REPORT OF COMMITTEE ON TRAFFIC ZONE PAINT

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ACCELERATED TESTING OF TRAFFIC ZONE PAINTS

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SYNOPSIS

The effort to correlate laboratory tests of traffic zone marking paints with practical road service tests has been continued

Ten white paints differing widely in durability characteristics were applied on nine roads in New Jersey, New York and Pennsylvania They were observed throughout their life and graded by several observers. Observations were made over 15 to 18-month periods

The same paints were submitted to seven cooperators for tests, with particular emphasis on the use of abrasion tests and overall ratings, using a variety of laboratory testing methods.

Generally satisfactory reproducibility was obtained in the road service tests One of the abrasion testing methods showed fair correlation with the service tests and warrants further investigation The abrasion testing method previously thought to be of interest showed less satisfactory correlation in this series of tests than in the series of tests reported on by the committee in 1941.

Two cooperators rated the durability of these paints fairly well, using testing methods based on weightings of abrasion, adhesion and flexibility measurements.

It was surprising to note that exposures of these ten paints to the weather on concrete and under circumstances where practically no wear due to traffic was involved resulted in evaluation of the paints in approximately the same order as road service tests Need for further study of accelerated weathering tests as applied to traffic zone marking paints is indicated.

The work described in this report[1] is a continuation of that described at the Twenty-First Annual Meeting (December, 1941) of the Highway Research Board (1).[2]

The purpose of the investigation has remained the same; namely, to determine the practical value of laboratory tests to evaluate the road durability of traffic paints under service conditions. By "road durability" is meant the resistance to wear by a combination of traffic and weather conditions

In the previously reported work, nine paints were evaluated by laboratory test methods by six cooperators and tested for road durability on twelve roads differing in type, amount of traffic carried, and in location

The conclusions drawn at that time were that the most accurate method of testing the paints was by road exposure tests, and that the type of laboratory abrasion test used by cooperator M gave more reliable indications of road durability than the other testing methods used, although there were indications that this method would require some modification to make it more reliable, especially when testing paints which do not differ as much in durability characteristics as the paints investigated.

In the present investigation, ten paints were selected to show widely varying durability characteristics A single large batch of each paint was prepared. Samples were distributed among seven cooperators, who made laboratory evaluations of the paints

The paints were then applied on nine roads in New Jersey, New York and Pennsylvania. The roads differed widely in type of surface

[1] See Appendix for code correlating this report with that presented at the Twenty-second Annual Meeting.

[2] Numbers in parentheses refer to the list of references at the end of the report.

and traffic carried. All applications except one (Rd. No. 9) were made by the same operators, using the lineograph machine. The applications on Road No. 9 were made by hand brushing. All paints were applied perpendicular to traffic. On one road the paints were also applied parallel to traffic on the extreme right of a two-lane road where they were subjected to almost no traffic. The object was to determine the effect of weather alone on the durability of the paints.

All paints were applied between May 20 and June 25, 1942, under good weather conditions.

on the sections of the lines which were subjected to abrasion by traffic. There is some difference of opinion as to whether this emphasis is justified and whether it is not more advisable to consider the whole line, or even to place greater weight on that portion of the line least exposed to traffic wear. However, even if the latter were done, major change in the ratings of the paints would not have resulted.

DISCUSSION OF RESULTS

Data on applications and results of road tests are given in Table 1.

TABLE 1
DATA ON ROAD TESTS WITH TRAFFIC ZONE PAINTS

Road No	Location of Road	Type of Road	Traffic Count	Spreading Rate[a]	Evaluation of durability of paints from road test results (Best to Poorest)[b]
1	Long Beach, N. Y.	Concrete	Medium	10	F Bvs Cvs H Jvs Kvs E A Dvs G
2	Rt. 309, Palmerton, Pa.	Concrete	High	10	B F C J K Hs A Es Dd Gs
3	Rt. 1, Newark, N. J.	Concrete	V. High	10	B Hvs C Fvs Jvs K E As Dd Gvs
4	Rt. 29, Scotch Plains, N J.	Concrete	Medium	10	F B C Jvs H Kvs As Es Gd D
5	Rt 828, Highland Park, N J	Concrete	Low	19	B F Cvs Jd Hs Ad K Ed Ds Gd
6	Rt. 28, Bound Brook, N. J.	Sheet Asphalt	Medium	12	C Bvs F J Hvs Ks Es As Ds Gd
7	Rt 2R6, Metuchen, N J.	Tar	Low	25	B C[c] J F H[c] Ks E A Dd G
8	Park Ave , N. Y. C.	Sheet Asphalt	V. High	23	B Cvs F J Hs D Ks As Es Gd
9	Troy, N. Y.	Concrete	Medium	15	F B C H A K J E D G
	AVERAGE				B F C J H K E A D G

[a] Spreading rate in gallons per mile for 6" stripe To convert to sq ft. of road covered per gal. of paint, divide 2640 by the spreading rate in gallons per mile.
[b] Paints grouped together were indistinguishable and rated equal for the life of the paints The letters "vs", "s" and "d" after the paint indicate that the differences from the preceding paint are "very slight", "slight", or "definite", respectively
[c] On Road No. 7, the first 5 paints are still in good condition after 15 months, and therefore some differences in final road durability ratings may occur

The performances of the paints on all except No. 9 road were observed and graded by the same persons Inspections were made at least once each month, and photographs were taken frequently so that a record was kept of the performance of each paint on each road throughout the life of the paint At the time of writing this report (Nov. 1943), several paints on one road (No. 7) were still in perfect condition, and could not yet be evaluated. On the other eight roads, however, the effective life of all paints had been completed.

Ratings of the paints on road tests were made on the basis of the proportion of the road area which remained covered by the paint at each inspection. Greater weight was placed

It may be seen from the data in Table 1 that the roads selected varied sufficiently in type of surface and traffic to form a representative group. Location and climate varied widely in the preceding series of tests. In this series, the locations were selected within a restricted area, in order that the majority of the tests could be graded by the same observers.

The traffic was classified as follows:

	Vehicles per Day
Low	1500
Medium	1500–5000
High	5,000–10,000
Very high	10,000

The roads were classified on the basis of traffic conditions as of June, 1942. Most of the

paints had completed their useful life by the end of 1942.

The paints selected showed a wide range of durability. The months required for 50 per cent (visual estimate) of the paint to be worn off the road varied from 2.5 to 5.0 for the poorest and best paints under the most severe conditions, and from 2.0 to 18.0 under less severe conditions.

TABLE 2
RATING OF ROAD DURABILITIES BASED ON TIME TO SHOW 50 PER CENT OF ROAD SURFACE REMAINING COVERED

Paint No.	Road No. 3	4	5	6	8
	Months				
A	3.4	3 4	2 0	6.3	3.2
B	4 2	8 2	8.2	18.0	6 6
C	4.2	8.2	8.2	18.0	6.6
D	2.5	2 7	2 0	5.3	4 8
E	3.8	4 1	2.7	7 4	3 8
F	4 2	8.5	8.2	18.0	6.3
G	3 3	2.9	1.4	2 0	1 2
H	5 0	4.4	7.5	8.5	5 7
J	4.2	8.2	6.2	8.5	5.9
K	3.6	3.7	2.7	7.7	3 2

as shown in Table 2. It is noteworthy that, in the case of the poorest paints (G and D), life varied only 3 months from the fastest to the slowest wearing road, whereas, in the case of the best paints (C, B and F), life varied by 14 months. In other words, the poorer paints are poor due—in considerable part, at least—to deficient weathering resistance, rather than to deficient abrasion resistance.

Generally speaking, the ten paints can be divided into six classes, according to durability, as follows:

1. B, F, C Definitely best, nearly equal and very good
2. J, H Good
3. K Fair
4. E, A Fair
5. D Poor
6. G Very poor

The practical value of a laboratory test would be judged according to the degree of correlation between its evaluation of the paints and the evaluation of the paints by road tests.

TABLE 3
ABRASION TESTS & CORRELATION WITH ROAD TEST DURABILITY
(Best to Poorest)

Cooperator & Rating for Abrasion Resistance														Average Road Durability
N		NJ		M	ND	J		B				Z		
1[a]	2	1	2	3	4	5	6	7	8	9		10		
B	B	B	B	J	E	B	B	B	B	G		B		B
F	F	F	F	B	F	F	F	C	C	H		C		F
J	C	J	J	F	B	J	J	D	D	B		K		C
C	J	C	C	E	J	C	E	H	H	D		F		J
E	E	E	E	C	D	E	H	G	E	F		J		H
H	H	H	H	H	C	H	C	A	G	A		E		K
D	D	A	A	D	H	A	A	K	J	K		A		E
K	K	D	G	K	G	K	G	F	K	E		H		A
A	A	K	K	A	A	G	K	E	A	C		D		D
G	G	G	D	G	K	D	D	J	F	J		G		G

[a] For description of Methods referred to by numbers, see page 272.

The correlation between the various road tests was generally good, although discrepancies are apparent. The abnormally good performance of paint H on Road No 3 (concrete—high traffic count)and of paint D on Road No. 8 (sheet asphalt—high traffic count) may be cited.

In inspecting five of the eight roads, estimates of the amount of surface remaining covered were made. Although the whole history of the life of the paint must be considered in judging its performance, it is of interest to compare the life to 50 per cent wear,

In view of the favorable results from abrasion tests in the previous work, greatest emphasis was placed on tests evaluating this property. Seven of the cooperating laboratories made abrasion tests, using both dry and wet methods, with essentially seven different types of equipment (Table 3). Correlation with the road durabilities were best in the cases of those cooperators using the Dorry Abrasion Test. The types of difficulties encountered in the application of any of these methods are illustrated by comparing the results obtained by cooperators, N, NJ and J,

all employing similar although not identical equipment and methods of testing. Obviously this method, although of considerable promise, would require some further study to allow satisfactory reproducibility.

Although the correlation obtained in these tests between the Dorry Abrasion Test and road durability appears quite promising past experience indicates that it cannot be used alone as a safe measure of road performance (2) The reason is that paints unsatisfactory in adhesion and flexibility may be graded as excellent by this method, but show rapid failure under practical conditions.

The excellent results obtained with the method of test employed by cooperator M in the previous series were not duplicated in these tests. The reason for the difference is not known

TABLE 4
RATING FOR PROBABLE DURABILITY ON BASIS OF SELECTED LABORATORY TESTS
(Best to Poorest)

Cooperator & Rating		Average Road Durability
N	BP	
B	B	B
F	F	F
C	C	C
H	E	J
J	J	H
E	H	K
D	K	E
G	A	A
A	D	D
K	G	G

Two of the cooperators, N and BP, averaged a combination of three laboratory tests which they felt should reproduce road durabilities, and after applying selected weightings, estimated road durabilities. The results (Table 4) show fair correlation with the road exposure durabilities, although the differences between laboratory tests and road tests are still somewhat greater than differences in road tests at various locations

Both of these cooperators employed abrasion resistance, adhesion and flexibility as the essential properties to be considered, weighting these properties as follows:

	N	BP
Abrasion Resistance	40	50
Adhesion	32	30
Flexibility	22	20
Alkali Resistance	6	0

In one case, N, adhesion was rated by conventional mandrel and "finger-nail" tests; in the other, adhesion to glass on outdoor and accelerated weathering was used. The abrasion resistance results of N were used by BP in calculating the weighted averages.

Although it has generally been accepted that resistance to weather influences alone is usually a minor factor in the life of a traffic paint, the data of Table 4 tend to contradict this viewpoint. All ten of these paints were exposed on Road No 4 close to the righthand side of the road in 6-in stripes parallel to traffic. The location was such that little or no traffic would be expected to pass over them Gradings were made, and photographs taken throughout the 14½ months' exposure (Table 5). The order of durability is very similar to that shown by the average road wear tests The possibility of combining weathering and abrasion tests, previously noted by Nelson and Werthan (10) and incorporated in some existent testing methods (7) obviously suggests itself again, and warrants further consideration.

TABLE 5
DURABILITY OF PAINTS
(Best to Poorest)

Weather[a]	Road Average
B	B
C	F
F	C
J	J
H	H
K d	K
E vs	E
A d	A
D s	D
G d	G

[a] Exposed to weather on concrete road without traffic (14½ months' exposure on road No. 4).

TABLE 6
GLASS ADHESION TEST FOR DURABILITY RATINGS
(Best to Poorest)

Glass Adhesion on Exterior Exposure	Glass Adhesion on Accelerated Unit Exposure	Avg Road Durability
B	B	B
C	F	F
F	H	C
A	C	J
K	K	H
J	G	K
E	A	E
H	E	A
G	D	D
D	J	G

Applications of the films on concrete panels should also be advantageous

One of the cooperators, BP, employed a laboratory weathering test This involved preparation of films on glass and exposure to weather, and in an accelerated weathering unit (9)

The results are shown in Table 6

The correlation is obviously poorer than the exposure tests on concrete, due perhaps to the accelerating influence introduced by the poor adhesion to glass

Other data have been obtained on other properties of these paints and are not reported herein, since they do not contribute directly to the main object of this study.[3]

CONCLUSIONS

1. Accelerated road tests (lines perpendicular to travel), under carefully controlled conditions, allow satisfactory estimates of service under practical conditions to be made. In some cases, however, a traffic paint with a particular combination of properties will show unusually good, or bad, performance under specific conditions of road surface, traffic count, or climate.

2. No entirely satisfactory and foolproof laboratory test or series of tests for road durability is indicated by these tests.

3. These data show a surprisingly good degree of correlation between the Dorry Abrasion Test and road durability, but it has been established by practical experience that this test alone will not exclude paints of such poor adhesion and brittleness that excessive chipping will result This test therefore appears inadequate when used alone, but represents the best of the abrasion tests, and is worthy of further investigation

4 In so far as these tests have gone, weathering resistance on concrete shows very good correlation with road durability. Obviously, this is useless as a test for selecting paints, since it requires a longer period for evaluation than road tests. It is of interest, however, to the paint technologist, and indicates that further investigations emphasizing accelerated weathering tests might be justified.

5. Some combination of abrasion, adhesion and flexibility may provide a quick laboratory test. Neither this, nor any laboratory test, however, can be expected to give 100 per cent correlation with road exposures under all conditions Recommendations of detailed testing methods must await further study at some later date

APPENDIX

Code Numbers

The progress report of the committee on traffic zone paint, as published in the Highway Research Abstracts No 98, (1943), used the numerical code employed on the paints sent out to the cooperators In order to improve readability, the alphabetical code employed on the road exposures was used in this report.

Road Letter	Paint No	Road Letter	Paint No
A	2	F	8
B	4	G	9
C	5	H	10
D	6	J	1
E	7	K	3

Code Designations of Organizations Cooperating on Traffic Zone Paint Committee Work

A American Gum Importers Laboratories, Inc. (Mr. Anthony Skett)

B National Bureau of Standards, U. S. Department of Commerce (Mr E F. Hickson)

BP Baltimore Paint & Color Works (Dr L H. Shuger)

C California State Highway Department (Mr. T E. Stanton)

D Pigments Department, E. I du Pont de Nemours & Co , Inc. (Dr. D. H Dawson, Mr M S Herbert and Mr. C. F. Oppermann)

J Joint Highway Research Project, State Highway Commission of Indiana, and Purdue University (Prof. K B Woods)

M Maine State Highway Commission Testing Laboratories and Technology Experiment Station (Prof H Walter Leavitt)

N New York State Highway Department (Mr J. E. Myers)

ND North Dakota State Highway Department (Mr. Keith Boyd)

NJ New Jersey State Highway Department (Mr F. H Baumann)

W Board of Wayne County Road Commissioners (Mr. Warren Worth)

[3] These paints were also used extensively by various groups of Sub-Committee IV, Committee D-1 of the American Society of Testing Materials The paints were furnished by the committee for the development of tests evaluating various properties of traffic zone paints.

Z The New Jersey Zinc Co. (Mr H A. Nelson, Mr S. Werthan and Mr G Ashman)

The cooperation of the New Jersey State Highway Department in making available assistance for application and periodic examinations was particularly helpful.

Abrasion Test Methods

No. 1 (Cooperators N and NJ). Dorry Hardness Machine on dry film (3)

No. 2 (Cooperators N and NJ) Dorry Hardness Machine on wet film (3).

No. 3 (Cooperator M) Paints were applied 0 005 in thick with a doctor blade on a concrete wheel which is revolved and in turn revolves a truck tire which rests on the surface of the paints (4). Paints were kept wet part of the time during the tests.

No 4 (Cooperator ND). Clean Ottawa sand (20–30 mesh) is dropped at an angle of 45 deg on a glass panel on which a 0 010 in. paint film has been placed with a doctor blade Panels are dried 48 hr at room temperature (5).

No. 5 (Cooperator J). Dorry Hardness Machine on dry film (6).

No. 6 (Cooperator J). Dorry Hardness Machine on wet film (6).

No. 7 (Cooperator B). Federal Specification TT-P-115 Method (7), results at 10,000 revolutions.

No. 8 (Cooperator B). Same as Method No 7, except at 20,000 revolutions

No. 9 (Cooperator B). Application of "Taber Abraser," after one month's exposure. Wet film thickness controlled at 0 012 in.

No. 10 (Cooperator Z) (8).

REFERENCES

1 Skett, A , and Herbert, M S , "Accelerated Testing of Traffic Zone Paints," *Proceedings*, Highway Research Board, Vol. 21, p 223 (1941)

2. Myers, J E , N Y State Highway Department—personal communication

3. State of New York Executive Department, Division of Standards and Purchase, Specification for Traffic Zone White, September 1, 1937

4. Sweatt, J. H., "A Machine for Testing the Wearing Qualities of Traffic Paints," Maine Technology Experiment Station, University of Maine, Paper No. 19, 1936.

5. North Dakota State Highway Department Specifications for White Traffic Line Marking Paint (December 12, 1941).

6. Goetz, W. H., "Field and Laboratory Investigation of Traffic Paints," *Proceedings*, Highway Research Board, Vol 21, p. 233 (1941)

7. "Federal Specification for Paint, Traffic, Exterior, White and Yellow," TT-P-115 (April 29, 1942), Paragraph F-2F (2).

8. Werthan, S , "Performance Tests as an Aid in Maintenance of Traffic Paint Quality," Official Digest of Paint and Varnish Products Clubs, No 213, p 75 (1942).

9. National Carbon Co 's Model X-1A For additional discussion of accelerated weathering devices, see Dawson, D. H., and Nutting, R D., *Industrial Engineering Chemistry*, Vol 32, p 112 (1940) and the references therein.

10. Nelson, H A., and Werthan, S , "Traffic Paints," *Industrial Engineering Chemistry*, Vol. 18, p 965 (1926).