

Commonwealth of Kentucky
Department of Highways

Highway Materials Research Laboratory
132 Graham Avenue, Lexington 29, Kentucky

December 30, 1953

P. 2. 4.
D. 1. 7.

MEMO TO: J. A. Bitterman, Director
Division of Materials

The attached report on Evaluation of Traffic Paints in 1953, as prepared by J. H. Havens, Research Chemist, is a record of the service-test program conducted during the past year. The report represents results in both tabulated and photographic form, and it also discusses the various procedures in such a way that all the steps can be followed by those who are interested in the work. Inasmuch as the program this year represented a joint endeavor of the Division of Materials and the Division of Research, representatives from the Testing Laboratory were present when most of the stripes were applied and when the final evaluation was made at the road-test site.

In view of the fact that responsibility for qualifying materials with respect to invitations for bids was shifted to the Division of Materials this year, the report contains no recommendations regarding qualifications other than the comments on limiting values which Mr. Havens made in the section headed "Rating Summary" beginning on page 16. Undoubtedly, the comments in that section and the tabulations to which he makes reference will facilitate the judging of materials for qualification purposes.

Before decisions regarding a program for 1954 are made, I believe that all of Mr. Havens' recommendations should be studied thoroughly. For example, there were too many samples accepted for test this year. A large portion of them had no bearing on the type paints which were to be used for marking pavements by the Division of Traffic, and consequently, the evaluation was complicated beyond reasonable limits. Other recommendations by Mr. Havens, such as those pertaining to the information that should be secured from prospective vendors and the desirability of developing performance records on paints of different composition should be adopted.

On the assumption that this may lead to establishment of a control material placed in the tests each year, we have attached at the close of this report a copy of the recommended specification for glass beads developed at the request of Mr. Ringo in May, 1952. So far as a desirable control paint is concerned, Mr. Havens called attention to the specifications in our 1952 report which were recommended for certain purposes. In combination, these specifications could determine a control material, if that is judged desirable.

Respectfully submitted

L. E. Gregg
Assistant Director of Research

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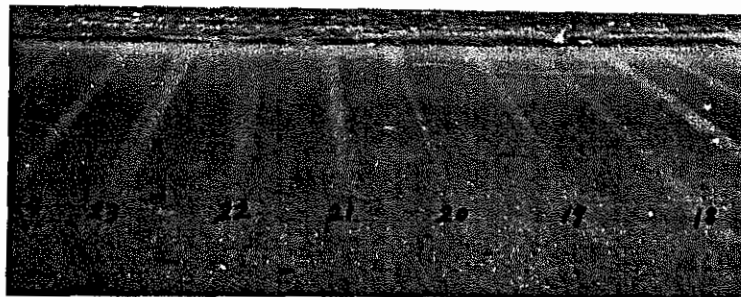
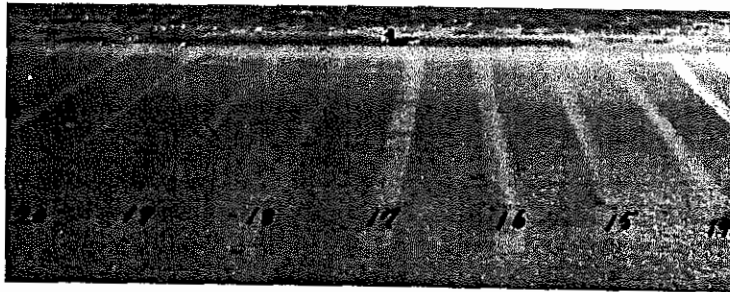
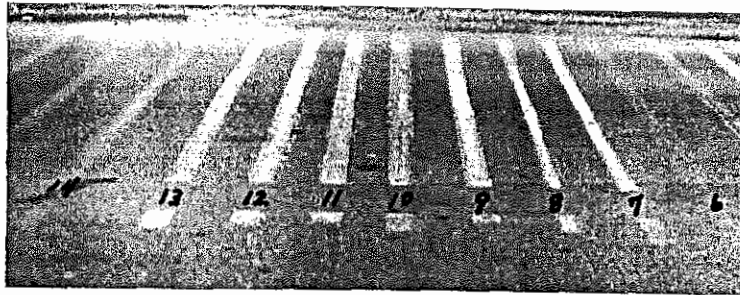
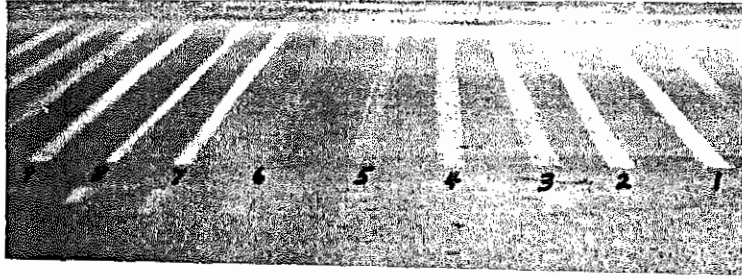
TRAFFIC PAINT SERVICE TESTS FOR 1954

This report documents the performance data obtained by the Research Laboratory in connection with field service tests and laboratory tests on traffic paint samples submitted by prospective suppliers for 1954. On the basis of these data and the adjudged performance of the samples offered, invitations to bid will be issued to any or all suppliers offering worthy materials. (See Division of Purchases's Memorandum of January 7, 1953 in Appendix) Winning bidders should be bound by oath to supply the same formulation of materials as furnished in the qualifying samples, and they should be further bound by such tests and analyses as may be considered necessary by the Department of Highways in establishing verification.

Under this system of procurement, it should be understood by the vendor and so stated in the contracts that all materials must be supplied in a usable condition without requiring additional diluents or laborious remixing. Failure of any material to meet these prime requirements, all other factors being equal, can only be construed as a reasonable cause for rejecting a shipment or forfeiture of the contract.

REVIEW OF LAST YEAR'S TESTS

For the year 1953, almost 100,000 gallons of traffic paint were purchased on a performance-cost basis. All of the white was supplied by the Baltimore Paint and Color Works (Gleem 35119A at \$2.42 per gallon). Most of the yellow was supplied by Sherwin-Williams (S & W C97YA41 at \$2.13 per gallon); but considerable difficulty was experienced by the striping crews in mixing this material. During the latter part of the year, additional quantities of the yellow were also supplied by the Baltimore Paint and Color Works (Gleem 35125A). The three materials used during the year are identified as service stripes No. 2, No. 17, and No. 14, respectively in the Research Laboratory's Report for 1952. As a matter of further interest, a recent photograph showing the same installation after some 16 months of service is included on page 3.



Condition photograph of transverse stripes placed August 19, 1952. These photographs were taken January 4, 1954 (after 16-1/2 months service). Paints represented by stripes No. 2, No. 14, and No. 17 were purchased during 1953. (Note: yellow stripes Nos. 14 through 25, normally photograph darker than the white ones.)

PROCEDURES

Seventy-one 1-gallon samples were forwarded to the Research Laboratory on March 19, 1953 (Note: letter of transmittal included in Appendix). Preparatory to application of the stripes, the following tests were conducted on each sample:

Specific Gravity The contents of each container were thoroughly mixed and the gravity read from a hydrometer. However, in the case of some very thick paints, it was necessary to use the pycnometer method.

Drying Time and Percentage Volatiles Upon completion of the specific gravity test, some of the paint was brushed onto an 8-1/2 x 11-inch sheet of white bond paper, previously tared, and weighed immediately. These were set aside and the time to dry "to touch" was recorded to the nearest minute. On the following day the sheets were re-weighed and the percentage volatiles calculated from the loss of weight of the paint.

Consistency in Krebs Units The Krebs Unit is simply the weight in grams added to the torque drive of the Krebs-Stormer Viscosimeter that is required to produce in 30 seconds 100 revolutions of a standard spindle immersed in the material to be tested.

Note: Disposable ice cream cartons served as convenient containers since they have approximately the same diameter as a 600 ml. beaker (The viscosimeter is calibrated for a 600 ml. beaker).

All of these tests required that the sample be mixed only once. The operation was usually completed and the sample resealed in less than 15 minutes.

Calculation of Application Rate in Gallons Per Mile For the tests this year it was elected to apply all samples at the same rate; and, by selecting the rate as 14 gallons per mile, it was found that the application rate in grams per foot was numerically equal to 10 times the specific gravity of the sample. Accordingly, in the application of the stripes, a 12-inch sheet of paper was placed in the path of the striper and its controls manipulated until a normal pass with the spray deposited the desired weight per foot for each individual sample. Then the stripe was applied transversly across two lanes - once on concrete and once on bituminous pavement.

Reflectance Measurements Reflectance measurements were made six times on each stripe up to the age of eight months. They were made with the Hunter Night Visibility Meter which simulates the viewing conditions of night-time driving; and the data should reflect, at least comparatively, a reliable evaluation of the night-time efficiency

of the samples. These measurements are easily made in daylight, simply by setting the instrument over the desired area of the stripe and manipulating the control knob to balance two light intensities on a split-field viewing screen.

METHOD OF RATING

Re-mixing The re-mixing quality was observed during preparation of each sample for laboratory tests and the application of stripes. Samples that were extremely hard to mix are noted in the Remarks column of the summary table on page 12. The ease with which a paint can be re-mixed is an important consideration. However, the observations mentioned above do not present a reliable evaluation of settling or caking tendencies because it was not possible to ascertain the undisturbed age of the sample at the time of this re-mixing. To properly evaluate this property, it would be necessary to set the samples aside for a period of about 30 days (shelf storage) and then attempt to re-mix them. Although that was not included as part of this year's tests, it should be incorporated into next year's program. That is, after re-mixing the samples for tests and application, set them aside for 30 days; then determine the ease of re-mixing. Hard-to-mix samples should, therefore, be eliminated from further competition.

Applicability It is a prime requirement that the paint work well in the striping equipment and that it be possible for the crews to clean their machines with gasoline. Some of the newer types of paints, such as sample 9E,

could not be cut with gasoline. Actually gasoline caused the sample to curd in the machine and it resulted in a difficult cleaning job for the crew. In the future, if samples require special solvents it should be so stated by the manufacturer and that statement supplied with the sample.

Although consistency is included as part of the laboratory evaluation, the final judgement of consistency should be delegated to the equipment operator. If he cannot lay an acceptable stripe within the full range of pressure and nozzle adjustments, the paint is not usable and should be eliminated.

Samples fitting into this category are noted in the Remarks column of the summary table on page 12.

Appearance The eventual objective in all of the evaluation work is to select materials which have good daylight appearance and night-time visibility and which preserve these features through at least one year of service on the road. Having satisfied all other prerequisites, appearance, reflective efficiency, and durability must be regarded as the factors governing the selection of samples to be qualified for competitive bidding.

Judgement of these qualifying features is largely based on personal observation. Also, it seems that the longer the stripes have been in service the greater the differentiation in performance between samples, and consequently the

judgement is more reliable. In some circles, however, visual ratings are not regarded as very convincing evidence. For that reason, appearance should be documented photographically and supported by instrumental measurements whenever possible.

Visual (daylight) ratings of all stripes, on both concrete and bituminous pavements, are listed in the tables on page 15, where the numerical rating values are given. Daylight appearances and night-time reflectivities are recorded on the strip-photographs on pages 13 and 14. These were taken at an elevation of about 15 feet (See page 11) using "flash" and the line-of-light - line-of-sight relationship represents a divergence angle of about $1-1/2$ degrees. From inspection of these photos, some stripes that appear dull in daylight appear very bright at night, and conversely. Some samples that did well on the concrete did badly on the bituminous pavement and conversely. Here again, personal judgement influences the selection of qualifying samples. Obviously such discrepancies in performance cast doubt upon the desirability of these samples.

In further support of these ratings, the instrumental reflectance measurements (obtained with Hunter Night Visibility Meter No. 125) were taken six times during the eight-month test period. Results of the measure-

ments are tabulated in the table on page 12. Considering the fundamental limitations of the instrument, there is a fair correlation between the night photographs and the reflectivity measurements.

Only those samples rated high by all methods should be considered worthy materials for future use.

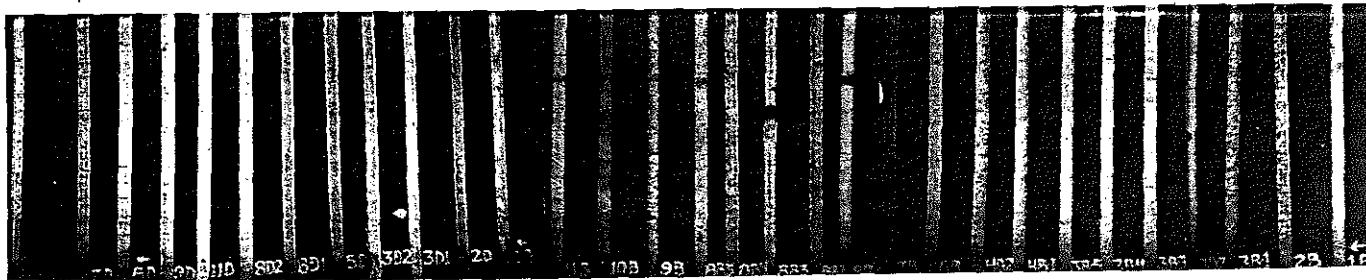


Photograph illustrating method of photographing stripes for preparing comparison mosaics. This method seemed to be the most practical for showing such a large number of stripes. Duplicate pictures were made in daylight with diffuse light and at night with flash. In this case, flash photography simulates the small divergence angle of night-time viewing conditions.

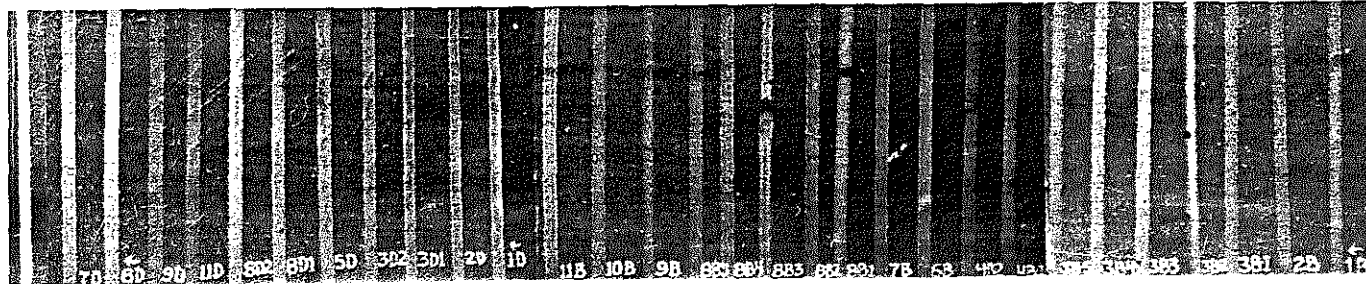
TABLE - TRAFFIC PAINT TEST DATA - SERVICE TEST STRIPES APPLIED APRIL 10-15, 1953
(Northbound Lane - Lexington-Nicholasville Road)

Sample No.	Specific Gravity	Drying Time min.	Consistency Krebs Units 25C	Volatiles %	Application Rate gal. per mi.		Reflectance Value						Remarks
					Conc.	Asph.	7-28-53		10-6-53		12-8-53		
							Conc.	Asph.	Conc.	Asph.	Conc.	Asph.	
Type I - White ReflectORIZED, Pre-Mixed													
1A	1.605	9	52	16.9	14.0	14.0	24.4	20.7	22.2	17.4	22.2	19.2	Very fine beads-abundant
2A	1.620	5	56	11.7	13.3	13.3	21.5	6.0	19.2	6.0	13.0	4.6	Very fine beads-abundant
3A-1	1.615	15	64	15.7	14.7	14.7	9.8	9.0	10.0	9.6	9.6	9.6	Adequately beaded (med.)
3A-2	1.725	12	86	17.7	13.4	13.4	7.3	9.6	8.4	10.0	8.0	12.2	Adequately beaded(coarse)
3A-3	1.650	12	66	17.8	13.3	13.3	10.8	9.4	10.1	9.6	10.2	12.2	Adequately beaded(coarse)
3A-4	1.655	7	78	14.8	13.3	13.3	8.5	9.9	8.5	8.8	7.5	10.1	Adequately beaded(coarse)
3A-5	1.680	9	92	13.3	14.5	14.5	13.0	15.6	10.1	15.6	10.8	12.2	Adequately beaded
4A-1	1.665	16	69	14.7	14.1	14.1	13.8	16.6	10.5	15.6	12.2	15.6	Adequately beaded (fine)
4A-2	1.650	6	64	21.1	15.2	15.2	10.2	11.5	12.2	11.5	10.1	10.6	Adequately beaded (fine)
6A	1.550	22	50	23.3	15.7	15.7	9.6	9.6	7.3	9.6	9.0	8.8	Graded beads - not heavy
7A	1.800	19	69	15.0	13.4	13.4	5.5	7.0	6.3	7.0	8.0	7.2	Graded beads - abundant
8A-1	1.610	11	74	17.5	14.7	14.7	13.8	9.6	12.2	8.5	15.6	9.6	Adequately beaded
8A-2	1.680	7	84	17.2	13.3	13.3	6.7	9.4	7.7	9.6	7.5	9.6	Not heavily beaded
8A-3	1.675	19	79	19.0	14.6	14.6	9.0	11.0	8.5	10.1	8.5	11.5	Adequately beaded(coarse)
8A-4	1.720	17	82	18.2	14.0	14.0	10.2	8.0	9.6	8.5	9.0	10.8	Adequately beaded(coarse)
8A-5	1.665	21	80	15.4	13.5	13.5	22.2	13.8	17.4	17.4	23.7	15.6	Adequately beaded (med.)
9A	1.680	15	72	19.5	14.1	14.1	9.6	5.3	7.5	5.5	7.5	6.5	Hard to mix - fine beads
10A	1.815	29	84	20.0	13.5	13.5	12.2	5.8	7.9	5.5	8.0	6.0	Beads too coarse
11A	1.615	26	52	27.8	13.4	13.4	9.6	9.0	9.3	9.0	9.6	11.5	Very thin - few beads
Type II - Yellow ReflectORIZED, Pre-Mixed													
1B	1.610	11	50	19.5	14.3	14.3	11.5	9.6	10.1	13.8	12.2	9.6	Abundantly beaded
2B	1.440	14	50	17.3	14.3	14.3	6.5	6.0	8.0	7.0	9.0	8.0	Abundantly beaded
3B-1	1.605	40	84	20.5	8.9	8.9	10.2	9.1	6.8	7.5	6.5	8.5	Abundantly beaded
3B-2	1.620	15	86	17.4	10.0	10.0	8.5	4.4	5.8	6.7	4.2	6.0	Not sprayable, beads-abundt.
3B-3	1.625	15	89	14.2	14.8	14.8	5.5	9.1	3.8	6.8	4.8	6.0	Not sprayable, beads-abundt.
3B-4	1.725		88		14.2	14.2	7.5	5.2	4.6	4.4	6.0	6.0	
3B-5	1.625	42	78	16.7	13.3	13.3	6.5	9.6	7.5	8.5	7.5	8.0	Adequately beaded
4B-1	1.630	20	63	17.3	14.3	14.3	5.5	11.5	5.5	9.6	5.5	8.0	Heavily beaded
4B-2	1.615	17	64	18.7	13.9	13.9	8.0	9.1	7.0	8.0	6.5	6.0	Adequately beaded
6B	1.510	48	63	18.3	12.9	12.9	9.6	9.1	7.0	7.3	8.0	8.0	Not heavily beaded
7B	1.760	25	79	15.5	12.9	12.9	6.0	6.0	5.5	5.3	5.5	6.0	Adequately beaded
8B-1	1.610	30	86	17.5	13.1	13.1	7.5	6.5	6.0	5.1	8.0	5.5	Adequately beaded
8B-2	1.670	15	85	18.8	14.7	14.7	12.2	6.8	8.5	6.8	8.5	7.5	Large beads - adequate
8B-3	1.675	11	90	16.7	13.7	13.7	8.2	9.6	9.0	8.5	9.6	8.5	Large beads - not heavy
8B-4	1.725	20	89	30.0	14.8	14.8	5.5	7.0	5.5	5.5	5.3	6.5	Adequately beaded
8B-5	1.690	28	77	18.7	13.4	13.4	9.6	12.2	9.0	7.8	10.2	8.0	Hard to mix, heavily beaded
9B	1.820	20	93	15.4	15.4	15.4	5.5	5.2	5.5	5.5	5.5	7.0	Superfine beads, (abundant) Very hard to mix - not sprayable.
10B	1.830	18	94	14.3	14.3	14.3	9.6	8.5	6.0	6.0	7.5	4.6	Hard to mix, beads too big
11B	1.615	25	59	21.4	21.4	21.4	7.5	9.3	8.5	10.1	7.5	9.6	Thin-not heavily beaded - Adequate
Type III - White Non-ReflectORIZED													
1E	1.200	25	62	30.0	13.7	13.7	5.7	3.4	4.4	3.8	5.0	5.0	
2E	1.290	26	63	30.2	14.8	14.8	5.0	4.2	5.0	3.4	5.5	3.8	
5E	1.535	23	96	7.6	14.4	14.4	6.0	2.3	4.9	2.2	2.4	2.2	
6E	1.580	15	75	25.4	14.7	14.7	3.3	4.2	3.0	3.6	3.6	4.2	
8E-1	1.510	18	76	16.3	15.1	15.1	3.0	4.2	4.0	5.3	5.0	3.6	
8E-2	1.735	9	75	15.7	15.1	15.1	4.1	4.6	3.3	4.2	4.2	4.6	Contains sandy filler
9E	1.090	6	68	33.3	15.3	15.3	3.8	3.0	1.6	3.0	-	2.9	Not thinnable with gasoline
10E	1.575	26	73	24.1	14.9	14.9	3.8	4.4	4.0	4.1	4.1	4.0	Had to be strained (lumpy)
11E	1.545	16	69	18.7	13.7	13.7	4.3	3.8	3.0	4.0	4.1	5.5	Stringy & lumpy
Type IV - White ReflectORIZED, Beads On													
1C	1.230	27	52	16.3	14.0	14.0	4.6	8.5	3.8	4.3	3.6	5.5	
2C	1.275	22	56	20.0	19.8	19.8	7.0	5.5	5.5	7.1	6.5	5.5	
3C-1	1.400	29	52	26.8	18.0	18.0	17.4	3.8	22.2	4.9	20.8	4.6	
3C-2	1.370	28	72	25.5	18.4	18.4	5.8	6.0	22.2	8.5	17.6	8.0	
3C-3	1.465	28	68	19.3	18.1	18.1	17.4	3.8	23.7	4.2	19.2	5.0	
5C	1.825	over 2 hours	100	16.0	16.8	16.8	28.0	12.2	20.7	19.2	22.2	22.2	Slow drying - high viscosity
6C	1.510	47	Thin	31.4	14.4	14.4	4.1	4.4	3.8	4.0	3.8	4.6	No beads furnished-verythin
7C	1.600	33	83	19.2	13.3	13.3	3.3	3.3	3.0	4.0	3.8	5.0	No beads furnished
8C-1	1.385	16	72	34.3	18.2	18.2	18.8	10.2	22.2	9.6	25.2	9.0	
8C-2	1.460	13	68	15.9	18.2	18.2	22.7	18.0	25.2	13.8	23.7	10.8	
8C-3	1.510	22	59	27.6	18.5	18.5	18.3	7.5	23.7	8.0	22.2	6.5	
9C	1.455	11	74	45.2	18.3	18.3	16.6	6.7	15.6	6.2	10.2	5.0	
11C	1.360	24	68	30.0	18.5	18.5	20.7	19.2	22.2	19.2	22.2	12.2	
Type V - Yellow ReflectORIZED, Beads On													
1D	1.265	19	Thin	25.0	14.1	14.1	13.8	19.2	13.7	10.8	27.0	10.1	Very thin
2D	1.240	23	Thin	20.0	13.5	13.5	10.8	11.5	19.2	4.6	8.5	5.0	Very thin
3D-1	1.505	10	73	20.8	13.2	13.2	15.6	35.2	12.2	30.3	11.5	17.4	
3D-2	1.435	28	93	22.0	14.5	14.5	19.2	23.7	17.4	25.3	17.4	20.8	
5D	1.575	17	77	21.6	13.2	13.2	17.4	19.2	12.2	8.0	15.6	7.0	
6D	1.420	27	56	22.4	14.0	14.0	4.6	2.2	3.4	2.2	3.4	2.4	No beads furnished
7D	1.675	21	94	20.0	14.6	14.6	4.4	2.5	2.7	2.4	2.4	2.7	No beads furnished
8D-1	1.510	28	76	20.5	13.5	13.5	8.0	3.4	13.0	3.5	11.5	3.8	O.K.
8D-2	1.420	25	77	25.0	14.0	14.0	8.0	11.0	9.6	8.0	10.8	7.5	O.K.
9D	1.505	25	75	21.4	13.5	13.5	25.3	27.0	20.7	13.8	25.2	19.2	O.K.
11D	1.385	37	74	20.0	15.1	15.1	19.9	35.2	22.2	30.3	25.2	30.5	O.K.

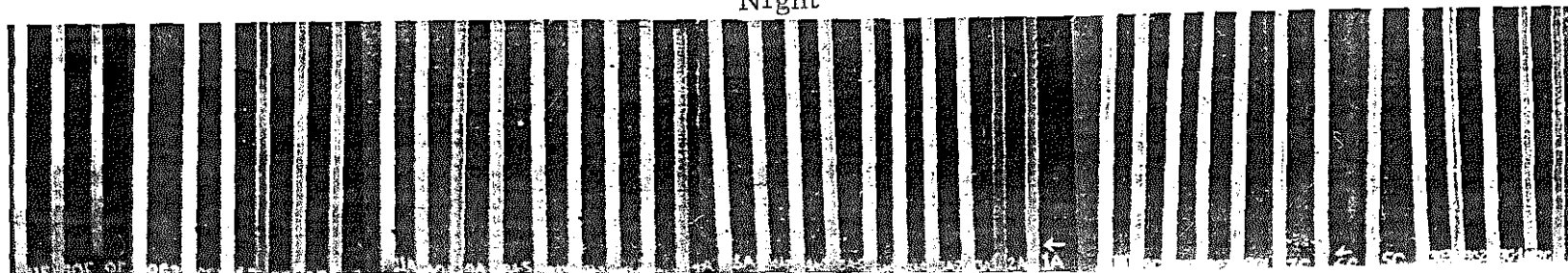
Night



Day



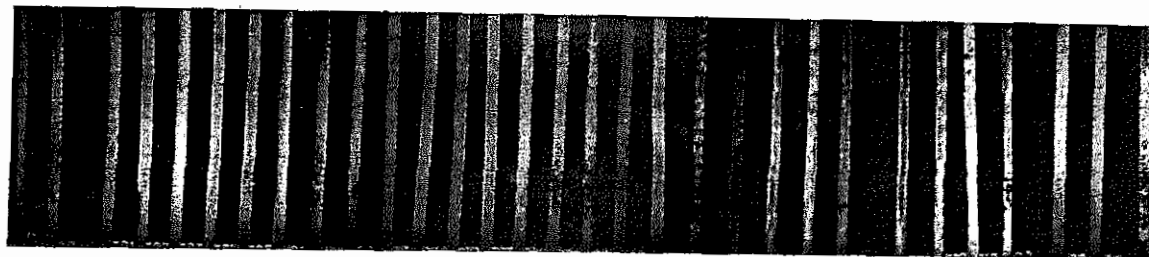
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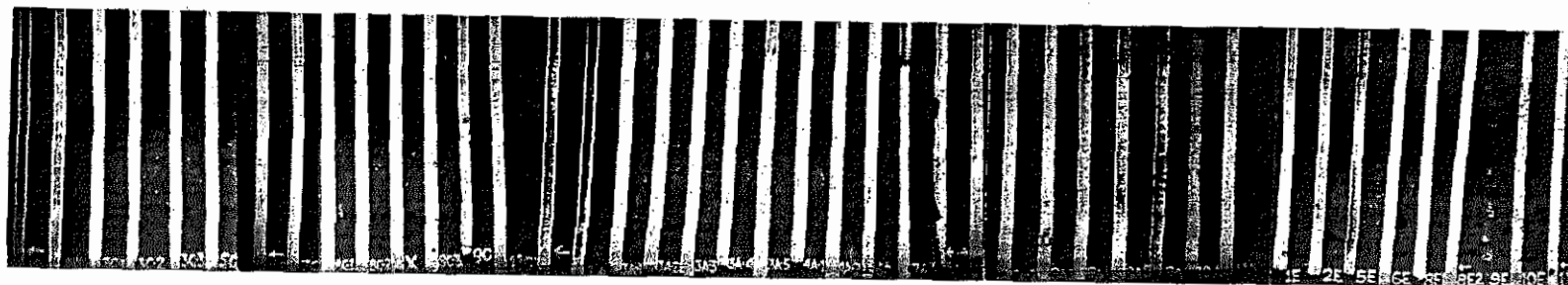
Day

Strip Photograph of 1953 Paint Stripes on Asphalt Pavement

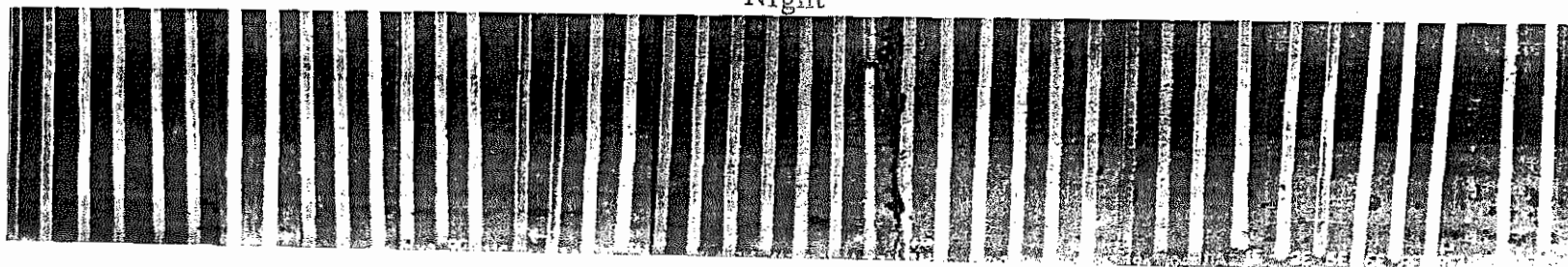
Night



Day



Night



Day

Strip Photograph of 1953 Paint Stripes on Concrete Pavement

APPEARANCE AND DURABILITY RATINGS, JANUARY 8, 1954

Stripe No.	Concrete		Bituminous		Final	Stripe No.	Concrete		Bituminous		Final
	Day	Night	Day	Night	Average		Day	Night	Day	Night	Average
<u>White Premixed</u>											
1A	18	18	18	16	17.5	11B	5	10	2	7	6
2A	19	19	19	18	18.6	<u>White Non-Reflectorized - Quick Drying</u>					
3A-1	6	4	4	10	6	1E	5	5	6	6	5.5
3A-2	1	1	2	4	2	2E	6	4	7	7	6
3A-3	2	2	1	5	2.5	5E	8	8	9	9	8.5
3A-4	9	3	3	9	6	6E	3	3	4	4	3.5
3A-5	15	8	15	15	13.3	8E-1	1	1	1	3	1.5
4A-1	8	7	9	8	8	8E-2	2	2	2	1	1.8
4A-2	7	5	10	9	7.8	9E	9	9	8	8	8.5
6A	11	6	5	3	6.3	10E	7	7	5	5	6
7A	12	14	17	14	14.3	11E	4	6	3	2	3.8
8A-1	3	13	14	7	9.3	<u>White - Beads on Type</u>					
8A-2	4	9	11	2	6.5	1C	11	11	11	9	10.5
8A-3	5	10	7	6	7	2C	10	10	10	8	9.5
8A-4	10	11	8	12	10.3	3C-1	-	5	1	1	2.3
8A-5	16	16	12	13	14.3	3C-2	-	6	9	7	7.3
9A	17	17	16	19	17.3	3C-3	-	7	8	3	6
10A	14	15	13	17	14.8	5-C	-	4	7	6	5.7
11A	13	12	6	1	8	6C	No Beads Furnished				
<u>Yellow Premixed</u>						7C	No Beads Furnished				
1B	8	16	12	1	9.3	8C-1	-	1	3	5	3
2B	15	14	17	13	14.8	8C-2	-	2	6	2	3.3
3B-1	14	8	16	14	13	8C-3	-	3	2	4	3
3B-2	3	2	18	15	9.5	9-C	-	9	4	10	7.7
3B-3	1	1	1	3	1.5	11C	-	8	5	11	8
3B-4	2	3	5	2	3	<u>Yellow - Beads on Type</u>					
3B-5	10	6	6	4	6.5	1D	7	5	2	7	5.3
4B-1	9	7	4	6	6.5	2D	9	9	9	8	8.8
4B-2	16	15	7	8	11.5	3D-1	4	3	5	4	4
6B	12	16	3	9	10	3D-2	6	2	6	5	4.8
7B	7	13	8	18	11.5	5D	3	6	3	6	4.5
8B-1	6	11	9	10	9	6D	No Beads Furnished				
8B-2	13	12	13	16	13.5	7D	No Beads Furnished				
8B-3	11	8	15	11	11.3	8D-1	2	4	4	6	4
8B-4	4	9	14	12	9.8	8D-2	1	7	1	2	2.8
8B-5	17	18	12	9	14	9D	8	8	7	3	6.5
9B	19	19	19	19	19	11D	5	1	8	1	3.3
10B	18	17	11	17	15.8						

RATING SUMMARY

On the basis of appearance and durability averaged from four conditions including day and night-time appearance on concrete and bituminous pavements, those samples rating highest in overall performance and judged to be of acceptable quality are tabulated below for each type of paint:

Type I: White, Pre-Mixed

- | | |
|---------|---------|
| 1. 3A-2 | 5. 6A |
| 2. 3A-3 | 6. 8A-2 |
| 3. 3A-1 | 7. 8A-3 |
| 4. 3A-4 | 8. 4A-2 |
| | 9. 4A-1 |

Note: Sample 11A rated equal to 4A-1 in appearance and durability, but was judged too thin for spray application.

Type II: Yellow, Premixed

1. 3B-3
2. 3B-4
3. 4B-1
4. 8B-1
5. 1B

Note 1: Sample 3B-5 was rated equal to 3B-4 in appearance and durability but was eliminated because of its long drying time.

Note 2: Sample 11B was rated slightly higher than 3B-4 in appearance and durability, but was eliminated because of low consistency. The most desirable range for consistency is believed to be in the range of about 65 to 85 K.U. although the extreme limits may depend upon other characteristics of a particular sample.

Note 3: Sample 1B had a lower consistency (50 K.U.) than 11B, above, but the striper operator did not judge it to be too thin for spray application. Since it was possible to apply the sample at the desired rate, it is considered as acceptable material.

Type III: Quick-Drying, White, Non-Reflectorized

Only samples 8E-2 and 9E of those submitted under this type have drying times that would qualify them as quick-drying paints. Of these two only 8E-2 has a high durability and appearance rating. It is noted, however, that samples 4A-2 and 8A-2 in Type I have comparably fast drying times to qualify for this type. Samples 4A-2 and 8A-2 have the additional advantage of reflectorization. Therefore, the samples listed below are considered acceptable as Type III:

1. 8A-2
2. 4A-2
3. 8E-2

Type IV: White, B.O.P.

1. 3C-1
2. 8C-1
3. 8C-3
4. 8C-2

Type V: Yellow, B.O.P.

1. 8D-2
2. 11D
3. 8D-1
4. 3D-1

QUICK DRYING PAINTS

The nine samples listed under Type III represent commercial offerings of so-called "quick drying" paints as requested by the Division of Traffic for use in urban areas for delineating cross-walks and parking lanes. The quick-drying feature sought by the Traffic Division would make it possible to paint those lines more frequently and without delaying traffic. Ordinarily, the "track-free" drying time for the paints customarily used in these places is about 45 minutes and traffic must either be diverted or funneled to one side while the other side dries.

A lacquer-base non-reflectorized paint of the quick-drying type was reported last year (See stripes No. 13 and No. 25, page 3), and the Division of Traffic requested that a specification be developed as a basis for procuring this type of material (same material was reportedly used in the city of Louisville). However, a general formulation - type specification could not be drawn up and validated because of diverse complexities in the cellulose derivatives and solvents. The possibility, of course, is continuing under consideration.

The particular advantage of the lacquer-type paints lies in the fact that the drying time is dependent only on the rate of solvent evaporation and not upon the slow reactions that characterize drying oils. A particular disadvantage lies in the fact that they are not soluble in gasoline, and special solvents are required for thinning and for cleaning equipment. They seem to dry too quickly to retain reflectorizing glass beads applied by the drop-on method, and the

premixed beads tend to clog the spray nozzle. - It would, of course, be highly desirable to retain the reflectorization feature in the quick-drying paints.

Of the nine samples submitted this year under the quick-drying category, only samples 8E-2 and 9E are actually quick drying. Sample 9E is probably of the lacquer type because it was not thinnable with gasoline. Samples 2A, 3A-4, 3A-5, 4A-2, and 8A-2 under Type I have equally short-drying times.

RECOMMENDATIONS FOR FUTURE WORK

Future invitations to submit samples should require that all samples be accompanied by the manufacturer's formulation plainly stating the type and quantity of pigment and pigment extenders, the type and quantity of vehicle, protective agents and solvents. In the cases of reflectorization with glass beads, the manufacturer should be required to state the size-gradation and the refractive index of the glass beads and also the quantity supplied per gallon (applies to both the pre-mixed and beads-on-paint types). Samples failing to comply with this request must be accompanied by a statement justifying the sample as being highly proprietary in composition. Otherwise, the Department of Highways will not be obligated to include the sample in the tests.

The intent here is to permit the Department to accumulate comparative historical data on the performance of various types of paint formulations and to screen out those types and formulations proven to be undesirable. This provision would eliminate the need for annual testing of those undesirable paints every year, and it would gradually raise the quality level of the samples submitted for the competition. It would eventually develop significant trends as to the general formulation types offering the best performance and economic advantages.

When invitations for samples are sent to prospective suppliers, each should be limited to not more than three samples for any general type. This should encourage them to select materials known to be high in

quality and merit for the competition. The sample invitations should be further restricted to only those general types which the Division of Traffic intends to purchase during the following year. Thus, if the Division of Traffic is interested only in premixed reflectorized paint and perhaps truly quick-drying paint, samples of non-reflectorized paint or paint reflectorized with beads applied on the surface should not be accepted for test purposes.

It is further recommended that service tests for next year include the revised specification material (dispersion resin vehicle and titanium pigment) which was suggested in the Research Laboratory report on paints tested in 1952*. The use of these materials (yellow and white) as reference standards should provide a sound basis for judging the comparative success or failure of this performance procurement program from year to year.

* Samples of specification paints may possibly be obtained from the Missouri and Illinois Highway Departments.

APPENDIX

January 7, 1953

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M E M O R A N D U M

TO: W. P. Ringo, Director
Division of Traffic
Department of Highways

SUBJECT: Method of Purchase for Reflectorized Traffic Paint

Confirming our recent discussion concerning the purchase of Reflectorized Traffic Paint, the following resume is intended to record the various points mutually agreed upon:

1. Since no adequate specification covering Reflectorized Traffic Paint has been promulgated, it is our decision to continue our present method of testing samples on performance bases until such time as a better system is devised or else until a good specification becomes available to us.
2. The Division of Purchases is charged with the responsibility of (a) requesting free samples from prospective bidders; (b) receiving samples and forwarding same to the Department of Highways Materials and Research Laboratory; and (c) advertising for bids your annual requirements of paint upon receipt of test results and your Purchase Requisition.
3. On or about the first of each year (including this year) the Division of Purchases will advise all prospective bidders to submit free samples for test purposes to be received at the Office of the Division of Purchases no later than a specified date (approximately March 1). All manufacturer's identification will be removed from each sample before forwarding sample to the Testing Laboratory. Each sample will, of course, be identified by some marking, the code to which will be available only to the Division of Purchases. This step will be taken merely to assure all suppliers of samples that all tests will be conducted without the knowledge of manufacturer's identification.
4. Since all samples will have been delivered to the Testing Laboratory prior to April 1, it is reasonable to assume that test results can be reported on or before October 1, at which time the Division of Traffic will be advised of test results.

Page 2

Memorandum to W. P. Ringo, Director of Traffic
January 7, 1953

5. At any time subsequent to the date test reports are received, the Division of Traffic will be able to submit a Purchase Requisition announcing the yearly requirements for Reflectorized Paint. If this proposed schedule is closely followed, it is a certainty that a contract can be placed with the successful bidder prior to the beginning of a new year.

The Division of Purchases is presently awaiting your advice indicating the types of paint samples you desire to have tested before our letter is prepared and mailed to all prospective suppliers. It is also requested you indicate the names of those firms who have participated in previous tests, as well as the names of firms who have expressed an interest in having their paint tested during the preceding year.

If in your opinion any of the above statements are inaccurate as related to our discussion, or if information covered is incomplete, please advise in order that proper corrections can be made.

/s/
C. A. Byrley
Assistant Director

CAB:at

cc: L. E. Gregg, Assistant Director of
Research Materials, Research Laboratory

B. H. Lowry, Director, Division of Purchases

J. R. Haselden, Assistant Director

George W. Sudduth, Buyer

Commonwealth of Kentucky

C
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DIVISION OF PURCHASES
Department of Finance
Frankfort, Kentucky

March 19, 1953

Mr. L. E. Gregg
Assistant Director of Research Materials
Research Laboratory
University of Kentucky
Lexington, Kentucky

Dear Mr. Gregg:

Traffic Paint Samples for the 1953 testing program are being forwarded to you today by Department of Highway truck delivery. A total of eighty-nine (89) separate containers or individual packages have been submitted by various Manufacturers and Distributors and have been included in today's delivery to you. Individual samples by type and code number have been identified by crayon markings in the following manner:

Type 1 - (White Reflectorized Traffic Paint - Premixed)

Sample Numbers: 1A, 2A, 3A-1, 3A-2, 3A-3, 3A-4, 3A-5,
4A-1, 4A-2, 6A, 7A, 8A-1, 8A-2, 8A-3,
8A-4, 8A-5, 9A, 10A, and 11A.

Type 2 - (Yellow Reflectorized Traffic Paint - Premixed)

Sample Numbers: 1B, 2B, 3B-1, 3B-2, 3B-3, 3B-4, 3B-5,
4B-1, 4B-2, 6B, 7B, 8B-1, 8B-2, 8B-3,
8B-4, 8B-5, 9B, 10B, and 11B.

Type 3 - (White Non-Reflectorized Traffic Paint - Quick Drying)

Sample Numbers: 1E, 2E, 5E, 6E, 8E-1, 9E, 10E, and 11E.

Type 4 - (White Reflectorized Traffic Binder or Adhesive - Beads
on type)

Sample Numbers: 1C, 2C, 3C-1, 3C-2, 3C-3, 5C, 6C, 7C,
8C-1, 8C-2, 8C-3, 9C, and 11C.

Type 5 - (Yellow Reflectorized Traffic Binder or Adhesive - Beads
on type)

Sample Numbers: 1D, 2D, 3D-1, 3D-2, 5D, 6D, 7D, 8D-1, 8D-2,
9D, and 11D.

Glass Beads for Types 4 and 5 (White and Yellow Traffic Binders)
Sample Numbers:

- 1F (Glass Beads for Samples 1C and 1D)
- 2F (Glass Beads for Samples 2C and 2D - Beads packaged in two (2)
Cloth Sacks containing 6 lbs. each)
- 3F (Glass Beads for Sample 3C-1)
- 3G (Glass Beads for Sample 3D-1)
- 3H (Glass Beads for Sample 3C-2)

L. E. Gregg

-2-

March 19, 1953

3I (Glass Beads for Sample 3C-3)
3J (Glass Beads for Sample 3D-2)
5F (Glass Beads for Samples 5C and 5D)
8F (Glass Beads for Sample 8C-1)
8G (Glass Beads for Sample 8C-2)
8H (Glass Beads for Sample 8C-3)
8I (Glass Beads for Sample 8D-1)
8J (Glass Beads for Sample 8D-2)
9F (Glass Beads for Sample 9-C)
9G (Glass Beads for Sample 9-D)
11F (Glass Beads for Sample 11-C)
11G (Glass Beads for Sample 11-D)

Please note that no glass beads were furnished for use in conjunction with Samples 6C, 6^D, 7C, and 7D.

A majority of the Manufacturers have failed to offer pertinent information regarding their samples submitted such as types of paint, basic formulae, et cetera. All information available to the Division of Purchases pertaining to various samples submitted is contained in the attached statement. Should it become necessary to obtain additional information regarding any sample submitted, please direct such requests for information to this Division.

Upon completion of tests it is requested that your report, Evaluation of Traffic Paints Tested in 1953, be made directly to the Division of Purchases. If tests can be concluded and evaluations made in November or early December, the 1954 total requirements can be advertised and purchased prior to the time many other principal buyers enter the market for their annual traffic paint requirements. Early seasonal buying should offer delivery advantages and possible price advantages. Your splendid cooperation in this Traffic Paint Testing program is appreciated.

Very truly yours,

B. H. Lowry, Director
Division of Purchases
S/
C. A. Byrley
Assistant Director

CAB:at

cc: B. H. Lowry, Director
W. P. Ringo, Director of Traffic
George W. Sudduth, Buyer

Encl.

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AVAILABLE INFORMATION ON TRAFFIC PAINT SAMPLES SUBMITTED

Samples: 10A, 10B, 10E
Vehicle alkyd type
Non-Volatite - Approx. 24%
Pigment:
White - Zinc Sulphate Type with Mag. Silicate
Yellow - Lead Chromate and Zinc Sulphate
Mag. Silicate and Calcium Carbonate
P.V.C. 61%

Sample: 11A
Pigment 62% by weight consisting of:
Rutile TiO₂ 9% by wt.
Rutile Titanium Calcium 23 by wt.
MgSiO₃; CaCO₃; SiO₂ pigments 22 by wt.
"b" Glass Beads 46 by wt.
Vehicle 38% by weight consisting of:
Alkyd Resin (SBO type)
(no rosin) 28.5% PA 3.95% by wt.
Suspending, wetting,
anti-skin agents 4.0
Naphtha & Min. Spts. 56.5
Viscosity - 72 KU; @ 77°F.
Wt / gal - 12.5# min.

Note - normal percentages of tolerance or deviation
from above would be experienced in production.

Sample: 11B
Pigment 62% by weight consisting of:
Medium Chrome Yellow 22% by wt.
Rutile Titanium Calcium 10 by wt.
MgSiO₃; CaCO₃; SiO₂ pigments 22 by wt.
"B" Glass Beads 46 by wt.
Vehicle 38% by weight consisting of:
Alkyd Resin (SBO type)
(no rosin) 28.5% PA 39.5% by wt.
Suspending, wetting
anti-skin agents 4.0
Naphtha & Min. Spts. 56.5
Viscosity - 72 KU @ 77°F
Wt / gal. - 12.8 min.

Note: - normal percentages of tolerance or deviation
from above would be experienced in production.

Sample: 11C
Pigment 48% by weight consisting of:
Rutile TiO₂ 17.5% by wt.
Rutile Titanium Calcium 44.0 by wt.
MgSiO₃; SiO₂ pigments 38.5 by wt.

Sample: 11C (Continued)
Vehicle 52% by weight consisting of:
Alkyd Resin (SBO Type) 42.0% by wt.
(no rosin) 28.5% PA
Suspending, wetting,
anti-skin, driers 3.0 by wt.
Naphtha & Min. Spts. 55.0 by wt.
Viscosity - 72 KU @ 77° F.
Wt / gal - 11.1# Min.

Note: normal percentages of tolerance or deviation from above would be experienced in production

Sample 11D
Pigment 48.5% by weight consisting of:
Medium Chrome Yellow 41.5% by wt.
Rutile Titanium Calcium 20.0 by wt.
MgSiO₃; SiO₂ pigments 38.5 by wt.
Vehicle 51.5% by weight consisting of:
Alkyd Resin (SBO type) 42.0% by wt.
(no rosin) 28.5% PA
Suspending, wetting,
anti-skin, driers 3.0% by wt.
Naphtha & Min. Spts. 55.0 by wt.
Viscosity - 72 KU @ 77° F.
Wt / gal - 11.4# min.

Note: normal percentages of tolerance or deviation from above would be experienced in production.

Sample: 11E
Pigment 60% by weight consisting of:
Rutile Titanium Calcium 47% by wt.
Zinc Oxide 6 by wt.
MgSiO₃; CaCO₃; SiO₂ pgmts. 47 by wt.
Vehicle 40% by weight consisting of:
Alkyd Resin (SBO type) 39.0
(no rosin) 28.5% PA
Suspending, wetting,
anti-skin agents 2.5
Naphtha & Min. Spts. 58.5
Viscosity - 71 KU @ 77F.
Wt / gal - 12.5# min.

Note: normal percentages of tolerance or deviation from above would be experienced in production.

Sample: 7A
Pigment 71.5%
Vehicle 28.5%

Composition of Pigment:
Titanium Dioxide 7.1
Zinc Oxide 5.7
Lithopone 14.0
Magnesium Silicate 27.4
Glass Beads 38.6
Pumic 7.2
100.0%

Sample: 7A (Continued)

Composition of Vehicle:

Vegetable Oil Alkyd Resin Solids	41.0%
Petroleum Thinners & Driers	59.0%
	<u>100.0%</u>

Sample: 7B

Pigment	68%
Vehicle	32%
	<u>100%</u>

Composition of Pigment:

Medium Chrome Yellow	12%
Zinc Oxide	8%
Magnesium Silicate	38%
Glass Beads	42%

Composition of Vehicle:

Vegetable Oil, Alkyd Resin Solids	37.0%
Petroleum Thinners Driers	63.0%

Sample: 7C

Pigment	55.5%
Vehicle	44.5%
	<u>100.0%</u>

Composition of Pigment:

Titanium Dioxide	11.0%
Zinc Oxide	8.8%
Lithopone	22.0%
Magnesium Silicate	58.2%
	<u>100.0%</u>

Composition of Vehicle:

Vegetable Oil Alkyd Resin Solids	39.6%
Petroleum Thinners & Driers	60.4%
	<u>100.0%</u>

Sample: 7D

Pigment	55.5%
Vehicle	44.5%
	<u>100.0%</u>

Composition of Pigment:

Medium Chrome Yellow	15%
Zinc Oxide	15%
Magnesium Silicate	75%
	<u>100%</u>

Composition of Vehicle:

Vegetable Alkyd Resin Solids	39.8%
Petroleum Thinners & Driers	60.2%
	<u>100.0%</u>

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS

Highway Materials Research Laboratory
132 Graham Avenue, Lexington 29, Kentucky

May 27, 1952

D.1.2.
S.3.2.

MEMO TO: W. P. Ringo
Director of Traffic

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

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

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

In his memorandum which is attached, Mr. Havens has outlined some of the considerations that you will want to give to refractive index and to size distribution. He will be glad to discuss this further if you wish, and after you have some beads of different characteristics on hand he would welcome the opportunity of making observations in different places where they are applied in order to give you some specific data on the effects of changes in refractive indices and bead sizes.

W. P. Ringo

- 2 -

May 27, 1952

On the assumption that you will want to bring this up with the Specification Committee eventually, I am taking the liberty of sending to Mr. Oberwarth sufficient copies to take care of all the members of that committee.



L. E. Gregg
Assistant Director of Research

LEG:DDC

Attachment

Copies to: D. H. Bray

Specification Committee Members

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS

Highway Materials Research Laboratory
132 Graham Avenue, Lexington 29, Kentucky

May 27, 1952

D.1.2.

MEMO TO: L. E. Gregg
Assistant Director of Research

SUBJECT: Proposed Special Specification for Reflectorizing Glass Spheres

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

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

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

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

A. **Application by Dropping** - In order to assure firm anchorage in the binder, the diameter of the sphere should not exceed twice the thickness of the paint film. Estimating the average dry-thickness of the paint at 0.015 in., the corresponding maximum size sphere would be about 0.030 in. or equivalent to sizes passing the No. 20 sieve. Also, they should not be smaller than 0.15 in., equivalent to the No. 100 sieve, because of the likelihood of total submersion and its consequences on non-traffic surfaces.

May 27, 1952

The gradation of sizes between these natural limits may be tempered somewhat by the fact that when purchases are to be made by the pound, greater economy may be derived from the selection of smaller spheres. That is, the projected reflecting area covered per pound of glass increases as the diameter of the spheres decreases. If the diameter of the sphere is reduced by one half, it takes eight times as many spheres to equal the same weight.

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

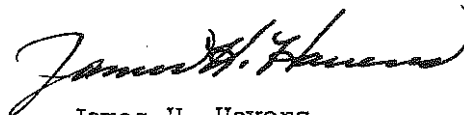
99% - 100% passing the No. 30 sieve
40% - 60% passing the No. 40 sieve
20% - 40% passing the No. 50 sieve
0% - 5% passing the No. 100 sieve

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

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

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

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



James H. Havens
Research Chemist

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS

SPECIAL SPECIFICATION NO. _____

GLASS SPHERES FOR REFLECTORIZING PAINTS
MARKING MATERIALS AND SIGNS

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

1. GENERAL:

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

2. QUALITY REQUIREMENTS:

- A. General - The spheres shall be clean, free of debris, oil, moisture, and dust. They shall flow freely and shall not cake or adhere together after one cycle of wetting and drying.
- B. Color - The glass spheres shall be water-clear and shall not visibly alter the characteristic color of paint-binders or the light reflected therefrom.
- C. Shape and Oddities - The particles shall be spherical in shape and shall not include more than 30% irregular shaped, milky, black, scratched, or frosted particles. Conformance with this requirement shall be determined by microscopic count.
- D. Chemical Stability - The glass shall be resistant to the influence of weather such as moisture, dilute acids, and alkalies. The spheres shall withstand immersion in water, dilute acid, and alkali in accordance with the procedure outlined in paragraph C under Method of Tests.

- E. Resistance to Crushing - The glass spheres shall be hard and resistant to crushing in accordance with paragraph F under Methods of Test.

3. SAMPLING:

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

4. METHODS OF TEST:

- A. Color - Color shall be determined visually under daylight-type lamps or sunlight. A bulk sample observed in a white cloth or paper bag, or other uncolored container, shall appear white.
- B. Shape and Oddities - A representative portion of the sample shall be dusted onto the adhesive side of a strip of adhesive-coated transparent tape (Scotch Tape) which may be secured to a glass plate by additional pieces of tape at each end. The mounted specimen shall be observed with the aid of a microscope of suitable magnification and 100 adjacent particles observed for oddities.

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

- C. Chemical Stability - A 10-gram portion of the sample shall be placed in each of three beakers and covered with 100 ml. of 1 N sulfuric acid, 1 N sodium hydroxide, and 100 ml. of water, respectively. They shall be allowed to stand undisturbed for 24 hours. The spheres shall then be washed six times by decantation using either distilled or tap water, and dried. The contents of each beaker shall then be observed microscopically for evidence of etching or dissolution. In no case shall the particles show etching or frosting nor shall they adhere together after washing and drying.
- D. Refractive Index - Refractive index tests shall be performed on such portions of the sample as may be applicable under the requirements set forth in the invitations for bids (Part 1, GENERAL). The tests shall be made by comparing the refractivity of the sample with standard refractive-index liquids in accordance with recognized immersion-method procedures (as applied to chemical microscopy and optical mineralogy).

E. Size Distribution, or Gradation - A 1000-gram sample shall be thoroughly shaken in a nest of U.S. Standard Sieves which shall include only those sieves corresponding to the size requirements set forth in the invitations for bids. (Part 1, GENERAL). The quantity retained on each sieve shall be weighed and expressed as percentage by weight of the total sample.

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

F. Resistance to Crushing - Crushing-strength tests shall be made only on those size-fractions as shall be applicable under the size requirements set forth in the invitations for bids (Para. 1, GENERAL) and as retained upon the corresponding sieves required under Para. E.

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

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

<u>No. of Sieve</u>	<u>Minimum Crushing Strength</u>
30	30 lbs.
40	20 lbs.
50	14 lbs.
60	8 lbs.
70	4 lbs.

5. PACKAGING:

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