENT PREFERENCES FOR TRAFFIC PAINT

G. W. Ashman, Research Department,
The New Jersey Zinc Company, Palmerton, Pennsylvania

SYNOPSIS

The results of a survey on traffic paint that was completed during the fall of 1950 are discussed in this paper.

Replies to questionnaires were received from 34 states that are well distributed geographically, and from 175 manufacturers of traffic paint that are representative of varying degrees of importance in all parts of the country. Compilation of the results of this very generous response affords an up-to-date and representative canvass of opinions and preferences expressed both by the consumers of traffic paints and by the manufacturers of the product

Estimated quantities of white and yellow road marking paints used in 1949 and 1950 by 33 states indicate that about 11 percent more whites and about 9 percent more yellows were used in 1950. The ratio of white to yellow was about 7 to 3 for both years.

A great increase in the use of retro-reflective road markings is indicated by the returns The reported estimated consumptions for 1949 and 1950 indicate that 67 percent more beaded whites and 59 percent more beaded yellows will be used in 1950 than in the previous year.

In types of opaque white pigments preferred, both the states and the manufacturers rate titanium pigments first, followed by zinc oxide and lithopone. Among the extender pigments, magnesium silicate has first preference, definitely.

Preferences on vehicle types selected indicated no significant change between the types used in 1949 and in 1950. About half of both groups reporting indicated a preference for the alkyd resin types, and about a third of both groups reported a preference for the phenolic resin varnish types. The phenolic varnish-dispersion resin type was voted as third in importance, being somewhat more popular among the states than among the manufacturers.

Both the highway departments and the traffic paint producers indicated the relative importance of those paint properties that will receive greater emphasis during the coming year. A summation of these preferences, both on a first-choice basis and on a weighted basis, indicates that both groups have voted "Improved Service Life" as definitely first in importance. There was decidedly less unanimity of opinion on the relative importance of the other properties Apparently, the highway departments desire better visibility and better film properties and do not stress "Cost per Gallon", while the manufacturers are emphasizing improved liquid paint and application properties while rating "Cost per Gallon" as quite important.

Those dealing extensively with traffic zone marking paints are aware of the widely varying and sometimes contradictory characteristics of these materials. They may not be as completely informed, however, on the detailed balancing and adjusting necessary in formulating the desired types of paints. The major difficulties involved are the cost and availability of the ingredients, and the preferences expressed or implied for the storage properties, liquid paint properties, application properties, and service properties of the product. To attain some of these requirements it may be necessary at times to sacrifice other desirable characteristics. To attempt to determine what type of formula is most suitable for a given consumer, one must first know what properties or qualities are of major importance to that consumer and which ones are of minor importance. Solution of this complexity is further complicated by changes in preferences, service requirements and money available for the project.

To obtain information on those preferences most widely held at this time, our Company has made a survey on the subject. Compilations of the

results of this survey are presented in this paper. Collations of the preferences indicated by current procedures are discussed first. The comparisons of the relative choices indicated by answers to identical questions by the highway departments and by the manufacturers of traffic paint then follow. Formulations sheets are appended for one white and two yellow paints that appear to satisfy a large number of the requirements and preferences reported.

Questionnaires on traffic zone marking paints were sent to state highway departments and to paint manufacturers during the summer of 1950. The highway departments were selected as the largest group of consumers of road marking paints, and the questionnaire that they received was designed to indicate their requirements and preferences. The questionnaire sent to the paint manufacturers was designed to obtain the opinions and preferences of the traffic paint producers. In both forms, however, there were identical lists of questions about preferred paint compositions and paint service properties. Both questionnaires were arranged for ease and convenience of reply, and a number of questions that might have been of general interest were omitted for brevity. Copies of the two types of forms are appended.

Knowing that the New Jersey Zinc Company does not produce paints, you may ask why we conducted a survey on the types of traffic paints preferred. The answer is that our pigment products are used in all types of paints, with considerable tonnages being used in white and colored traffic paints. To secure information on the most effective use of these pigments, regardless of the type of vehicle used or the service conditions, our laboratory has conducted continuing investigations on the subject for almost thirty years. Some of these investigations have been quite comprehensive, and both the manufacturers and the highway departments have cooperated in making service tests on the traffic paints. Without identifying the cooperators, it has been a consistent policy of our Company to report the results obtained to all of those interested. Indeed, the idea of the 1950 survey originated during a consideration of the most effective methods for using the information obtained from more than two hundred road service tests made in 1949. Each questionnaire was accompanied by a brief summary of the 1949 test results, a copy of which is appended.

The state highway departments, with their paint testing laboratories, trained personnel, and experienced background in specific properties needed for road marking paints in their areas, can set up standard requirements for traffic paints. Also, they can purchase these specific formulas in sufficient volume to assure the economical production of the desired types. Other users of traffic paints, namely the counties, municipalities, industry, railroad, airports, etc., seldom have the facilities, personnel and experience necessary for setting up specific traffic paint requirements. Even if these specifications are set up, the individual purchase orders may not be large enough to justify their special preparation without a price premium. Consequently, these groups of consumers usually rely on the competence, experience and integrity of the paint manufacturer to obtain the best paint for their needs.

The response to the questionnaires was very generous and the ratio of returns was surprisingly large for this type of survey, due probably to the widespread interest in new types of paints, the increased use of glass beads, and the possible necessity for considering substitute materials in the near future. Replies were received from 34 states that are well distributed geographically and from 175 manufacturers of traffic paints who are representative of varying degrees of importance in all parts of the country. We wish to express our sincere appreciation to all of those who participated.

Thirty-four state highway departments replied to questions on the "Highway Department" form, but some did not answer each group of questions. Therefore, some of the compilations discussed below represent a fewer number of states.

Estimates on the gallons of white and yellow traffic paints used in 1949 and 1950 were reported by 33 states. The respective totals for the retro-reflective type paints were also reported. Summations of these reported totals, together with reported data on black marking paint, are given in Table 1.

TABLE 1

ESTIMATED GALLONS OF ROAD MARKING PAINTS USED IN 1950 AND 1949, 33 STATES REPORTING

	1950	1949
White	580,025	677,290
White with Beads	519,080	310,034
Total White	1,099,105	987,324
Yellow	178,805	250,430
Yellow with Beads	298,100	187,865
Total Yellow	467,905	438,295
Grand Total	1,576,010	1,425,619
Ratio of White to Yellow	70 to 30	69 to 31
Black	104,650[a]	143,500

[a]Four states reporting. This represents about 11 percent increase over the total for these states in 1949. A fifth state reporting for 1949 will not apply black in 1950.

The estimated totals for white and yellow paints used in 1949 and 1950 are represented in Figure 1 together with the estimated total of white and yellow paint used in 1948 by the same 33 states.

Based on 1948 data reported by Waters[1] for these states, the 1950 total for white and yellow traffic paints is about 16 percent higher than the 1948 total. The total 1948 usage of white, yellow and black reported by Waters (for 44 states only) is in excess of 1,893,000 gallons. Assuming a 16 percent average increase from 1948 to 1950 for these 44 states, their estimated total usage in 1950 would be more than 2,202,000 gallons. It is probable, therefore, that the 1950 total usage of road marking paints for all states might be about 2-1/2 million gallons.

[1]"Progress Report of Comments on Roadway Pavements Markings", by C. R. Waters, Highway Research Abstracts, July 1949.

The proportions of the various types of paints used in 1949 and 1950 and the percentage changes in 1950 for the estimated paint quantities listed in Table 1 are shown in Table 2.

It will be noted that the ratios for the states completing this portion of the questionnaire show that for the white traffic paints the beaded applications represented about one-third of the total in 1949 and about one-half of the total in 1950. In the yellow traffic paints, the use of beaded marking lines increased from about two-fifths of the total in 1949 to about three-fifths of the total in 1950. During both of these years the ratio of all whites to all yellows was about 7 to 3.

TABLE 2

RATIOS OF WHITE AND YELLOW TRAFFIC PAINTS USED IN 1950 AND 1949, 33 STATES REPORTING

	1950 Percent	1949 Percent	Change in 1950 Percent
White	53	69	- 14
White with Beads	47	31	+ 67
Total White	100	100	+ 11
Yellow	38	57	- 29
Yellow with Beads	62	43	+ 59
Total Yellow	100	100	+ 9

The right hand column of Table 2 shows increases from 1949 to 1950 of 67 percent for the white beaded markings and of 59 percent for the yellow beaded markings. These very large rates of change serve to emphasize the rapidly increasing and widespread adoption of glass beads in traffic paints. This conversion to the beaded type road markings was accompanied by a moderate increase in the total amount of traffic paint used. The increase in quantity of white paints used in 1950 versus 1949 amounted to about 11 percent, that of the yellow paints to about 9 percent, while the combined increase for both types was slightly less than 11 percent.

Table 3 summarized the replies given by 34 states regarding the basis of traffic paint purchases by their depart-

ment. Twelve of the states indicated that a single major requirement was used, and none of these cited cost per gallon as the requirement. Thirteen states indicated that two requirements were used, and nine of these cited cost per gallon as one requirement. Nine states reported that three or more requirements were used, with six indicating that cost per gallon was one of the bases of purchase.

TABLE 3

BASIS OF TRAFFIC PAINT PURCHASE IN 1950, 34 STATES REPORTING

Basis of Purchase	Number of Requirements per State			Total Votes
	Single	Double	Multiple	All States
Specification	4	8	8	20
Composition	2	7	5	14
Performance	6	2	6	14
Cost per Gallon	None	9	6	15
Other	None	None	2	2
Number of States	12	13	9	34

TABLE 4

MONTHS ESTIMATED ROAD SERVICE LIFE
34 STATES REPORTING

Type of Stripe	Average Normal Service	Average Optimum Service	Range[a]
White Paint	6	13	4 to 20
White with Beads	9	14	6 to 20
Yellow Paint	6	12	5 to 18
Yellow with Beads	8	14	3 to 20

[a]Two of the 34 states indicated a possible life of 24 months and one a possible life of 36 months These estimates are not included in the ranges listed

Considering the total votes listed in Table 3, purchase of paint by specification, either general or composition, or combined with performance, is the most general procedure in 20 of the 34 states. Of the 14 other states replying, two purchase solely on a composition basis and six purchase solely on a performance basis. According to these results, the survey indicates that purchase on a cost per gallon basis is of minor importance in most of the states. This is consistent with the enthusiastic trend towards the use of glass beads regardless of the significant increase in first cost.

Questions on the relative road service life obtained with the various types of paint were answered by 34 states. Most of those pointed out that their estimates were for average service under average conditions, since the type of road, traffic concentration, film thickness, and many other factors

TABLE 5

EFFECT OF BEADS ON FILM LIFE OBTAINED

	Shorter Life for Beaded Paints (States)	Same Average Life for Beaded and Non-Beaded Paints (States)	Longer Life for Beaded Paints (States)
Whites Only	-	2	4
Whites and Yellows	1	7	6
Yellows Only	-	1	1
Total States	1	10	11

might cause significant variations in service obtained. The replies received are summarized in Table 4. These results indicate that average non-beaded applications may be serviceable for about six months, while the beaded paints are serviceable for slightly longer periods.

An analysis of the specific replies as to the effect of glass beads on the service life of the films is tabulated in Table 5 according to the effects reported for white and yellow paints.

The Table 5 results confirm in part the averages reported in Table 4 but indicate that the Table 4 data are not

consistently applicable. The differences of opinions listed in Table 5 probably result from the effects of formulation and service variables. They also probably indicate the possibility of obtaining misleading indications in a too-brief summary of the variety of estimates condensed for the Table 4 values. The net result of the Table 5 summation is to indicate that beads affected a shorter film life in one state, had no significant effect in ten states, and effected longer film life in 11 states. Four of the other states reporting indicated no comparisons of film life, three did not use beads, and five used beaded paints only.

The estimates given by the individual states on film life also offered comparisons of the relative service periods of white and yellow paints applied without beads. These comparisons are listed in Table 6.

These opinions indicate that the color of the traffic paints did not consistently affect the service of the films. Six of the other states reporting use white paint only, three use yellow paint only, and three did not indicate the color of the paint used. Three of the

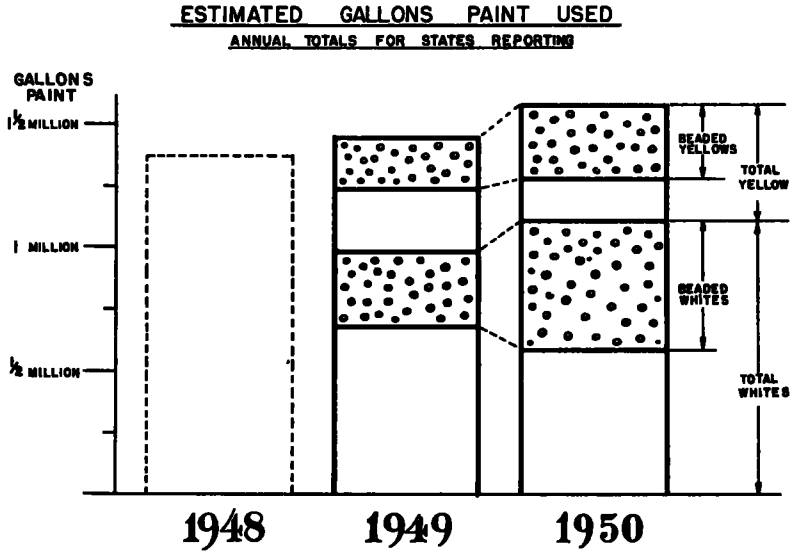

Figure 1

TABLE 6

RELATIVE FILM LIFE OF NON-BEADED WHITE AND YELLOW PAINTS

Same Average Film Life for White and Yellow Non-Beaded Paints	14 States
Longer Average Film Life for White Paint Stripes	2 States
Longer Average Film Life for Yellow Paint Stripes	3 States

TABLE 7

TYPE OF TRAFFIC PAINT MADE DURING 1949

Color of Product	Number of Manufacturers	Ratio of Total Replies Percent
White	173	99+
White with Beads	40	23
Yellow	145	83
Yellow with Beads	32	18
Other	57[a]	33
Produced White Paint Only	24	14
Produced No White Paint	2	1
Produced White and Yellow Only	115	66
Produced Other Colors (Green, Red, Orange, Black)	34[a]	20

[a]Some of those replying did not indicate which colors were produced

six using white paint use only beaded paints.

Table 7 summarized the replies received from several hundred paint manufacturers of whom 175 reported that they produce road marking paints. With some, this is a major part of their business. With others, it is of relatively minor importance even though the quantity produced may exceed that of a smaller company engaged mainly in traffic paint production. Data given in this paper, however, do not consider the relative quantities produced by the individual companies.

markings, and a summation of these results is given in Table 8. While it may appear that the highway departments might have more complete information on the relative effects of the several variables, they are probably no more interested than the manufacturers. Indeed, much of the business obtained by the manufacturers might depend upon their proper evaluation of the various factors. Their replies were listed according to first choice, second, third, etc. The total weighted votes for each item, listed in the middle column in Table 8, were determined and

TABLE 8

PAINT MANUFACTURERS' OPINIONS ON THE RELATIVE IMPORTANCE OF VARIOUS FACTORS TO THE SERVICE LIFE OF THE FILM

Factors Cited	Number of First Choices	Total Weighted Votes[a]	Relative Order of Preference
Type of Vehicle	108	744	1st
Film Thickness	18	360	2nd
Application Variables	16	327	3rd
Type of Pavement Surface	15	296	4th
Type of Hiding Pigment	4	250	5th
Type of Extender Pigment	1	229	6th

[a]Where five choices were indicated, the first choice was weighted as five votes, the second as four, etc The totals given in this column represent the resulting sums for the respective items

Almost all of the 175 traffic paint manufacturers reported that they produce white marking paints; 83 percent reported the production of yellow traffic paints; 66 percent reported the production of whites and yellows only; and 33 percent reported the production of other colors, such as green, red, orange or black. Only 23 percent of the companies produce beaded white paints, and only 18 percent produce beaded yellows. This might indicate that the highway departments had taken the initiative on expanding the use of beaded paints, or it might indicate that they preferred to add the beads at the time of paint application rather than purchase paints containing glass beads.

The paint manufacturers were asked to list their opinions on the relative importance of half a dozen factors influencing the service life of the road

these values were found to agree in relative order with the order of preference indicated by totals of the first choices.

Of the 163 manufacturers replying to this section of the questionnaire, more than half selected the type of vehicle as being the most important factor in service life of the film. There was much less agreement as to the second most important factor but it was generally agreed that film thickness, application variables, and type of pavement surface were all fairly important factors.

The relatively low position of importance assigned to the effects of the hiding pigments on service life is somewhat surprising. There have been occasions when our customers have expressed contrary opinions about the effects of some of the hiding pigments.

The results summarized in Table 9 represent the replies received from the states and the manufacturers regarding the pigments used. The questionnaire sent to the highway departments asked for an indication of the opaque and extender pigments preferred in white traffic paints, beaded and non-beaded types. The paint manufacturers' questionnaire contained a similar list of questions but they were asked to indicate those pigments that were used in substantial percentages in traffic paints made by their company in 1949. Thirty-four states and 175 producers of traffic paint replied, and the frequencies, of preferences are indicated in Table 9. It will be noted that the respective percentages for each group total more than 100 percent, signifying the use of more than one pigment in the formula.

Three of the states replying used only yellow marking paints in 1949 and 1950. Of the 31 states using white paints, five indicated no preference in the opaque pigments or in the extender pigments used. Considering the differences indicated between the non-beaded and the beaded paint formulas, three of the states reported that they used only beaded paints, 25 reported that the same pigment combinations are used both with and without beads, four change the opaque pigment when beads are used, and two change the extender pigments when beads are used. The percentages indicated in the left-hand column in Table 9 are for the non-beaded paints but the replies regarding the use of beads did not materially change the ratios and, therefore, are not indicated in the table.

TABLE 9

WHITE PIGMENTS PREFERRED BY HIGHWAY DEPARTMENTS AND BY PAINT PRODUCERS

	Frequency of Choice (States) Percent	Frequency of Choice (Manufacturers) No Beads Percent	Frequency of Choice (Manufacturers) Beaded Percent	Average Order of Preference
White Opaque Pigments				
Titanium Dioxide	50	61	71	1st
Titanium-Calcium	44	59	55	2nd
Zinc Oxide	29	49	55	3rd
Lithopone	18	35	13	4th
Extender Pigments				
Magnesium Silicate	56	80	90	1st
Diatomaceous Earth	15	39	47	2nd
Whiting	18	33	29	3rd
Pumice	18	21	8	4th
Other (Extenders Only)	18	13	16	5th

FREQENCY OF CHOICE- WHITE OPAQUE PIGMENTS USED IN NON-BEADED TRAFFIC PAINTS

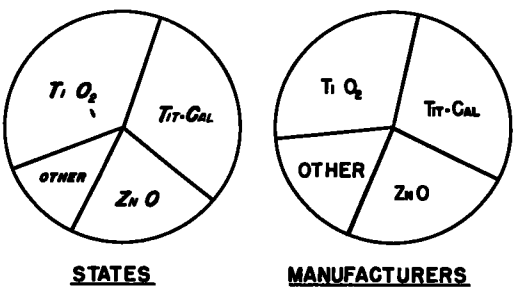

Figure 2

As the Table 9 results indicate, the titanium pigments have first preference, followed by zinc oxide and lithopone, both among the traffic paint manufacturers and among the highway departments. In the non-beaded paints, the manufacturers seem to be more cognizant of the advantages of zinc oxide

than are the states, and they further increase the use of this reinforcing pigment for the beaded formulas. More changes are made also in other pigments used by the manufacturers when formulating for the retro-reflective road markings than are made by the states when beads are used. The increased use of titanium dioxide and of zinc oxide by the manufacturers when formulating for beaded paints is evidence that cost is not the most important factor in designing the formula.

Figure 2 represents the relative frequencies of choices for white opaque pigments used in non-beaded traffic paints by the states and by the manufacturers. paint manufacturers than by states, but the frequency of use decreased slightly in the beaded formulas. "Other" types of extender pigments used included aluminum silicate, mica and various forms of barium sulfate. There is evidence that both the state highway departments and the traffic paint manufacturers are giving increasing attention to the use of barium sulfate in road marking paints.

Considering preferences for types of vehicles, 28 states voting on the types found to be most satisfactory and 175 traffic paint manufacturers voting on the types used by their companies in 1949 have indicated their respective

TABLE 10

PREFERENCES INDICATED FOR VFHICLE TYPES BY HIGHWAY DEPARTMENTS AND BY PAINT MANUFACTURERS

Vehicle Type	Frequency of Choice (States) Percent	Frequency of Choice (Manufacturers) No Beads Percent	Frequency of Choice (Manufacturers) Beaded Percent	Average Order of Preference
Alkyd Resins	54	52	62	1st
Phenolics	29	34	32	2nd
Phenolic-Dispersion Resin	21	10	19	3rd
Copolymer-Chlorinated Paraffin	11	9	11	4th
Ester Gum	0	18	13	4th
Natural Gums	7	14	5	6th
Cumar (for Yellows)	3	4	-	-
Styrenated Oils	0	2	-	-
Other (All Types)	21	14	11	-

Considering the extender pigments, both the states and the manufacturers indicated a definite preference for magnesium silicate. The ratios of use by the states in non-beaded paints and in the beaded types were so similar that data for the beaded paint formulas are not given in Table 9. A considerably larger proportion of the traffic paint manufacturers indicated the use of magnesium silicate, both in the non-beaded and in the beaded paints. The manufacturers, however, also used other types of extenders more frequently, with the diatomaceous earth being the most favored. Whiting was also more generally used by traffic

choices. The frequency of choice for each vehicle type is listed in Table 10, data for the state highway department preferences being listed for the non-beaded paints and data for the manufacturers preferences being listed both for non-beaded and for beaded paints. Frequency of choice values for beaded paint vehicles preferred by the states are not listed in Table 10 because they are so similar to the values for the non-beaded types.

The relative orders of choice for the types of vehicles preferred in traffic marking paints place the alkyd resin type as definitely first choice by both groups reporting. Phenolic resin

varnish types are the second choice of both groups, and the phenolic-dispersion resin type is rated third in frequency of preference. No data are available on the total quantities of the respective types of vehicles that are used annually.

In the category of "other" vehicle types, the state highway departments reported the acceptance of pentaerythritol ester resins, chlorinated rubber, phenolic modified pentaerythritol, maleic modified phenolic, zinc resinate, and tung oil varnishes. Under the same classification, the manufacturers listed most of the types cited by the states.

and the report by one state that a different type vehicle was specified where glass beads are used than is specified for the non-beaded paints. Six states indicated no preferences as to the type of vehicle specified for their white and yellow road marking paints. No significant changes in types of vehicles used in 1949 versus 1950 were indicated in the preferences reported.

Of all the results indicated in this survey, perhaps the most interesting phases were those expressing the trends in opinions and preferences, as shown in Table 11. Some of these have been enumerated in the results previously

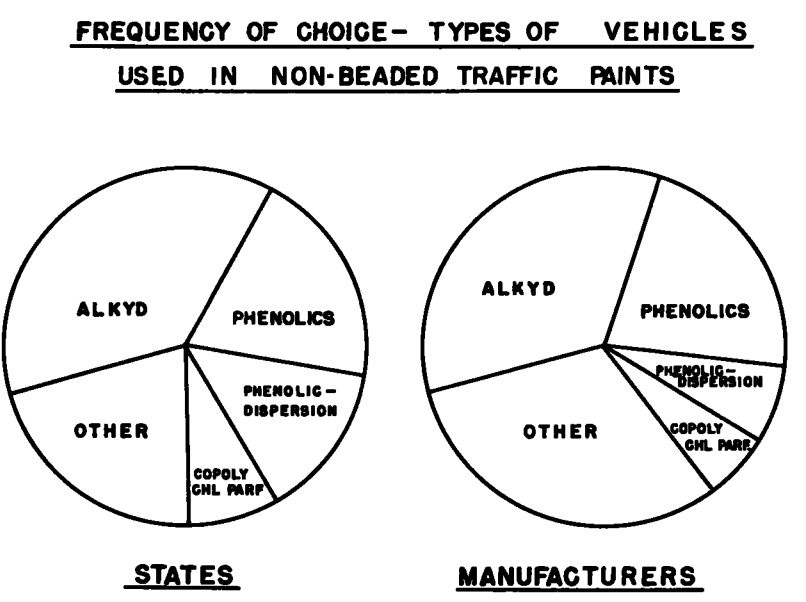

Figure 3

Comparisons of the relative frequencies of choice by the states and by the manufacturers for types of vehicles used in non-beaded traffic paints are shown in Figure 3.

Pertinent details that may be of interest to the highway departments include the report by 16 states that the same types of vehicles are purchased for non-beaded and beaded marking paints, the report by three states that they apply beaded marking lines only, the report by two states that bead-containing paints are purchased for their retro-reflective markings,

discussed and some have been indicated by inference. Table 11 summarizes the replies received from identical lists of questions in both the state highway and the "producer" forms. The wording in the questionnaire was: "To aid us in the following trends, indicate on which properties you intend to place greater emphasis in the coming year . . ." Eight options were listed and it was requested that at least three of these, but not more than five, be numbered in order of importance.

The response received from both groups was most gratifying. Space does

not permit detailed analysis of the preferences reported but the orders of preference indicated in Table 11 are believed to be a fair presentation of the consensus. Comparisons of the choices indicated by some of the highway engineers with the traffic paint specifications for their respective states would indicate that revision or expansion of some of the specifications was badly needed. The results indicated that both for the state highway departments and for the traffic paint manufacturers the thinking regarding future trends was considerably in advance of present practice. Both groups are to be congratulated on their alertness to future possibilities in road marking paints.

Considering the individual returns, 34 state highway departments and 162 traffic paint manufacturers replied to this list of questions. For the states, 30 indicated their first, second, etc., choices. For the manufacturers, 148 indicated their choices in descending order of importance. A summation of the preferences on a weighted[2] basis agrees with the order of decreasing preferences that is indicated by the respective first-choice totals, both for the highway department replies and for the manufacturers replies.

In the individual replies, "Improved Service Life" was definitely the first choice of both groups for greater emphasis during the coming year. The relative ratings on "Rate of Dry" and "Storage Stability" were also in fairly good agreement, but the unanimity of agreement on the importance of the other properties was less pronounced in the two groups. In general, the Table 11 comparisons probably indicate the concern on the part of the consumers for better service properties of the film without stress on the paint cost, and the concern on the part of the manufacturers for better liquid paint and application properties at competitive costs. The de-emphasis of cost by the highway departments is a logical reaction to the great increase in interest in retro-reflective road markings, and it is probably coupled with their desire to keep such films on the road as long as is practical.

TABLE 11

RELATIVE ORDER OF PREFERENCE FOR FUTURE EMPHASIS ON PAINT PROPERTIES

Paint Properties	State Highway Departments	Traffic Paint Manufacturers
Improved Service Life	1st	1st
Night Visibility	2nd	6th
Rate of Dry	3rd	2nd
Storage Stability	4th	4th
Day Visibility	4th	7th
Cost per Gallon	6th	3rd
Bleeding Resistance	6th	4th
Other	Negligible	Negligible

In conclusion, I again wish to express our deepest gratitude to all of those who participated in the survey, and to your committee who made this presentation of preferences possible. Limitations of space prevented comment on many of the details reported but these will be freely available to those interested, with the exception that the identity of those organizations making the comments manifestly cannot be revealed.

[2]Where five choices were indicated, the first choice was rated as five votes, the second four votes, etc. The resulting sums for each item determined the orders of preference listed in Table 11.

APPENDIX A

Traffic Paint Formula T-4418-TAEI - White
Traffic Paint Formula T-5418-MEAI - Yellow
Traffic Paint Formula T-1451-MEAI - Yellow

TRAFFIC PAINT FORMULA T-4418-TAEI

	Formula Percent	Representative Formula
Pigment - 57-59 Percent		
Titanium Dioxide (1)	10	74 lb.
Lithopone (2)	40	295 lb.
Zinc Oxide (3)	10	74 lb.
Pumice (4)	10	74 lb.
Magnesium Silicate (5)	29	214 lb.
Aluminum Stearate	1	7 lb.
Vehicle - 43-41 Percent		
Alkyd Resin Solution (6)	65.6	44-7/8 gal.
V. M. and P. Naphtha	33.3	29 gal.
Lead Drier (24 % Pb)	0.9	5 pt.
Cobalt Drier (6 % Co)	0.2	1 pt.

Yield	100 gal.
Non-volatile in Vehicle	40 Percent
Weight per Gallon	12.7 lb.
P. F. V.	52 Percent

(1) Rutile or anatase type may be used. Rutile provides better durability; anatase, better color and cleansing.
(2) Albalith-351 (high consistency) or Albalith-73 (lower consistency).
(3) XX-2, XX-50, XX-55, XX-503 or XX-601.
(4) Should be added after paint is ground. Where application is by spray gun, use No. 0-1/2, 1/2 or 0-3/4. When application equipment permits the coarser pumice, No. 1 or 1-1/2 may be used. If glass beads are to be used, the pumice may be omitted.
(5) Medium consistency fibrous type.
(6) Glyptal 2475 (60 percent non-volatile) or any recommended alkyd that is compatible with zinc oxide may be used. If non-volatile is not 60 percent, adjustment should be made in quantity of alkyd and V. M. and P. Naphtha. If paint is to be applied under unfavorable conditions or more rapid drying is desired, a V. M. and P. Naphtha-alkyd solution should be used instead of a mineral spirits-alkyd solution.

The properties and cost of the paint may be varied by changing the composition of the pigment, the vehicle, or the proportions used.

Increasing the TiO_2 or zinc oxide content in the pigment increases the length of service obtained. High zinc oxide content is especially desirable when the paint is to be glass beaded. Substitution of water-ground mica for part of the magnesium silicate also increases the durability of the film. Replacing part of the lithopone by additional magnesium silicate lowers cost at a sacrifice in the service obtained; also replacement on an equal weight basis of the pumic and magnesium silicate by an inexpensive ground whiting lowers cost at a sacrifice in durability.

The use of high viscosity resins or high consistency pigments, which permit an increase in the vehicle content or volatile content in the vehicle, reduces cost, although generally accompanied by a decrease in service. Increasing the non-volatile vehicle usually results in improved service.

Note: The information contained herein is from sources which we believe to be reliable and is intended to offer helpful suggestions. We do not, however, guarantee the results to be obtained from its use.

TRAFFIC PAINT FORMULA T-5418-MEAI

	Formula Percent	Representative Formula
Pigment - 58 - 60 Percent		
C. P. Chrome Yellow	40	318 lb.
Zinc Oxide (1)	15	119 lb.
Lithopone (2)	15	119 lb.
Magnesium Silicate (3)	29	230 lb.
Aluminum Stearate	1	8 lb.
Vehicle - 42-40 Percent		
Alkyd Resin Solution (4)	65. 6	46-1/2 gal.
V. M. and P. Naphtha	33. 3	30 gal.
Lead Drier (24 % Pb)	0. 9	4 qt.
Cobalt Drier (6 % Co)	0. 2	1 pt.

Yield	100 gal.
Non-volatile in Vehicle	40 Percent
Weight per Gallon	13. 5 lb.
P. F. V.	48. 9 Percent

(1) XX-2, XX-50, XX-55, XX-503 or XX-601.
(2) Albalith-351 (high consistency) or Albalith-73 (lower consistency).
(3) Medium consistency fibrous type.
(4) Glyptal 2475 (60 percent non-volatile) or any recommended alkyd that is compatible with zinc oxide may be used. If non-volatile is not 60 percent, adjustment should be made in quantity of alkyd and V. M. and P. Naphtha. If paint is to be applied under unfavorable conditions or more rapid drying is desired, a V. M. and P. Naphtha-alkyd solution should be used instead of a mineral spirits-alkyd solution.

The properties and cost of the paint may be varied by changing the composition of the pigment, the vehicle, or the proportions used.

The chrome yellow is the most expensive pigment constituent, especially on a volume basis. Pigmentations containing combinations of C. P. lead chromate, zinc oxide, lithopone and magnesium silicate provide more durable paints than those containing C. P. chrome yellow alone or in combination with inerts All indications are that both zinc oxide and lithopone improve the durability of the paint and the limit on their substitution for chrome yellow is the inclusion of sufficient chrome yellow to assure the desired yellow color. High zinc oxide content is especially desirable if the paint is to be beaded. Replacement of a portion of the magnesium silicate by water-ground mica or by pumice improves the durability of the film.

Increasing the non-volatile content of the vehicle usually improves durability, while the use of high viscosity resins or high consistency pigments, which permit an increase in the vehicle content or an increase in the volatile content of the vehicle, reduces cost but usually with a sacrifice in the service obtained from the paint.

Note: The information contained herein is from sources which we believe to be reliable and is intended to offer helpful suggestions. We do not, however, guarantee the results to be obtained from its use.

TRAFFIC PAINT FORMULA T-1451-MEAI

	Formula Percent	Representative Formula
Pigment - 53-55 Percent		
C. P. Chrome Yellow*	40	265 lb.
Zinc Oxide (1)	15	100 lb.
Lithopone (2)	15	100 lb.
Magnesium Silicate (3)	29	192 lb.
Aluminum Stearate	1	7 lb.
Vehicle - 47-45 Percent		
Varnish (4)	43	33-3/4 gal.
Dispersion Resin (5)	28. 7	21-3/4 gal.
Butanol	4. 5	3-3/4 gal.
V. M. and P. Naphtha	23. 3	21-1/2 gal.
Lead Drier (24 % Pb)	0. 31	1-1/2 pt.
Cobalt Drier (6 % Co)	0. 13	3/4 pt.
Manganese Drier (6 % Mn)	0. 06	3/8 pt.

Yield	100 gal.
Non-volatile in Vehicle	37 Percent
Weight per Gallon	12-1/4 lb.
P. F. V.	41 Percent

*The chrome yellow is the most expensive pigment constituent, especially on a volume basis. Pigmentations containing combinations of C. P. chrome yellow, zinc oxide, lithopone and magnesium silicate provide more durable paints than those containing C. P. chrome yellow alone or in combination with inerts. All indications are that both zinc oxide and lithopone improve the durability of the paint and the limit on their substitution for chrome yellow is the inclusion of sufficient chrome yellow to assure the desired yellow color. High zinc oxide content is especially desirable if the paint is to be beaded.

(1) XX-2, XX-50, XX-55, XX-503 or XX-601.
(2) Albalith-351 (high consistency) or Albalith-73 (lower consistency).
(3) Medium consistency fibrous type.
(4) 25-gallon 80 percent tung oil-20 percent Ź-3 dehydrated castor oil, modified phenolic resin varnish. (Bakelite EF-1368 traffic paint varnish or equal).
Volatile - 49 percent, Viscosity - B-C, Weight per Gallon - 7. 18 lb.
This varnish must be compatible with zinc oxide.
(5) Bakelite Dispersion Resin BK-16624 (50 percent K. V. O or equal).

Note: The information contained herein is from sources which we believe to be reliable and is intended to offer helpful suggestions. We do not, however, guarantee the results to be obtained from its use

APPENDIX B

Traffic Paint - Summary Submitted with each Questionnaire
Questionnaire - Road Marking Traffic Paints - Form Sent to Highway Departments
Questionnaire - Road Marking Traffic Paints - Form Sent to Paint Manufacturers

TRAFFIC PAINT

For a number of years, we have conducted extensive investigations on traffic paint, both as laboratory studies and as field service tests. The laboratory work included the preparation of varnishes from conventional and from new type ingredients, the making and testing of paints containing these varnishes, and the development of new test methods. Practical road tests have been made on a variety of road surfaces with varying traffic conditions. Also, cooperative road service tests have been run with paint laboratories and with highway departments in a number of states and cities. As a result, much information on pigments and vehicles has been developed and passed out to paint manufacturers, highway departments, and others interested.

In 1949, much more work was done. Pigment formulas previously found satisfactory in traffic paints were retested, vehicles that had been formerly accepted were rechecked, and new vehicles that had come before the public were put under test. Paints in both white and yellow were investigated and the performance of a number of beaded paints was observed. The road service tests were made on a concrete highway previously used for this purpose, a highway traversed daily by twelve to twenty thousand vehicles moving at high speed, with about one-third being heavy trucks. It is the purpose of this paper to comment on this work to date.

In the earlier work on the pigments, we found that paints made with Albalith (lithopone) and Cryptone BT (titanated lithopone) gave excellent whiteness and necessary hiding power. The presence of zinc oxide improved performance. White water-ground mica extended the life of the paint. Pumice, either coarse or fine, added measurably to the life of the paint, and the coarse grade, through adding roughness to the paint surface, greatly improved night visibility.

These conclusions were again substantiated in 1949. As a rule, anatase titanium dioxide paints had better whiteness and appearance than the rutile titanium dioxide or the calcium-base pigment paints, and were comparable in whiteness and visibility to Cryptone BT or lithopone paints. The calcium-titanium pigment formulas have consistently shown more dirt collection, poorer color, and poorer durability. In the yellow paints, when some of the chrome yellow was replaced by Albalith and/or zinc oxide, there was no degradation in color or durability - usually both were improved - and a reduction in cost was achieved.

The vehicles used in earlier investigations together with those tested in 1949 represented every type of standard or alternate state highway department specification. These white and yellow paints were formulated both with the specified pigmentations and with substitutions or modifications In addition to the conventional type vehicles, several new types not in common use were included in the tests. Brief comments on several different vehicles are given without attempting to list the various pigment combinations found to be effective in each type.

Modified Phenolic Tung-Linseed Vehicle (Federal Specification TT-P-115)

This vehicle is one of the oldest in point of use that has had popular acceptance by the trade. It is of the modified phenolic resin tung-linseed oil varnish type Our 1949 tests confirmed our former findings that, if the varnish is properly cooked, this vehicle gives paints of satisfactory performance. In looking over the states now specifying this vehicle, we find that it has lost some of its popularity to alkyds Good quality white or yellow paints are equally durable in this vehicle.

Alkyd Vehicles

Our 1949 tests again checked our previous work in indicating that alkyds performed remarkably well. With these vehicles, failure to dry to tack-free condition sometimes causes difficulty, but it is not insurmountable. A survey of the use of this type vehicle shows that half of the states and many of the cities use it in their standard or alternate specifications. It is equally good for whites or yellows.

TRAFFIC PAINT (Continued)

Manila Vehicles

The Manila gum type vehicle has been used quite extensively by some western states and has become identified as the "California Vehicle". We again found its performance poor in our climate, significant failure developing in less than a month. Paints made from it seem to have lost favor in some states formerly specifying it.

Bakelite Varnish-Dispersion Resin Vehicle

This is a comparatively new-comer in the field and consists of a modified phenolic resin tung-linseed oil varnish plus dispersion resin. It has found favor in a few states. It has the advantage of quick drying, which is much to be desired, particularly for city use. Our 1949 tests with it were exploratory and did not permit drawing of final conclusions, but it appeared that satisfactory service could be obtained with yellow paints.

Goodyear Pliolite-Chlorowax Vehicle

Another of the newer type of vehicle is the combination of Pliolite, a copolymer of butadiene and styrene, and chlorinated paraffin. It has been used in Texas and is finding some acceptance in other states. Paints made from it dried satisfactorily. Here again the work was exploratory and definite conclusions could not be drawn, but yellow paints appeared to give good service.

Hercules Pentalyn 802A-Parlon Vehicle

This is probably the newest type traffic paint to be advocated in a large way. So far, it has gotten to the testing stage by states and cities. It is a combination of a Pentalyn 802A resin-tung oil varnish and a Parlon solution, the latter being a solution of chlorinated natural rubber. Paint made from it dries very fast and has aroused considerable interest. So far as our work has gone, the paint performance looks interesting.

Yellow Paints

Aside from the differences in service properties of yellow pigmentations and white pigmentations in certain types of traffic paint vehicles, probably the most interesting indication of the 1949 tests was that the addition of either lithopone or zinc oxide to the yellow paints effected significant reductions in cost without harming road service and frequently improving it. These additions caused no noticeable degradation of the color, in fact, they effected better color retention and dirt elimination. Several states now specify white pigment additions to yellow traffic paints. The economies effected by the addition of these white pigments are substantial.

Glass Beaded Paints

The recent widespread interest in glass beaded traffic stripes is of special interest because it focuses attention on the increased road service usually obtained by adding zinc oxide to traffic paint formulations. This improvement is evident in both the zinc sulfide and the titanium pigment paints. In the past, it has been of little interest to highway departments to gain a few months added road service by the addition of the zinc oxide when such improvement would merely extend the service period into the early winter months. Now the added cost of glass beaded lines makes an extension of the useful road service period very attractive, and extra cost that may be put into the paint is of minor importance in comparison with the improved service given. Although most of the vehicles tested with beads in 1949 and in previous years had good performance records, an important improvement is achieved if the life of the paint itself is extended, and if the vehicle is strengthened to hold the imbedded beads longer. Some users are now asking for sixteen months' service, as compared with previous interest in five to seven months.

The high cost of glass beads has resulted in interest in some states in extending the beads with cheaper materials. The rounded glass-like particles of Ottawa sand have been considered for this purpose Our 1949 tests indicated that there may be some merit in this practice. The tests have also indicated that beads or bead-sand mixtures do not significantly improve the paint stripe durability The apparently longer service obtained with beaded lines seems to be due solely to prolonged visibility at night of the worn lines. All results indicate that increased durability in the paint must originate in formulation modifications, such as vehicle improvement, reinforced pigmentation, or modified pigment-vehicle ratios.

TRAFFIC PAINT (Continued)

Because of the realization of possible differences of opinion as to the relative importance of road service versus other factors, no attempt has been made in this paper to suggest specific formulations. If those interested will indicate the factors that are of greatest importance in their specific requirements, we will be pleased to submit suggestions that we believe will be of most value under the specific requirements.

State Highway Department — June 1950

QUESTIONNAIRE

ROAD MARKING TRAFFIC PAINTS

Please estimate the quantities of road marking traffic paints used by your department:

	Gallons 1949	1950
White	____	____
White reflectorized with glass beads	____	____
Yellow	____	____
Yellow reflectorized with glass beads	____	____
Other _____	____	____

Please check on what basis paints are purchased for use by your department.

	Purchase Requirement
Cost per Gallon	_____
Specification	_____
Composition	_____
Performance	_____
Other _____	_____

What period of road service life is obtained from painted road stripes now used by your department?

Type of Stripe	Number of Months
White	_____
White plus glass beads	_____
Yellow	_____
Yellow plus glass beads	_____
Other _____	_____

To aid us in following trends, indicate on which paint properties you intend to place greater emphasis in the coming year. Please do so by numbering (e.g. 1, 2, 3, etc.) at least three but not more than five from the following list:

Bleeding Resistance	_____
Storage stability	_____
Rate of dry	_____
Improved service life	_____
Visibility	
Day	_____
Night	_____
Cost per gallon	_____
Other _____	_____

What pigments do you prefer in white traffic paints? Please indicate by check marks in the following list.

QUESTIONNAIRE (Continued)

	Non-beaded type of paint	Beaded type of paint
Opaque White Pigments		
Titanium dioxide		
Titanium-calcium		
Lithopone		
Zinc Oxide		
No preference		
Extender Pigments		
Magnesium silicate		
Diatomaceous earth		
Pumice		
Whiting		
No preference		
Other		

What vehicle types have you found most satisfactory for traffic paints? Please indicate by check marks on the following list.

	Non-beaded type of paint	Beaded type of paint
Alkyd		
Copolymer-Chlorinated Paraffin		
Phenolic-Dispersion Resin		
Other Phenolic Resins		
Ester Gum		
Natural Gum		
Styrenated Oils		
Cumar (for other than white paint)		
Other		

Organization _____
Address _____
Name and title of individual _____

P. S. Please attach a copy of the latest issue of your specification.

Paint Manufacturer June 1950

QUESTIONNAIRE

ROAD MARKING TRAFFIC PAINTS

Please check whether your company manufactured road marking traffic paints of the following types during 1949:

White	
White for use with glass beads	
Yellow	
Yellow for use with glass beads	
Other	

Which of the following pigments were used in substantial percentages in traffic paints made by your company in 1949?

QUESTIONNAIRE (Continued)

	Non-beaded type of paint	Beaded type of paint
Titanium dioxide		
Titanium-calcium		
Lithopone		
Zinc Oxide		
Magnesium silicate		
Diatomaceous earth		
Pumice		
Whiting		
Other _____		

Which of the following vehicle types were used in traffic paints made by your company in 1949?

	Non-beaded type of paint	Beaded type of paint
Alkyd		
Copolymer-Chlorinated Paraffin		
Phenolic-Dispersion Resin		
Other Phenolic Resins		
Ester Gum		
Natural Gum		
Styrenated Oils		
Cumar (for other than white paint)		
Other _____		

To aid us in following trends, indicate on which paint properties you intend to place greater emphasis in the coming year. Please do so by numbering (e.g. 1. 2. 3. etc.) at least three but not more than five from the following list:

Bleeding Resistance	
Storage stability	
Rate of dry	
Improved service life	
Visibility	
Day	
Night	
Cost per gallon	
Others _____	

Based upon your direct experience, what is the relative importance to service life of the factors listed below? Please rate their order of importance by numbering (e.g. 1, 2, 3, etc.) at least three but not more than five.

	Importance Rating
Application variables	
Type of hiding pigment	
Type of extender pigment	
Type of vehicle	
Film thickness	
Type of pavement surface	

Is traffic paint a substantial part of your business? Yes No

Company _____

Address _____

Name and title of individual _____

Date _____

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The National Academy of Sciences is a private organization of eminent American Scientists, chartered under a special act of Congress in 1863 to "investigate, examine, experiment, and report on any subject of science or art." The Academy maintains the National Research Council as its operating agency.

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