8 A Practical Method for Determining the Relative Stability of Fine-Aggregate Asphalt Paving Mixtures, P Hubbard and F C Field Proc American Society for Testing Materials, 1925
9 Researches on Asphalt Paving Mixtures, P Hubbard and F C Field Proc Fourth Annual Paving Conference, Detroit, Michigan, 1925

HIGHWAY TRAFFIC LINE (ZONE) PAINT [1]

SUGGESTIONS CONCERNING PHYSICAL TESTS FOR TRAFFIC PAINTS

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The conditions under which traffic paints are used suggests that the following are the most important factors involved and are those for which laboratory tests of one kind or another are essential in selecting paint for such service

I Consistency (i e, freedom from clogging tendencies when applied by mechanical method)
II Spreading Rate
III Hiding Power (opacity)
IV Drying Time
V Light Resistance
VI Visibility (Day and Night)
VII Durability (Resistance to weather and abrasion)

I. *Consistency*—Where mechanical means are used for application, it is difficult closely to define proper consistency Obviously different types of apparatus will vary in their capacities for handling a wide range of consistencies Proper consistency will, then, have to be largely determined in relation to the peculiarities of the apparatus in question

Unsuitable consistency would probably be evidenced by (1) heavy paint, (2) too thin paint, and (3) presence of coarse material that might clog openings in the apparatus One sample of paint examined which was classified as "unsatisfactory," because it clogs the apparatus, besides being very thick, had a considerable amount of coarse material present (possibly sand), which had separated out Either factor would undoubtedly contribute to bring about trouble in any mechanical apparatus, where the material must flow through a restricted orifice under moderate pressure

The subject of consistency is being studied with the ultimate aim that some laboratory apparatus can be devised to give accurate determinations on suitable consistency required for machine application, giving proper consideration to spreading rate

[1] The Research Division of the New Jersey Zinc Company cooperated in this report and furnished much valuable data

II *Spreading Rate*—Deficiency in spreading rate would be associated with unsatisfactory thin consistency Given openings of a certain size, the paint must not flow too freely unless the speed of the spreading apparatus can be increased proportionately The controlling conditions of the standard spreading apparatus having been determined, the minimum time allowed for flow in the consistency test would determine the minimum spreading rate Then assuming that a film sufficiently opaque to hide is obtained, the paint that gives the slowest uniform flow without clogging the apparatus, will be ideal from the standpoint of spreading rate

A sample examined which was labeled as having unsatisfactory spreading rate, was observed to be of a rather thin, watery consistency (i e, low yield value and high mobility) that naturally would cause, too rapid flow from a spreading machine normally adjusted to use paints of heavier consistency

III *Opacity or Hiding Power*—Relative hiding powers of the wet paints, in terms of square feet per gallon, may be determined by the improved Pfund Cryptometer[2] It will be necessary to use the improved type of cryptometer because of the coarse material which might be present

On account of the high volatile content of traffic paints (about 60 per cent of the vehicle), the cryptometer reading will be lower than the hiding power of the solid film after the volatile has evaporated If films of the same relative thickness could be spread, by ordinary means, a paint-out test would be a more desirable way to compare for hiding power Moreover, brush tests are not satisfactory for inclusion in specifications Also, on account of the coarse pigment used in these paints, it will be difficult to spread films grading uniformly in thickness from zero to complete hiding Various schemes for obtaining solid films in uniform wedges, such as are made with liquid films in the cryptometer, are being investigated and will be reported later

It is also possible that, knowing the pigment-vehicle ratio and percentage volatile in the paint, it will be feasible to calculate from the cryptometer reading what the hiding power of the wedge of paint under the slide will be when the volatile has evaporated This idea is also being investigated

It has been pointed out that the paint spreading machines used actually apply such thick films that the hiding power of the paint loses most of its ordinary significance and that for this reason the lower limit to be specified can be made very lenient It is obvious, however, that this is done at the expense of potential spreading rate A thin paint of high hiding power, used in a machine that restricts the flow (or oper-

[2] See Journal of the Franklin Institute, July, 1923

ates at a higher speed), would make an ideal combination from an economic point of view

IV *Drying Time*—Temperature and humidity are the important factors to be considered in drying-time specifications If the specifications demand drying within a specified time limit, a simple glass-walled cabinet, equipped for temperature and humidity control, and provided with a small electric fan to obtain constant and uniform air currents within, will serve Sufficiently close humidity control can be obtained by passing the fresh air through a series of 2-liter bottles containing sulfuric acid of proper strength Tables showing the strength of acid to use for any relative humidity have been published by R E Wilson, Jr, Ind Eng Chem Vol 13, No 4 A train of at least three bottles is suggested, the first bottle (i e, next to the air line), being filled with fresh solution and moved into last place (nearest the chamber) about every 24 hours

Drying tests should preferably be made at low temperatures and high relative humidities (at least 80 per cent relative humidity is suggested) since this is the most severe drying condition for a paint to meet For highway paints, lower testing temperatures, or about 34° to 35° F, might be desirable However, low temperature testing is complicated by the more elaborate temperatures and humidity-control equipment that will be required

V *Light Resistance (Resistance to Discoloration)* [3]—Long experience has approved the accelerated testing of paints and paint materials for their relative light resistance by exposure to light sources strong in the ultra-violet region of the spectrum In so testing traffic paints, the following precautions will be essential to obtain reliable results

1 Always run the sample against a standard or standards

2 The humidity conditions must be maintained constant throughout

The following procedure is recommended

Spread the paints as obtained from the can (well stirred) side by side along with the standard, on a porcelain plate or palette in smooth, even layers at least 1 by 3 inches in area

The palette is put in a warm place and dried for about 30 minutes (or for a time found most suitable for traffic paints) A strip of opaque black paper or a rule is laid across and above the samples to shadow a portion, and the samples then exposed to the ultra-violet light under a thin layer of water 1/16 to 1/4 inch deep (Exposure under water insures a uniform humidity) The water is flowed over the surface and not allowed to get hot A desirable length of exposure to bring out signifi-

[3] A full description of the apparatus used and the factors that enter into the light resistance test, as applied to lithopones, is given by Breyer, Nelson and Farber in Paint Manufacturers' Association of U S Circular No 194, Jan, 1924, pages 175 to 185

cant differences is about 5 minutes at a distance of 12 inches from the mercury arc light, when the current is 4 amperes at 180 volts across the line.

VI. *Visibility (Day and Night)*.—Experience with traffic paints has shown that there is little relation between day visibility and night visibility. The latter is subject to peculiar conditions that make it necessary to deal with it apart from the question of mere relative brightness or contrast. By "night visibility" is meant the visibility of a surface when illuminated at a large angle of incidence (as by an automobile headlight), and viewed at a large angle of reflection (as from the driver's seat of the same automobile). These two conditions are the most difficult that may be imposed on a reflecting surface.

Measurements made on a number of motor vehicles indicate that the average height of the headlights above the road is about 35 inches, while the height of the driver's eye above the road is about 60 inches. Assuming the reflecting surface to be 150 feet ahead of the car, the angle of incidence (angle between the normal to the reflecting surface and the path of the beam from the headlight), is 88° 53′, while the angle of reflection (angle between the normal to the reflecting surface and the path of the beam to the driver's eye), is 88° 6′. If the reflecting surface is assumed to be 100 feet ahead, the angle of incidence becomes

[4]This apparatus was developed at the Research Division of the New Jersey Zinc Company.

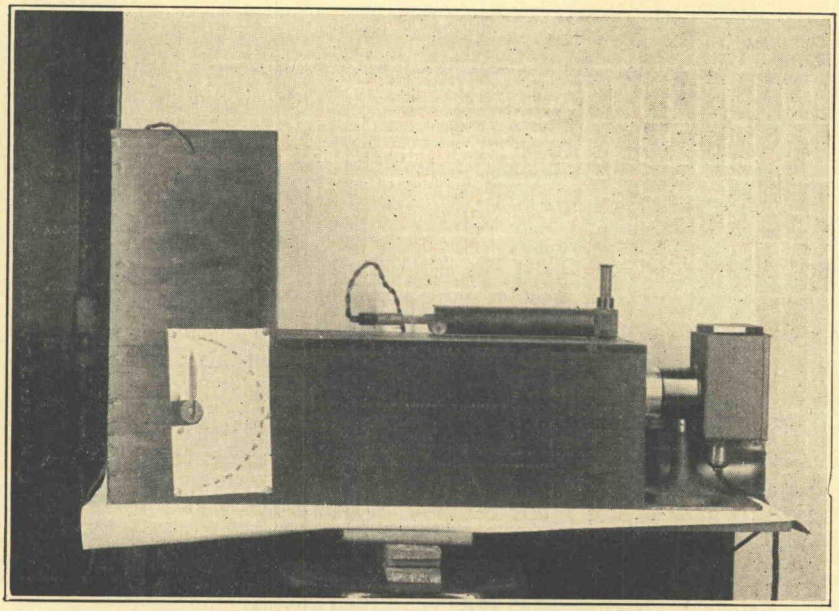

Figure 1—General view of photometric apparatus

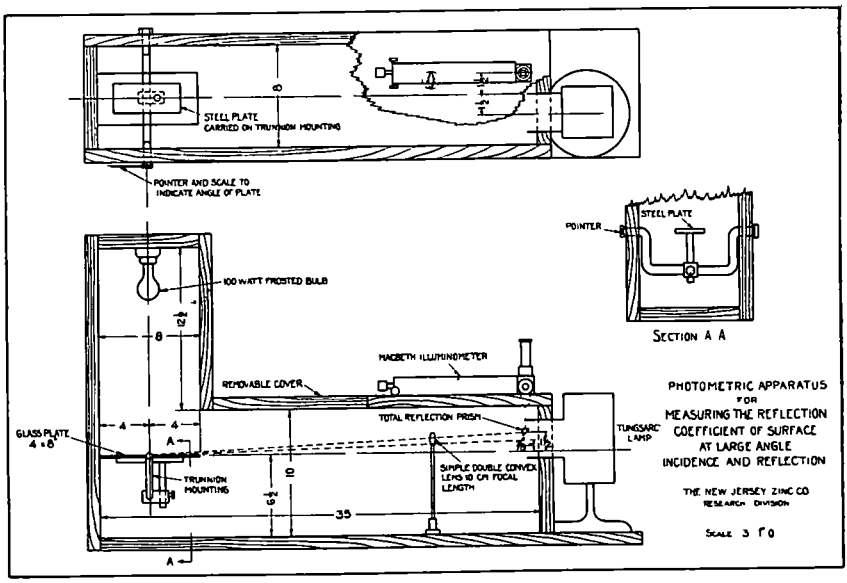

Figure 2—Dimensional sketch

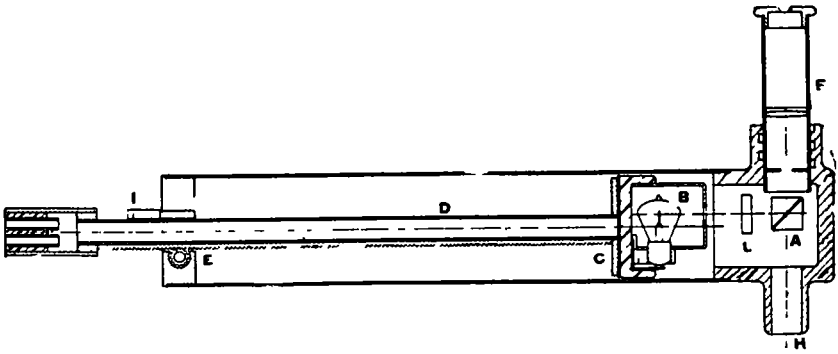

Figure 3—Cross-section of illuminometer

88° 20′, and the angle of reflection becomes 87° 8′. The latter condition is realized in an instrument that has just been developed[4] for measuring the coefficients of reflection of painted surfaces at large angles of incidence and reflection

Description of the Apparatus—Figure 1 gives a general view of the instrument, Figure 2 gives the dimensions, and a detailed cross-section of the illuminometer is shown in Figure 3

Any fairly strong light source may be used to simulate the automobile headlight. It must be capable of throwing a uniform spot of light on a surface 30 inches away, and must be *constant* in intensity Because

it admirably fits these requirements, the Bausch and Lomb Tungsarc Lamp has been used

The center of the surface illuminated is placed 30 inches from the front of the lamp casing, and seven-eighths of an inch below the center of the lamp A glass plate, reasonably plane (a good grade of window glass is satisfactory), size 4 by 8 inches is used, the paint being applied so that the brush marks are parallel to the 4-inch side The plate is so placed that the 4-inch side is toward the light

A total reflection prism is placed 30 inches from the surface and 1½ inches above it, reflecting the light into a Macbeth Illuminometer The image of the surface is focused on the photometer cube of the illuminometer by means of a 10-centimeter focal length simple double convex lens The relative brightness of various surfaces are measured directly on the scale of the illuminometer It is highly desirable to have a photometer cube in the instrument giving a divided field of view This enables one to make a brightness match on a narrow field with comparative ease The image of the reflecting surface is very narrow because it is so greatly fore-shortened

To correct for the variation in thickness of the glass plates upon which the paint is applied, the plate rests upon a steel support having a vertical adjustment with thumbscrew

Since the effect of varying the angle of incidence is of interest, the support for the plate is so arranged that it may be rotated The support is carried on a U-shaped trunnion that allows the plate to be rotated without raising or lowering its center, the axis of the trunnion being on a line with the center of the plate A pointer attached to the trunnion shaft and scale is placed outside the box to indicate the angle between the reflecting surface and the beam from the lamp

To simulate daylight conditions (illumination by means of light normal to the surface), a 100-watt frosted electric bulb is placed above the surface, giving a diffuse illumination down upon the surface

The whole apparatus, except the lamp and illuminometer, is enclosed in a light-tight wooden box, painted black on the inside To further reduce the reflections from the inside surfaces of the box, it is absolutely essential to line the back, bottom and top with black velvet

A standard plate, having a constant coefficient of reflection, is provided by grinding the surface of a piece of milk glass, size four inches by eight inches, with No 80 carborundum grains The coefficient of diffuse reflection of the standard used in this laboratory is 77 per cent

Manipulation of the Apparatus —The instrument is first standardized, using the milk-glass plate The lamp is adjusted to throw its beam over the whole surface, and the current through the illuminometer lamp is varied until the scale reads 2 when the fields are matched The painted panels to be tested are then placed successively in position and

a photometric balance established The photometer readings are a direct measure of the intensity of the light from each surface

Results Obtained—Several samples of traffic paint, which had been tested in service were painted on the glass panels and examined in the instrument Results obtained are given in Table I

TABLE I

Identification No	Rating given in service test	Reading on instrument, horizontal illumination (Night Visibility)	Reading on instrument vertical illumination (Day Visibility)
Standard Plate		2 0	13 7
M 215	Furnishes poor visibility	1 3	9 0
M 1276	Furnishes fair visibility	3 2	10 7
M 2186	Good visibility	7 1	12 5
M 1278	Good visibility	6 8	11 7

It will be noted that the night visibility readings show the same order as the rating given in service test The range between a poor paint and a good one is quite large, permitting a high degree of accuracy in the determination

The poor paint has almost as large a day visibility as the good one, indicating that the brightness of the painted surface is not the governing factor in night visibility as it is in day visibility Night visibility is a function of the roughness of the surface The more irregularities there are to turn the light back in its path, the greater will be the night visibility Therefore, a grooved or corrugated surface, with the grooves perpendicular to the direction of the beam of light, will furnish the highest night visibility

In order to measure the night visibility under practical conditions, and thus determine the effect of dirt collection, wear, etc , it was suggested that the measuring device be mounted upon an automobile in the following manner the Macbeth Illuminometer should be mounted at the level of the driver's eye, a telescope being placed in front of it with which an image of the white line on the road is projected upon the photometer cube of the illuminometer The current through the headlight lamps should be kept constant by means of an adjustable rheostat Under such conditions of constant intensity of illumination, and with the automobile and the road strip at the same level, the relative brightnesses of any number of paints, at various locations, probably can be measured with a fair degree of accuracy

VII *Durability*—Traffic paints are subject to severe abrasion as well as to ordinary wear, due to the weathering of sun, moisture, freezing, etc Ordinarily, the effect of abrasion probably is more important, and yet the resistance to ordinary weathering must contribute in one way or another to the resistance to wear For example, a paint that chalks away rapidly under light, could hardly be expected to wear well even if it shows superior resistance in an abrasion test. Hence, true conclusions as to actual durability could be arrived at only by testing for resistance to both weather and ordinary abrasion

Accelerated weathering tests have been successfully applied on all kinds of paint surfaces Such tests may vary from simple exposure to an ultra-violet light-moisture combination alone, which indicates relative chalking tendencies in particular, to combinations of light, water, refrigeration, etc , into a complete cycle designed to simulate outdoor weathering While the more complete system gives more accurate and representative results, valuable results may also be obtained by the more limited light-moisture test alone

Accelerated weathering tests are discussed in the Proceeding of the A S T M , Vol 22, Part II, 1922, and Vol 24, Part II, 1924 Also, see Gardner—"Physical and Chemical Examination of Paints, etc " second edition—page 71 By this method an approximate acceleration of 7 or 10 to 1 has been obtained Recently the acceleration has been practically doubled by increasing the oxygen content of the air in the light exposure chamber Assuming that a life of at least one year is wanted, comparative tests can be completed within about 15 to 20 days, if the test is carried out as in this laboratory Obviously, the light source used for the light resistance test can be used for this purpose as well

A new design [5] for laboratory accelerated weathering testing equipment of moderate testing capacity is now being worked out and it is suggested that any extensive installations be delayed until this design has been tested

A number of abrasion tests have been suggested for paints, most of them based on dropping emery or sand through a long tube on to the paint surface There is no record of extensive work having been done on these tests and their usefulness would have to be determined

[5] This design is being developed by the research division of the New Jersey Zinc Company