Physical Properties of Traffic Paints

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● TRAFFIC or zone paints have become a major item of expenditure for highway departments with their increasing mileages and with the increase in traffic using the highways. Extending the mileage requiring marking and increasing the traffic wear on the marking has necessitated successively larger purchases of paint and associated equipment. As this market became larger, increasing numbers of manufacturers have entered the field with a great diversity of formulations having differing properties.

In order to bring some order out of this situation, the research laboratory in cooperation with the Division of Traffic of the Kentucky Department of Highways undertook a study of the paints as offered by some of the principal producers. Toward this end 1-gal. samples of such paints as the producers deemed worthy of consideration were procured. The choice was left to the discretion of the manufacturer in order to assure procurement of paints which are currently in production and which the maker would like to sell. Previous experience with samples obtained from brokers and distributors has indicated that they are not reliable sources of either fresh samples or the latest formulations. This procedure, of course, leads to the possibility of obtaining hand-picked or laboratory-made paints which are better than production runs of the same formula. Any apprehension on this point can be relieved by further testing of any paints purchased in quantity to assure their compliance with specifications and performance of the original specimen.

In some instances the manufacturers have specified certain of the samples they submitted as laboratory or experimental mixes which they would like to have tested. This implies a desire on the part of the producer to make this paint, if the testing shows it to have merit, and consequently these samples were included without discrimination in the program.

Early in this project it was decided to make a comparative physical study of the paints without regard to chemical compositions, since the highway department is not interested in paint manufacture but rather in application and service of paints which can be purchased commercially. Hence, this work concerns itself only with the physical characteristics of the various paints as they manifest themselves in application with Kentucky Department of Highways machines and personnel.

Cost is a big factor in the purchase of traffic paints, but these prices vary so often that it was deemed advisable not to consider cost in this project. Thus the data are presented objectively, and the purchaser can use this information in conjunction with current market quotations to make an intelligent selection.

TRAFFIC PAINT CHARACTERISTICS

Paints designed for traffic purposes differ considerably from paints used for decoration and protection of building, machinery, etc. Since they are applied almost entirely outdoors on a horizontal plane, they must have good weathering properties. In order that there will be a minimum of interruption to traffic when paints are being applied, they must dry as quickly as possible after placement so traffic can pass over them without tracking. This is a point of particular importance when the marking is to be done in cities where traffic is heavy, constant, and cannot be blocked for more than the shortest of intervals. But conversely, this rapid drying must not be so fast as to cause skimming when the paint container is open for stirring or clogging in the nozzle of the spray machine, if such is used.

Traffic paints are thicker and more-heavily pigmented with a coarser pigment than most other paints, in order to increase their covering power and abrasion resistance even when thinned down; as a result, they dry to flat or semigloss finishes. Indeed, this rough surface is desired; it increases night visibility at the low angles of incidence encountered from vehicular headlighting. Toward this end, pumice and other inert materials are sometimes added to the paints to increase the roughness of texture of the finish, and incidentally, these materials increase wear resistance also. In the last few years the greatest strides in increasing the effectiveness of traffic markings at night have been made by reflectorizing them with minute glass spheres. Each tiny bead serves individually as a lense, backed up by a spherical mirror, and its action is to collect light falling on it and return the light in the general direction from whence it came. Collectively the effect is to make the line many times brighter than it would appear without the reflectorization. In fact, the markings seem to glow with a light all their own, which has led many drivers upon casual observation to the erroneous conclusion that the lines are luminous. The beads may be mixed with the paint before it is applied, or they may be dispersed on the wet surface by hand or mechanical dispenser.

The heavy pigmentation and inert additions of beads, pumice, and sand lead to two more necessary characteristics of traffic paints. First, the mixtures must not show too great a tendency to settle and it must be easily redispersed by stirring once it has settled. Second, it must form a good strong bond with the reflectorizing materials, so they are not easily dislodged from the stripe after it has dried in place. This same property of adhesion is also necessary if the paint is to last through a useful life on the pavement. Paints with poor adhesive properties usually crack and chip away from the surface long before their effectiveness is diminished by abrasion.

To accomplish a desirable combination of the above-mentioned properties, there are many different formulas and processes. The fact that the ultimate in all characteristics is not available in one paint is attested to by the number of manufacturers in the field, each of them offering many different mixes with differing compositions and characteristics. Indeed, it has been observed that paints meeting the same specification as to composition yield widely varying results in service. The difference probably lies in the method of mixture and cooking in the varnish kettle. For this reason, specifications based on composition do not assure the procurement of uniformly serviceable paints. Thus, the best traffic paint specification should have as its basis physical and service tests, rather than mere chemical composition data.

In general, traffic paints consist of quick-drying-varnish vehicle, pigments, ester gum or gum copals, volatile thinners, and driers. These are combined in various proportions and by various processes to achieve traffic paints with varying properties. Often one or more of the generally used components is replaced by a different substance to make a paint with special properties. Thus, rubber latex, chlorinated rubber, cold-cut resins, and cellulose laquers are often encountered as vehicles in place of the more common varnish, and thinners and driers may be any of a variety of low-boiling petroleum or coal tar fractions. Almost universally these thinners are compatible with gasoline, as this is the thinner-solvent most readily available to paint crews working in the field. Paints requiring special thinners should be avoided for highway use, unless they offer very attractive properties to compensate for the inconveniences of having to buy usually expensive special solvents and having to transport them with the striping crews.

Pigments are chosen for traffic paints on the basis of cost, hiding power, and suitability of color. For white paints, the pigments in largest use are zinc oxide, titanium-base, and lithopone, plus the aforementioned silica materials for increasing visibility and abrasion resistance. Colored paints have carbon black, organic dyes, iron oxides, or chrome yellows, depending upon the color desired. Zinc oxide is added to most of these to increase the color retention under the severe weathering conditions encountered by traffic markings.

METHOD OF TESTING

As mentioned previously, this test program has been designed and conducted as a comparative physical test of paints on Kentucky roads, under Kentucky weather, using Kentucky striping equipment and technicians. As close an approximation as possible has been made to the conditions of application and service that these paints would encounter were they adopted for use by the Kentucky Department of Highways. The striping crews were allowed to place the field test stripes exactly as they would in using the paints in general service. No attempt has been made to achieve optimum rates of application for each sample except the adjustments which the sprayer operator makes to secure the type of line desired from the different paints. This was done in order that the stripes not be put down under controlled conditions which could not be maintained in service.

The transverse field-service stripes were placed August 21 and 22, 1950, on days which were uniformly sunny with a temperature in the upper seventies and a relative humidity of near 50 percent. They were located about 3 mi. south of the Lexington city limits on US 27. At this point a divided, four-lane cement-concrete surface adjoins a divided, four-lane bituminous surface, both relatively new. Identical sets of stripes were located in the west lane on both the concrete and bituminous pavements (see Fig. 1). Immediately prior to the date of field placement, all of the paints were dispersed by shaking them in a mechanical paint-shaking machine. Thus, only minor stirring was needed to condition the paints when they were opened at the field location.

It will be noted that there are considerably more stripes than paint samples. The reason for this is that those paints which the producer designated as suitable for use with or without external bead application have been applied both ways, i. e., one stripe reflectorized and the other one not. In a few instances extra stripes were placed when the first one did not appear satisfactory.

The rate of application was determined for each of these samples by placing a previously weighed piece of brown kraft board measuring 6 in. wide and 14 in. long with a removable strip of 1-in. masking tape across the short dimension at each end (Fig. 2). The striper was passed over this and a stripe placed upon it. Then removal of the masking tape at each end left a section of stripe 1 ft. long. Weight of the paper and paint minus the original weight of the paper gave the weight of paint per foot. This information, coupled with the laboratory determined specific gravity of each paint, allowed computation of the covering power or rate of application, which is shown in Table 1 in two forms: feet per gallon and gallons per mile.

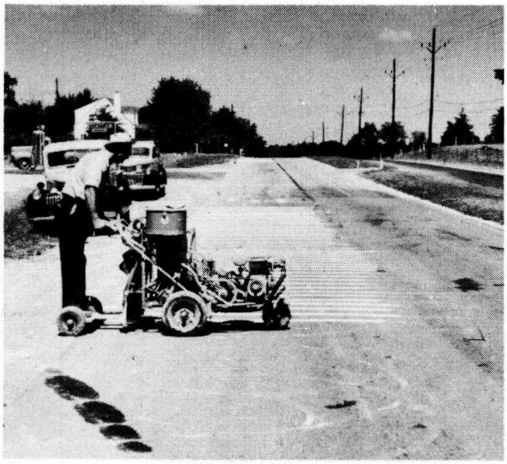

Figure 1. 1950 Transverse stripe location. Stripes on bituminous surface are immediately behind striper and on concrete surface in the background.

Figure 2. Application-rate determination; 1-ft. strip of kraft paper is shown in place after striping machine has passed over it.

TABLE 1

Sample and Stripe No.	Specific Gravity	Wet Weight Per Foot Grams	Feet Per Gallon	Gallons Per Mile	Loss in Weight on Drying %	Approximate Track Free Drying Time* Min.	** Type Reflect-orization	*** 8-Months Transverse Stripe Evaluation	Color
1&2	1 29	6.3	775	6 82	15.8	12	1-NR 2-B.O.P.	0 & 0	W
3&4	1.751	10.4	637	8 3	16.4	9	3-NR 4-B.O.P.	0 & 0	W
5&6	1.411	9.2	580	9 12	22.8	8	5-NR 6-B.O.P	0 & 1	W
7&8	1 291	10 5	465	11.37	32.4	22	7-NR 8-B.O P.	1 & 1	W
9&10	1.448	26.4	208	25 4	20.5	21	9-NR 10-B.O.P.	3 & 3	W
11&12	1.556	12.5	471	11.22	12.0	9	11-NR 12-NR	2 & 2	W
13	1 604	10.0	607.1	8 7	9.0	14	13-NR	3	W
14&15	1.308	13.1	378	13.98	21.4	13	14-B.O.P. 15-NR	2 & 2	W
16&17	1 394	9 2	574	9.22	17 4	13	16-B O.P. 17-NR	2 & 2	W
18&19	1.351	6 7	764	6.93	15 0	12	18-NR 19-B.O.P.	3 & 3	W
20&21	1 306	11.6	426	12 41	10.4	18	20-B.O P. 21-NR	2 & 3	W
22&23	1.351	8 4	609	8 68	12 0	17	22-NR 23-B.O.P.	2 & 3	W
24&25	1.355	8.0	641 5	8.24	12 5	15	24-B.O P. 25-NR	2 & 3	W
26&27	1.353	9.8	523.5	10.1	14.2	10	26-B.O.P. 27-NR	1 & 2	W
28	1.457	9.4	587	9 0	19.2	10	B.O P.	1	W
29	1.619	14.0	437 8	12.07	23.6	15	B.O.P.	0	W
30	1.512	10.7	535	9 88	14.0	24	NR	2	Y
31	1 418	7.9	679 8	7.78	10 2	21	NR	1	Y
32	1.436	5 6	970	5 45	5 5	13	NR	1	Y
33	1.422	5.8	928.5	5.69	8.5	11	NR	0	Y
34&35	1.336	8.7	581.5	9 09	21.8	10	34-NR 35-B.O.P	4 & 3	Y
36&37	1.582	8.4	713	7.41	16.6	12	36-B.O P. 37-NR	1 & 3	Y
38&39	1.48	13.5	415	12.75	13.4	12	38-B.O.P. 39-NR	1 & 2	Y
40&41	1 389	7.0	751.5	7 04	5 7	15	40-B.O P. 41-NR	2 & 2	Y
42	1.491	7.0	806	6 55	18.6	12	B.O.P.	1	Y
43&44	1 435	9.3	585	9.04	10.7	15	43-B.O P. 44-NR	1 & 2	Y
45&46	1.316	7.8	640	8 25	19.2	24	45-B.O P. 46-NR	1 & 2	Y
47&48	1.604	12.9	471	11 22	14 6	32	47-B.O.P. 48-B.O.P.	2 & 2	Y
49&50	1.316	23 3	214.1	24.68	25.0	10	49-B.O.P. 50-NR	1 & 3	Y
51&52	1 544	13.0	449.5	11.75	22.3	15	B.I.P.	0 & 0	Y
53	1.694	12.1	529.5	9.98	5 0	15	B.I P	1	Y
54	1.706	13.8	468.5	11.29	11 6	16	B.I.P.	1	Y
55	1 831	28.6	242.3	21 8	14.4	10	B.I.P.	0	Y
56	1 573	8 3	717 5	7.37	2.4	10	B.I.P.	1	Y
57	1.579	7.2	830	6.36	7.0	15	B.I.P.	2	Y
58	1 621	7.5	817 8	6.45	4.0	23	B.I.P.	1	W
59	1.668	9.7	651	8 12	12.4	7	B.I.P.	0	W
60	1 714	12 0	540	9 79	6 6	5	B.I P.	0	W
61	1 344	10 9	466.5	11.31	11.0	18	B.I.P.	2	W
62	1.582	7.1	843.5	6.28	1 4	13	B.I.P.	2	W
63&64	1.356	3.8	1351	3.91	5 2	11	63-B.O.P. 64-NR	2 & 2	W
65&66	1.312	7.6	653.5	8 09	13 1	13	65-B O P. 66-NR	2 & 2	W
67&68	1 398	8.4	630	8 9	13.1	16	67-B.O P. 68-NR	3 & 3	W

* - Noon Temperature 79F., relative humidity 56 percent

**-B.O.P. = beads on paint
B.I.P = beads in paint

*** - Transverse-stripe evaluation scale
0 - Useless, paint barely discernible if at all
1 - Poor, traces remain but not serviceable
2 - Fair, serviceable but dim
3 - Good, still serviceable
4 - Excellent, fully serviceable

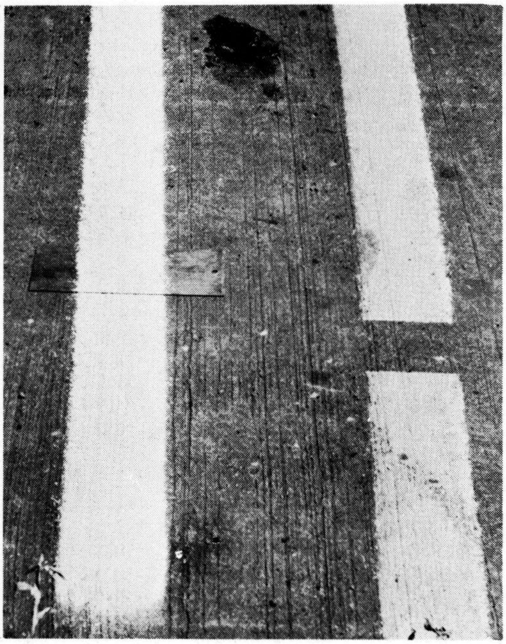

Figure 3. Weathering-reflectance panel. Panel is in place in left hand stripe after application of paint. Gap in right hand stripe was left by previous panel.

A similar arrangement was used to obtain the sample for laboratory use in determining reflectance and weathering properties. In this instance 3- by 9-in. metal panels were placed in the path of the striper and a specimen of the paint was thereby obtained (Fig. 3). A panel can be seen in place after the striper has passed over it in the left hand stripe. The gap left in the stripe can be seen in the right-hand stripe in the photograph. These panels were subsequently taken to the laboratory and their reflectance was measured; then they were placed in an accelerated weathering chamber, where they were subjected to over 500 hrs. of strong radiation and water spray. This length of accelerated weathering is roughly equivalent to one year of exposure to normal weathering. The panels were then scrubbed with a brush and water to remove any scum or chalk and the reflectance was then a measure of the weather resistance of the paint: those paints losing the least reflectance have better weathering characteristics than those which lost more reflectance. These data are tabulated in Table 2. It is to be noted that this information is not available on a few of the samples. This was due to a lack of space in the weathering chamber for all of the panels. This limitation caused the rejection of some of the poorer panels upon which the paint was not well placed or was "splotchy" and would consequently have given unreliable results.

The track-free drying times given in Table 1 were determined by starting a stop watch when the strip was placed and stopping it when a finger run along the stripe failed to find any soft or tacky spots along the length of the stripe. This was largely a matter of judgement; but since the same person noted all of these times, it is probable that they are consistent as a relative measure of drying time and are indicative of the drying time necessary before traffic can be permitted over the stripe without tracking under these particular conditions of humidity and temperature. All drying times were determined on the concrete surface in the interest of uniformity. However, a few impromptu checks revealed that the drying times were almost identical on the bituminous surface.

The percentage volatile material given in Table 1 was determined by subtracting the dry weight of a specimen from the wet weight and dividing this difference by the wet weight, then multiplying the quotient by 100 to obtain the result expressed as a percentage. This figure is a measure of the amount of volatile thinner, drier, or other vaporizable substance in the mixture and serves to differentiate between very heavy paints and those which are diluted or cutback. In general the lower this figure the greater the covering power of the mixture assuming possible dilution in the field to the proper consistency for sprayer application.

An accelerated abrasion test has also been started on these specimens on the circular track road testing machine in the Highway Materials Research Laboratory. Briefly the installation consists of a circular track 45 feet in circumference at the centerline of the 24 in. width paved area. The pavement consists of a dense plant mix bituminous surface. A rotor, consisting of a metal framework mounting a 30 horsepower direct current motor on one end driving a pair of 7.50 x 20 truck

TABLE 2

Sample and Stripe No.	Panel No.	Type Reflectance NR.	B.O.P.	B.I.P.	Initial Reflect-ance	500 Hr. Reflect-ance	500-Hr. Change In Reflect-ance %	600 Hr. Reflect-ance	600-Hr. Change In Reflect-ance %
2	1		X		0.0701	0.0781	+11.4	.066	-5.8
4	2		X		.0906	.0960	+ 5.9	.080	-11.7
6	3		X		.0496	.0527	+ 6.2	.0498	+ 0.4
7	4	X			.0484	.0485	+ 0.2	.0437	- 9.7
9	5	X			.0484	.0517	+ 6.8	.0487	+ 0.7
11	6	X			.0484	.0527	+ 8.9	.0467	- 3.5
13	7	X			.0515	.0508	- 1.3	.0440	-14.5
14	8		X		.0647	.0681	+ 5.2	.0600	- 7.2
16	9		X		.0488	.0519	+ 6.3	.0400	-18.0
19	10		X		.1229	.1068	-13.1	.0800	-34.9
20	11		X		.119	.1129	- 5.9	.0950	-20.2
23	12		X		.0529	.0519	- 1.9	.0380	-28.2
24	13		X		.0542	.0509	- 6.1	.0582	+ 7.4
26	14		X		.0753	.0798	+ 5.9	.0883	+17.3
28	15		X		.0506	.0509	+ 0.5	.0542	+ 7.1
29	16		X		.0493	.0499	+ 1.2	.0583	+18.2
30	17	X			.0419	.0399	- 4.7	.0401	- 4.3
31	18	X			.0262	.0389	+48.5	.0401	+53.0
32	19	X			.0388	.0399	+18.1	.0400	+18.3
33	20	X			.0432	.0399	- 7.6	.0400	- 7.4
35	21		X						
36	22		X		.0432	.0409	- 5.3	.0400	- 7.4
38	23		X		.1035	.0898	-13.2	.0899	-13.1
40	24		X		.1022	.0898	-12.1	.0891	-12.8
42	25		X		.0444	.0409	- 7.9	.0400	- 9.9
43	26		X		.0481	.0477	- 0.8	.0472	- 1.8
45	27		X		.0506	.0507	+ 0.2	.0533	+ 5.3
47	28		X		.0320	.0389	+21.6	.0372	+16.2
49	29		X		.0617	.0789	+27.8	.0794	+28.7
51	30			X	.0296	.0389	+31.4	.0361	+21.9
53	31			X					
54	32			X	.0296	.0380	+28.4	.0342	+15.5
55	33			X					
56	34			X					
57	35			X	.0320	.0404	+25.3	.0387	+20.9
58	36			X	.0394	.0512	+29.9	.0509	+29.2
59	37			X	.0501	.0522	+ 4.2	.0509	+ 1.6
60	38			X	.0487	.0502	+ 3.1	.0509	+ 4.5
61	39			X	.0501	.0492	- 1.8	.0469	- 6.4
62	40			X	.0487	.0492	+ 1.0	.0469	- 3.7
63	41		X		.0638	.0619	- 2.9	.0810	+26.9
65	42		X		.0627	.0700	+11.6	.0691	+11.2
67	43		X		.0353	.0619	+75.4	.0584	+65.4

tires through a standard truck differential and a 30 horsepower direct current generator on the other end which is driven by an identical set of truck wheels and differential, is mounted on a center pedestal by a gear box which imparts an eccentric motion to the rotor. Thus the rotor is driven about the track by the motor through one set of wheels while it is "loaded" by the other set of wheels connected to the generator. In other words, one end of the rotor is driving while the other is dragging. The eccentric motion imparted to the rotor causes the wheels to cover the track surface uniformly and at an almost constant skid. The direction of motion of the wheels is tangent to the circle of rotation only instantaneously once each revolution. At all other times the wheels are skidding slightly. This, of course, imparts a great deal of abrasion to the sur-

Figure 4. Accelerated-abrasion test. Paint segments are shown on the surface of the circular test tracks.

face and hence can be called an accelerated abrasion test.

For the purpose of testing paints this apparatus is excellent in that samples are mounted on a road surface material just as in practice, and they are abraded by loaded tires just as they will be in service. It is possible with this device to add some elements of weathering if desired.

The paint samples were applied to the track immediately after they were used for the transverse stripes at the field location. The remainder of the samples was brought in and applied by brush to radial segments marked off on the track surface with masking tape. There is one of these segments for each of the paint specimens. Figure 4 shows a portion of the test area on the track before any abrasive action was started. This work is not yet completed.

INTERPRETATION OF DATA

Most of the data in Table 1 are self-explanatory. It is meant to serve as a reference table covering the physical properties of the 43 brands and formulations tested. The purchaser is usually confronted with a narrow field of selection as price quotations in hand normally dictate that the best bid of the lowest two or three be selected. A quick reference to the information in the table will probably allow the selection of one of the group as the best for the particular purposes.

The reflectance data in Table 2 must also be considered in selecting a paint. Here one must be careful to compare paints of like color and reflectorization, i.e., white premixes should be compared only with other white premixes and not with yellows, or paints designed for external bead application.

It will be noted in Table 2 that the majority of the specimens gained in reflectance with the 500 hrs. of weathering. This is doubtless the result of bleaching action of the radiation on the pigment and the roughening of the surface by chalking of the paint and also the deposition of calcium carbonate residue from the water spray. This process will of course reach a peak and then the reflectance will begin to diminish. This does not seem to have happened within the 500-hr. test. However, reference to the 600-hr. data substantiates this, in that some of the paints which had gained in reflectance at 500 hr. have started to lose reflectance at 600 hr. Those paints which have lost reflectance have done so as a result of the darkening of some of the pigments or other organic materials and some loss of beads.

In the case of premixes, the reflectance should go up as the paint film initially covering the beads wears away, bringing the reflex action of the beads into play. Paints in this category which fail to increase their reflectance with weathering and abrasion are probably either thick and the paint film is not yet worn from the beads or else the paint is so slow in drying that the beads all sink to the bottom of the paint stripe, becoming well covered by a thick coating of paint. Weathering alone would not serve to bring these premixes to their full reflectance, so each time that the panels were taken from the weathering chamber for a reflectance measurement all of them were scrubbed with forty passes of a wet brush and mild abrasive. Then they were rinsed in running water and allowed to dry before the measurements were made. All of the panels were treated in this manner, in-

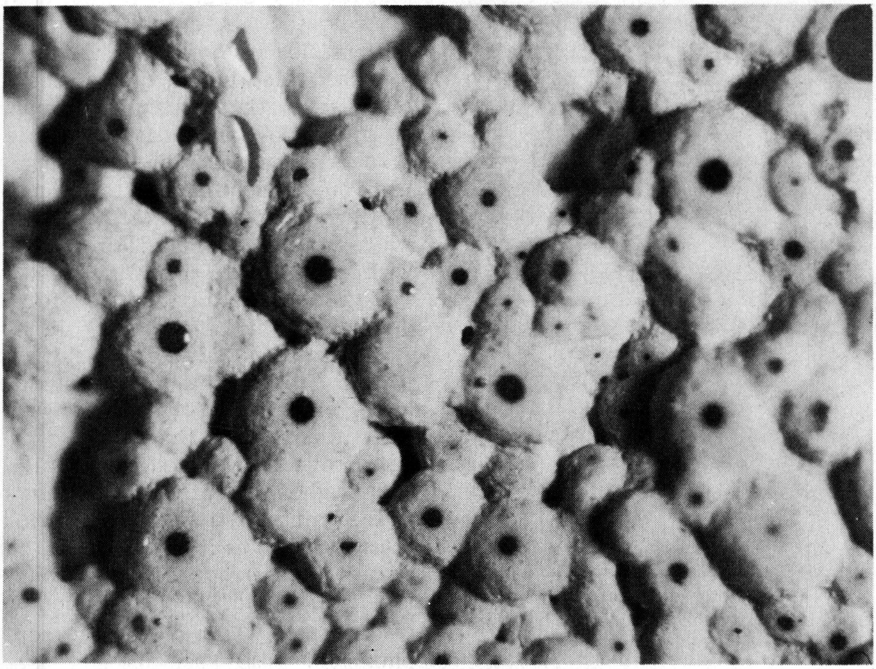

Figure 5. Photomicrograph (30X) of Sample 47 after 500 hours of accelerated weathering and mild abrasion. This slow drying paint used with external beads has allowed the beads to sink into the paint so that it appears as a premix and performs as one.

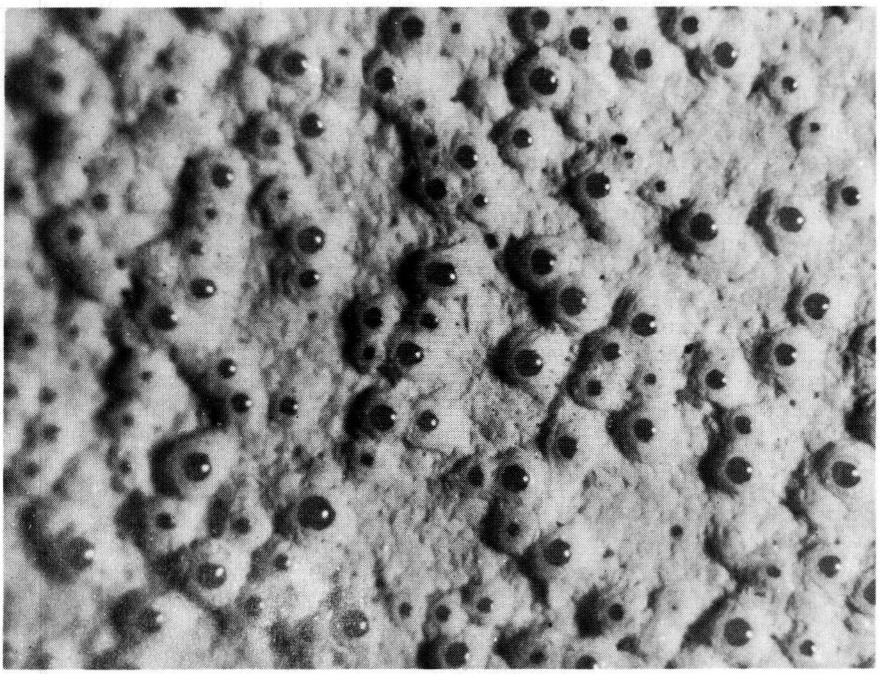

Figure 6. Photomicrograph (30X) of Sample 50 premix after 500 hours of accelerated weathering and mild abrasion. Except for smaller more uniform bead size there is little to distinguish this from the slow drying external bead paint of Figure 5.

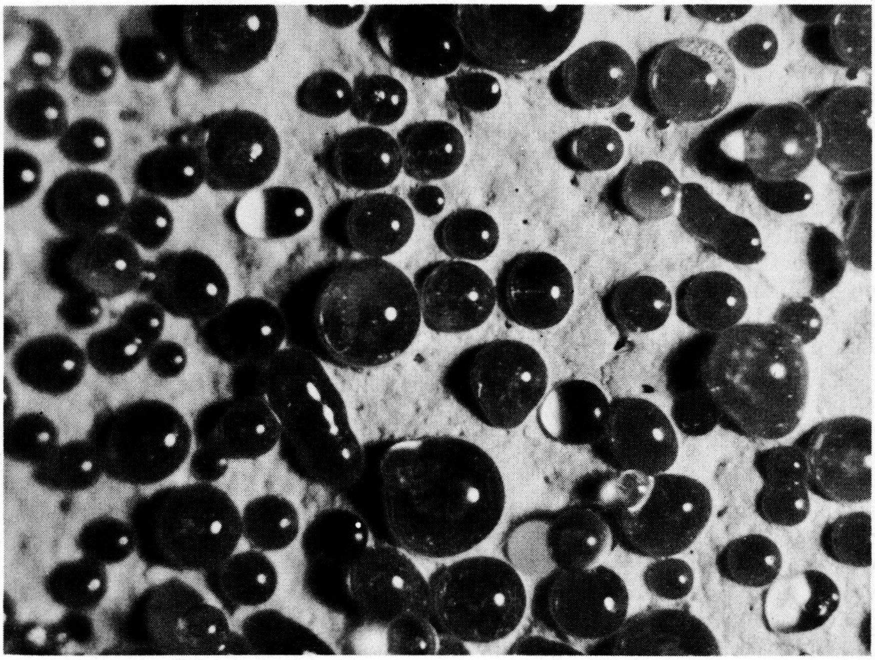

Figure 7. Photomicrograph (30X) of Sample 49 which is a rapid drying external bead paint. Note that due to the rapid drying, beads are only imbedded on the bottom and there is no paint up over the sides of the spheres.

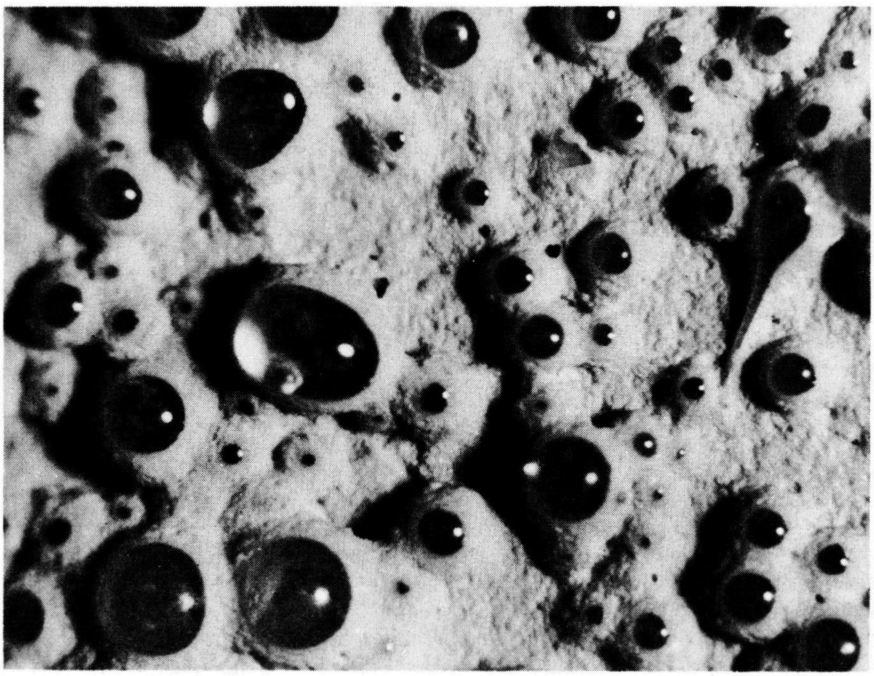

Figure 8. Photomicrograph (30X) of Sample 25 which is a medium fast drying type of paint used with external bead application. Note the pillaring of the beads by the paint extending up about half way on the spheres.

cluding the external bead and nonreflectorized specimens.

Paints which are reflectorized with externally applied beads should exhibit their highest reflectance at the initial reading, and their loss in reflectance after this is due almost entirely to beads being torn away from the paint film. As a result, paints of this type with poor adhesive properties or too-rapid drying properties lose their reflectance sooner than paints which retain their beads better. Paints of this type which gain in reflectance are usually of a slow-drying type which allows the beads to sink into the paint film and become covered by paint before drying. This is demonstrated by Samples 45 and 47 which show a large increase in reflectance with weathering. Reference to Table 1 shows these two paints to be slow driers, 24 and 32 min. respectively. As a consequence of this, they perform more as premixes, and as shown in the photomicrograph, Figure 5, it can be seen that they appear almost like premixes. Figure 5 shows Sample 47 after 500 hr. of accelerated weathering and mild abrasion. Note the similarity to Figure 6, which is a premix after the same treatment.

Figure 7 represents the opposite condition to Samples 45 and 47. In this case the drying time is so fast (10 min.) that the beads have no opportunity to sink into the film. In fact, a skin probably forms so fast that the beads are held up and are unable to sink into the paint. One would expect in this situation that the beads would not adhere. However, in this particular instance the adhesion seems good, and there is little noticeable loss of beads after the 500 hr. of accelerated weathering and mild abrasion. Reflectance of this specimen was high initially and dropped off only slightly with weathering, due probably to darkening of the yellow pigment and some slight loss of beads. It is worthy of note that this type of paint does not impart its characteristic yellow color to the markings at night as well as one in which the beads are surrounded more completely by the paint film. At the low angles of incidence and viewing encountered at night, these markings reflect the color of the light source. Thus, although they do appear as yellow at night, it is a diluted yellow as compared to their color under daylight conditions.

Figure 8 represents a median condition between the above two extremes. The drying time of 14 min. lies between Samples 47 and 49, and it will be noted that the beads have penetrated the film about half way, and upon drying and shrinking this has left each bead at the top of a little pillar of paint. This, of course, makes for an excellent light intercepting and reflecting position for the beads. Because of the lower half being surrounded by the paint, more of the pigment color is imparted to the low angle light at night, and the light reflected is more nearly identical to the daytime color. This pillar effect is also noted in Figure 5, which is the slow-drying external-bead paint and also in the premix of Figure 6; but as might be expected, the beads are more deeply imbedded in these instances. It is possible that wetting agents may be added to some of the paints to lower the surface tension of the paint film, allowing the beads to become more deeply imbedded. This possibility has not been explored, and there is little cause to in a comparative physical-performance test program such as this one.

Figure 9 is a photomicrograph of Sample 60, which is a type of premix not exhibiting this shrinkage and consequent pillaring effect of the beads. In this specimen, the beads are deeply imbedded in the film beneath a smooth top surface. Only a small top sector of the uppermost beads is exposed by abrasion, and little reflection could be expected at low incidence angles. Also visible in the photograph are some of the cracks which have developed as a result of weathering. These are general over the surface and would contribute to dulling of the markings by becoming filled with road scum.

Figure 10 shows Sample 1, which is nonreflectorized. Note the porous nature of the finish which would quickly become filled wirh road scum and darken to a dull nonreflecting gray. This is the likely result of a paint which is too thin, even though the percentage of volatiles is not excessive. This paint has the lowest specific gravity of any of the samples tested.

Figure 11 represents a much-better

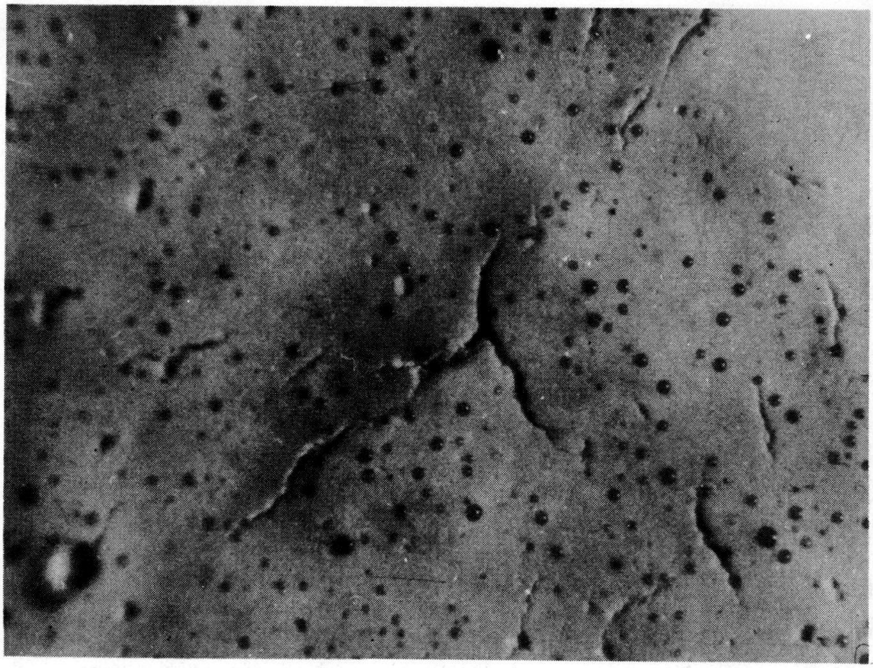

Figure 9. Photomicrograph (30X) of Sample 38 a premix which does not shrink differentially on drying and thus presents a smooth top surface with only the top sectors of the beads being uncovered by abrasion. Cracks are the result of accelerated weathering.

type of surface for nonreflectorized service. The surface is closed but, nevertheless, rough enough to offer a fair reflective surface at night. This condition is probably brought about by the addition of inert granular materials, as discussed earlier in this report. This particular photo is of Sample 7.

The size and quality of beads will, to a certain extent, determine the reflectance of a specimen. In this test all the beads used for external application are the same-taken from the stock of the Kentucky Department of Highways Traffic Division. Since these are the beads currently used by the department, it was deemed advisable to use them on all the samples designed for external bead application. If different beads are purchased in conjunction with paint supplies, some variation can be expected from the data contained in this report. Since no specific study of various bead types and their properties has been included in this report, only some general statements can be made without substantiating data. More complete analysis will be presented with the data in the second part of this report.

Smaller bead sizes (120 to 200 mesh), such as are used in the premix to inhibit settling of the mix and clogging of the spray nozzle, offer wide-angle reflective properties, good adhesion properties, and a homogenous reflectivity, due to the breaking down of the marking into very small reflective units. But this small size contributes to a diminishing of the reflectance of the line when the surface is wet. It takes only a slight film of water to immerse these small spheres, preventing their being effective as reflex reflectors. The larger bead sizes are not so easily covered and can be expected to be more effective on wet roadways. The larger sizes (40 to 80 mesh), are subjected to easier stripping away from the film, in addition to being unsuitable for premix use because of settling and clogging considerations.

In general, the smaller-sized beads have higher refractive indices, which is very desirable. But these higher indices

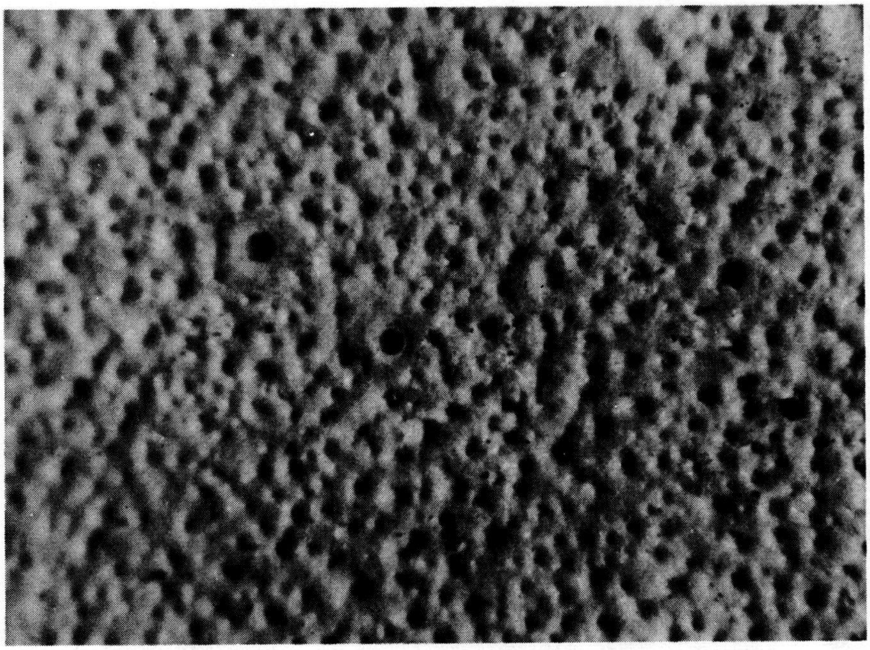

Figure 10. Photomicrograph (30X) of Sample 1 which is a nonreflectorized paint which was too high in volatile materials and dried to this honeycombed surface which would soon become filled with road scum.

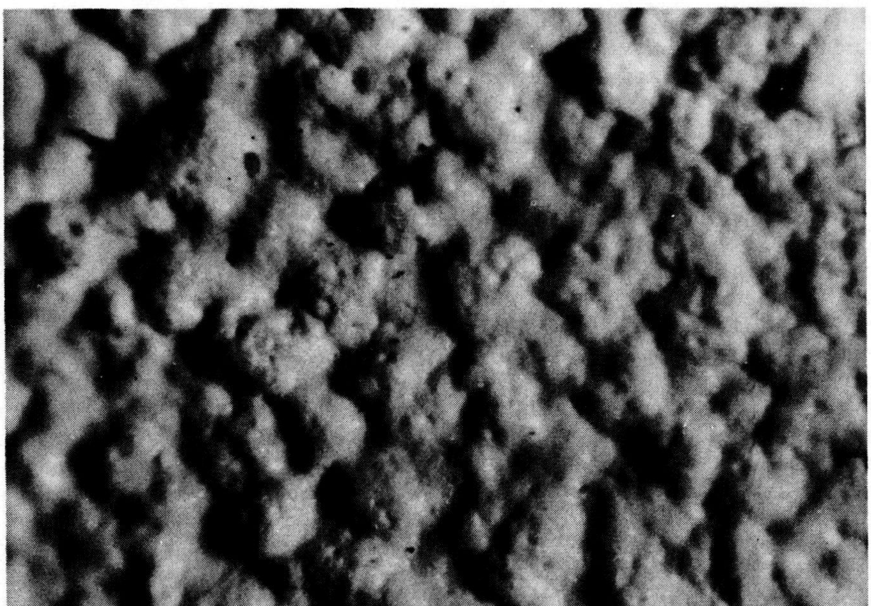

Figure 11. Photomicrograph (30X) of Sample 7 showing a nonreflectorized surface which is closed to dirt, but is made rough enough by inert additions to give it a fairly good reflecting property.

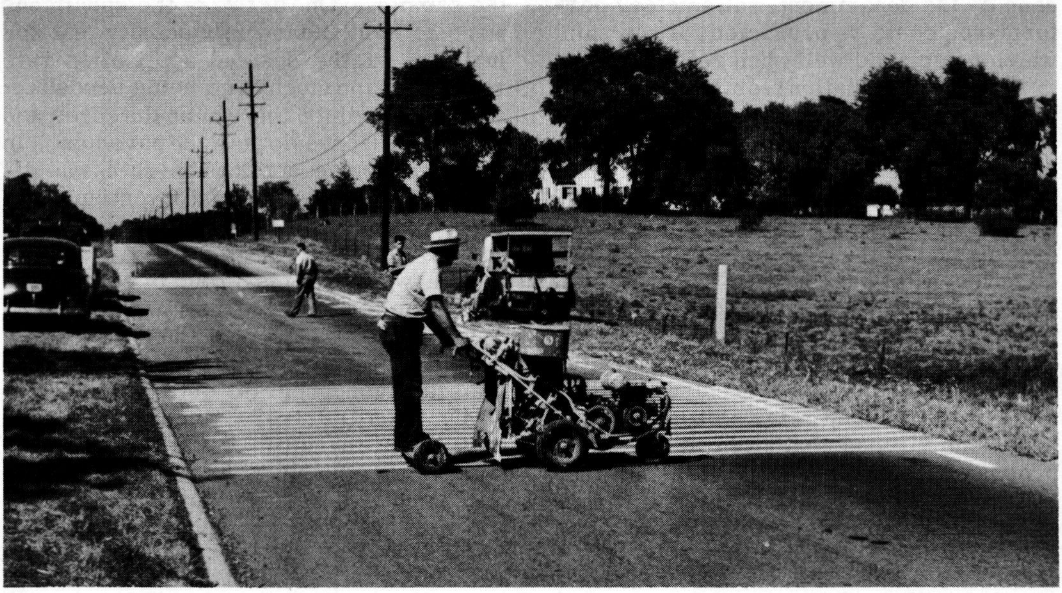

Figure 12. 1951-transverse-stripe location. The set of stripes in the foreground are on bituminous surface while the identical set on concrete surface is visible in the background.

are also indicative of softer glass, which makes the bead more susceptible to crushing. Thus a balance must be achieved between acceptable hardness and the highest refractive index consistent with this desired degree of hardness. This can be tied down in a specification by including specifications and tests of the refractive index, silica content, and size gradation.

The uses of these diminutive beads for increasing the night visibility of traffic markings have not yet been fully explored. There appears to be some promise to their use in black, bituminous paints for cement-concrete-pavement markings. It seems likely that such a paint could be devised which would yield a black line in daylight and a white one at night. Also, with the increasing use of formed white-cement curbing and centerline of special conformation to increase reflective properties, there is some room for experimentation in addition of glass beads to the white mortar to increase its reflective efficiency.

Other attempts to make traffic markings of greater permanence than paints include colored plastic discs cemented and nailed to the road surface. Clear plastic discs of similar design containing sheets of beaded reflective material inside the body of the disc are being tried. Asphalt-composition blocks inlaid in the surface are now coming into wide-spread use for crosswalk markers, and in England plastic centerline stripes have been inlaid in some roads. Only time will tell if this offers a solution to the problem of annual remarking of pavements.

1951 PROGRAM

The continuation of this testing program in 1951 was slightly modified in the light of the previous year's experience. The selection of paints was somewhat smaller, seven manufacturers supplied 24 formulations. This was not a conscious effort to dimish the scope of the investigation but was the result of the suppliers narrowing their own submissions voluntarily to those formulations which they felt would make the best showing.

Another point of difference was that the duplication of transverse stripes, one reflectorized and one nonreflectorized, side by side, was eliminated. Since the current policy of the traffic division is to reflectorize all centerline stripes, it was felt that any paint purchased should be considered on the basis of its performance as a reflectorized stripe, and for the small amount of nonreflectorized painting done by the department, satisfactory performance could be presumed for any paint which performed well when reflectorized.

The major deviation from the procedure of the previous year was in the application-rate control. Whereas in the 1950 application the rate was merely measured after the spray machine operator had adjusted for the optimum stripe he could obtain with each paint, in the 1951 program the application rate was set at 15 gal. per mi. of solid stripe, and the machine was adjusted at this rate plus or minus 5 percent, except in a few instances where the consistency of the paint prevented achievement of the desired rate. One mix was so heavy and viscous that even at maximum pressure and nozzle opening the desired rate could not be forced through the sprayer. No thinning was permitted with any of the samples. One or two of the specimens were so light and low in viscosity that adjustment to the desired application rate resulted in too much paint being deposited; as a result, the paint ran at the edges and puddled in depressions in the pavement. In these cases the application rate was diminished until a satisfactory stripe was achieved and the altered rate was recorded.

The work on this group of samples is not complete, since they were applied August 22, 1951, and the transverse stripes are being evaluated according to the scale and program outlined in ASTM Designation D 821-47, which will be continued until the ultimate failure of all the transverse stripes. The laboratory data and service-evaluation data will be presented in a subsequent report on this work.

TABLE 3

1951 TRAFFIC PAINT EVALUATION PHYSICAL PROPERTIES

Sample and Stripe No.	Specific Gravity	Wet Weight Per Foot	Feet per Gallon	Gallons per Mile	Loss in Weight on Drying	*Approximate Track Free Drying Time	** Type Reflectorization	Color
		Grams			%	Min.		
1	1.542	20.6	324.2	16.3	14.2	11	B.O.P.	W
2	1.447	21.4	331.9	15.9	15.0	9	B.O.P.	W
3	1.506	24.7	387.7	13.8	2.2	19	N.R.	W
4	1.412	21.7	305.4	17.3	10.5	13	B.O.P.	W
5	1.538	24.7	368.4	14.3	8.5	16	B.O.P.	W
6	1.481	21.0	309.7	17.0	16.4	12	B.I.P.	W
7	1.604	20.9	430.5	12.3	3.1	11	B.I.P.	W
8	1.438	23.4	409.2	12.9	9.2	9	B.I.P.	W
9	1.412	22.4	321.9	16.4	12.9	22	B.I.P.	W
10	1.313	22.9	376.5	14.0	15.4	17	B.I.P.	W
11	1.383	23.0	422.1	12.5	12.1	16	B.I.P.	W
12	1.398	24.4	350.4	15.1	8.8	15	B.O.P.	W
13	1.490	25.7	343.9	15.3	13.5	12	B.O.P.	Y
14	1.611	19.5	417.6	12.6	7.4	10		Y
15	1.497	22.3	327.5	16.1	9.4	14	B.I.P.	Y
16	1.304	24.8	376.8	14.0	8.9	16	B.I.P.	Y
17	1.692	27.0	349.9	15.1	7.1	10	B.I.P.	Y
18	1.586	24.0	438.2	12.0	8.7	18	B.O.P.	Y
19	1.090	26.1	338.1	15.6	10.4	9	N.R.	Y
20	1.710	25.9	249.9	21.1	13.9	18	B.I.P.	Y
21	1.434	25.6	313.7	16.8	13.6	16	B.O.P.	Y
22	1.550	22.8	388.5	13.6	8.1	14	B.O.P.	Y
23	1.883	26.2	272.0	19.4	16.4	17	B.O.P.	Y
24	1.813	SPOILED SAMPLE						

* Noon Temperature 79°, Relative Humidity 56%

** B.O.P. = Beads on Paint

B.I.P. = Beads in Paint