New-Old Cost-Cutting Concept in Traffic Marking

HAROLD C. RHUDY AND JAMES R. RITTER

Paint is the predominant traffic marking material in use today. With respect to traffic marking, the needs of traffic engineers, as expressed in 1950, are similar to the needs of traffic engineers today. North Carolina has used a premixed paint dual system for more than 30 years, and has gained experience about the benefits of premixed paint and has solved many of the equipment problems. The experience in North Carolina has indicated that, when compared with a standard paint line, the premixed dual system has the following characteristics: increased service life, extended night visibility, a 3-min dry time, satisfactory daytime visibility, and lower cost. The different theories about a standard line and a premixed line are described. A white centerline placed as a premixed dual line in 1970 is still effective after 12 years of use. Of the 46,000 paved miles of roads in North Carolina, the premixed system is so durable that less than 1 percent of the roads need to be restriped during the same season. The cost savings to the state are substantial, and a low cost per foot of applied line per day of useful life is obtained. The questions raised concerning the use of premixed paint are discussed, and some of the misconceptions held about the premixed dual system are explained. Suggestions are also given on how to specify striping equipment for applying premixed paints.

The greater mobility of people has continually applied pressure on traffic engineers to upgrade their traffic marking systems. In 1950 the relative order of preference for future traffic marking systems, as emphasized by state highway departments, was as follows (1):

1. Increased service life,
2. Night visibility,
3. Increased rate of drying,
4. Storage stability,
5. Day visibility, and
6. Lower cost per gallon.

The needs of state highway departments in 1950--obtaining a fast drying pavement marking material that would have increased durability for day and night visibility and a low cost per foot of applied line per day of useful life--are similar to current needs. Also, the predominant striping material used in 1950 and in use today is traffic paint.

Therefore, it is appropriate to either introduce or reintroduce a new-old cost-cutting concept in the use of traffic paint. The traffic marking system used in North Carolina has saved millions of dollars and many lives over more than 30 years of use. This method is a dual system of premixed traffic paint that has glass spheres dropped on the surface.

BACKGROUND

The premixed dual system was available and was used before 1950. It was reported in 1950 (1) that 50 percent of the states were using a premixed system and 33 percent of the 48 states were using a premixed dual system. In 1955 the states that used a premixed system dropped to 40 percent, and only 17 percent used a premixed dual system (2). In 1965 only 20 percent of the states were using a premixed system of any type (3).

As states decreased their use of the premixed dual system, North Carolina increased the amount of premixed dual system that was applied. For example, in 1950 North Carolina used 95,600 gal of premixed traffic paint and 573,000 lb of glass spheres. By 1960 use had increased to 315,800 gal and 1,894,800 lb; and in 1965 it had increased further to 767,515 gal and 4,605,000 lb. During fiscal year 1981-1982, North Carolina used 840,000 gal of premixed traffic paint and 5,100,000 lb of glass spheres. During the period between 1950 and 1982, approximately 58 percent of the glass spheres were premixed in this paint and 42 percent were drop-on glass spheres.

PREMIXED DUAL PAINT SYSTEM

There are two basic traffic paints available for general highway use. One is a traffic paint in which glass spheres are dropped onto the wet paint immediately after application; this is called the drop-on paint system. The other system adds glass spheres to the paint during the manufacturing process, and this mixture is then sprayed on the road. Additional glass spheres are dropped onto the wet paint film during the application, thereby giving immediate retroreflectivity; this is called a premixed dual (or combination) paint system. Only these two systems are discussed in this paper (plain paint and premixed paint without drop-on glass spheres are not acceptable for general highway use).

A normal plain traffic paint has approximately 6 lb of glass spheres per gallon dropped onto the surface of the wet paint line. The North Carolina premixed traffic paint has a minimum of 3.5 lb of glass spheres per gallon added during the manufacturing process. An additional minimum of 2.5 lb of drop-on glass spheres per gallon are dropped on the wet paint for immediate nighttime reflectivity. Therefore, the 6 lb of glass spheres per gallon is equal in both systems.

In order to appreciate the differences in a standard drop-on line and a premixed system, it is useful to understand both systems. The drop-on glass spheres used by North Carolina are similar to those used by other states (4). The sizes of the glass spheres are given in the following table:

U.S. Standard Sieve Size	Percentage Retained	
	Minimum	Maximum
Passing No. 20, retained on No. 30	5	10
Passing No. 30, retained on No. 50	40	80
Passing No. 30, retained on No. 80	15	40
Pan	0	5

The glass spheres have a refractive index between 1.50 and 1.52 and 80 percent minimum overall rounds per screen.

The glass spheres mixed into the paint during the manufacturing process have the following gradations:

U.S. Standard Sieve Size	Percentage Passing
No. 40	100
No. 60	80-100
No. 100	30-50
No. 200	0-5

These glass spheres also have a refractive index between 1.50 and 1.52, and there are 80 percent minimum overall rounds and 70 percent minimum rounds per screen.

The sizes of these glass spheres are shown in Figure 1. This graph shows that glass spheres are available from 3 to 28 mils, with an average of 14 mils for the drop-on glass spheres and 6 mils for the premixed size. Because a glass sphere should be embedded to a minimum of 50 percent of its diameter,

a 14-mil glass sphere is the ideal size for a 7-mil dry paint film. However, because of the inconsistent thickness of an applied paint line, larger and smaller glass spheres are available to maximize the retroreflectivity of a thicker or thinner paint line.

Because smaller glass spheres are premixed into the paint, the specific gravity of the paint will increase slightly, and the solids content will also increase. As this happens, the cost per mil of the paint decreases.

Both the standard plain paint with drop-on glass spheres and the premixed dual paint are applied the same way from some form of paint storage tank through a paint gun; the glass spheres are then applied by a bead dispenser. Both paints are applied at a film thickness of 15 mils wet, 4 in. wide, at 10 to 15 mph.

When a 15-mil wet standard paint line dries to 7.35 mils, the traffic paint is 49 percent solids by volume. The premixed paint in North Carolina is 62 percent solids by volume and dries to 9.3 mils. Therefore, a gallon of standard paint (49 percent solids) and a gallon of premixed paint (62 percent solids) would both cover 321 linear ft, 4 in. wide, and 15 mils wet. The area covered is the same but, as mentioned, the standard line would dry to 7.35 mils and the premixed line would dry to 9.3 mils. The premixed line would be 26.5 percent thicker than the standard line, which influences durability and the life of the line.

The standard 15-mil wet line with 49 percent solids by volume, which then dries to 7.35 mils and has all glass spheres smaller than 45 mesh (13.9 mils), can be embedded a minimum of 50 percent in the line, as shown in Figure 2a. If this line is worn to 40 percent of its original 7.35 mils, then only 2.94 mils of paint will remain and all the glass spheres will have been lost, thereby leaving a nonreflective paint stripe, as shown in Figure 2b.

A premixed paint applied at 15 mils wet and 62 percent solids will dry to 9.3 mils, as shown in Figure 2c. When this line is worn to 40 percent of the original 9.3 mils, it will still be 3.72 mils thick and contain glass spheres smaller than 80 mesh (7 mils), as shown in Figure 2d. The data in Figure 1 indicate that drop-on beads are generally larger than 6 mils; this explains why no glass spheres are remaining in Figure 2b. A comparison of the data in Figures 1 and 2d indicates that 5 percent of the drop-on spheres and 79 percent of the premixed spheres are still intact. Therefore, 1.5 billion glass spheres would remain in every 321 linear ft of a 4-in. line. Data for 60, 40, and 20 percent remaining paint on the road surface are given in Table 1. The 9.3-mil premixed line is capable of holding all spheres up to 35 mesh (19.7 mils) at 50 percent embedment. As stated previously, because no application of traffic paint can be controlled to a close tolerance, an extra percentage of larger glass spheres are included for those times when the dry film thickness would reach 14 mils. The thicker the paint film, the larger the glass spheres that should be used as a drop on.

Figure 1. Size of drop-on and premixed glass spheres in relation to paint film thickness.

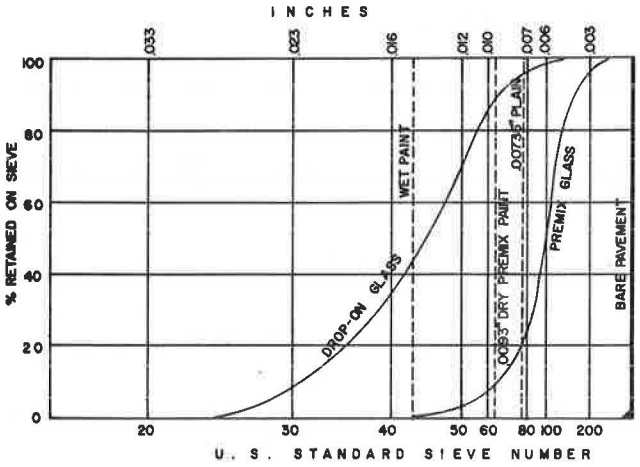


Figure 2. Glass spheres embedded in various dry paint films when new and after wear to 40 percent of original dry film thickness.

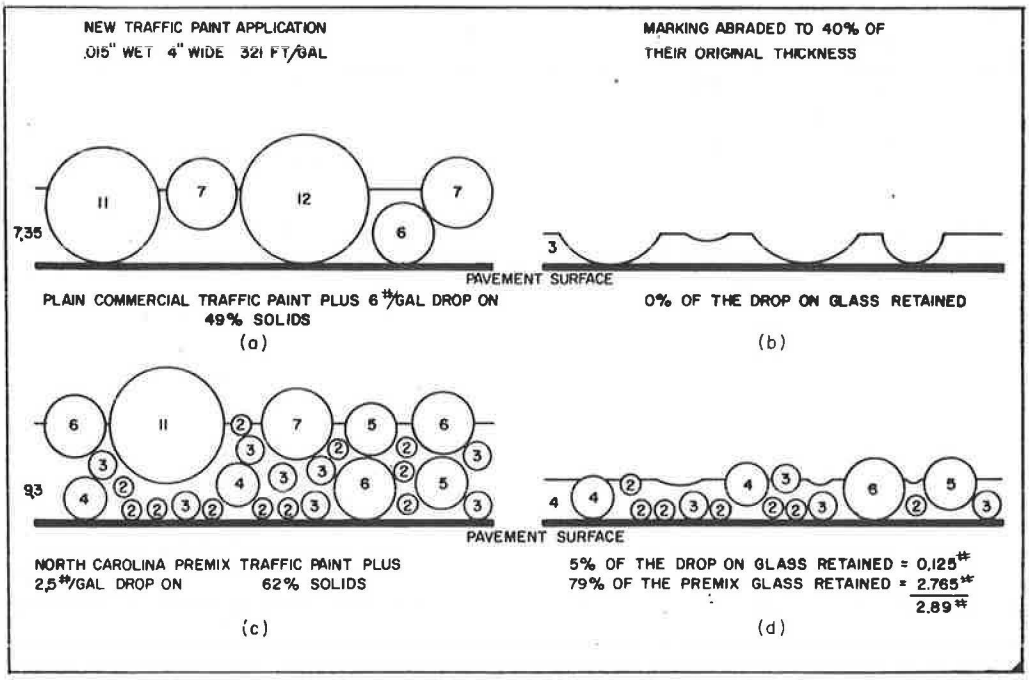


Table 1. Data for remaining paint on road surface.

Item	Plain Traffic Paint Plus 6 lb of Glass Beads per Gallon Dropped on (avg nationwide)	Paint with Premixed Glass Plus 2.5 lb of Glass Beads Dropped on (North Carolina standard)
Percentage of solids by volume	49	62
Dry film thickness, T (in.)	0.00735	0.0093
Maximum size of glass retained [T + 0.5 (in.)]	0.0147	0.0186
Remaining paint on road surface		
60 percent		
Thickness (in.)	0.0044	0.0056
Maximum glass size (in.)	0.0088	0.0112
Glass retained (%)	8 DO	30 DO 97 PM
Weight (lb)	0.47	0.75 DO 3.395 PM
Total		4.145
40 percent		
Thickness (in.)	0.0029	0.0037
Maximum glass size (in.)	0.0058	0.0074
Glass retained (%)	0 DO	5 DO 79 PM
Weight (lb)	0	0.12 DO 2.765 PM
Total		2.890
20 percent		
Thickness (in.)	0.0015	0.0019
Maximum glass size (in.)	0.003	0.0038
Glass retained (%)	0	0 DO 7 PM
Weight	0	0 DO 0.245 PM
Total		0.245

Notes: DO = dropped-on glass beads and PM = premixed glass beads.
It is assumed that all lines are applied at 0.015 wet film thickness, at a 4-in width, for a 321-ft line.

TESTS AND RESULTS

The premixed dual system increases durability, which therefore increases reflectivity. A test of a standard line with drop-on glass spheres was conducted in Alabama, and the standard line was compared with a premixed dual system (5). It was reported that the greater quantity of drop-on beads on the standard line had better initial nighttime visibility, but it had lower durability over a long period of time when compared with the premixed dual system. Also, it was reported that the premixed dual system gave better distribution of the beads in the paint film and had better durability than the standard drop-on line (6). It has also been reported that the main advantage of a premixed line is its greater durability (7).

In order to determine the validity of the North Caroline experience, a series of test lines that used a premixed system were applied next to a standard line in approximately 0.5-mile sections. The standard line consisted of a 15-mil wet commercially available plain paint on which were dropped 6 lb of North Carolina specification drop-on spheres per gallon of paint. The lines were applied on a rural two-lane road to determine the reflectivity and durability under actual driving conditions. These lines were placed so that they were exposed to snow, sand, salt, and studded tires as early as November. A visual evaluation of these lines was made each month by an experienced team of evaluators, which included township policemen and other officials. Photographs and motion pictures were also taken each month. These were used only for illustration, and not for evaluation purposes.

One test area was used to determine if drop-on beads were necessary on premixed lines. A premixed line that did not have drop-on beads applied was placed next to a standard line. The evaluation revealed that, initially, the premixed line did not have satisfactory night visibility when compared with the standard line. Nevertheless, after 8 months of testing, which included 4 winter months, the premixed line was more visible because the standard line was badly worn, as shown in Figure 3. (The premixed line is on the left and the standard line is on the right.)

Another test area was used to determine if the addition of 2.5 lb of glass beads per gallon dropped on the premixed paint increased the night visibility when compared with a standard line. The additional drop-on beads gave greater nighttime visibility than the premixed line without drop-on beads, but it was not as bright as the standard line with 6 lb of glass beads per gallon. The 2.5 lb of beads per gallon droped on the premixed line increased the durability of the premixed line, and after 8 months it was more visible than the standard line, which was more worn. This is shown in Figure 4.

Because North Carolina formulates its own premixed paint, it was necessary to determine whether the advantages with the North Carolina paint were because of the better formulation of quality paint or because of the inherent advantages of the premixed system. A commercially available premixed paint was applied with 2.5 lb of drop-on beads per gallon and compared with a standard line. The test indicated that a commercial premixed paint also had advantages similar to the North Carolina paint, as shown in Figure 5 (the standard line is on the left and the commercial premixed paint is on the right).

North Carolina has not used white centerlines on two-lane, two-way highways since 1970. Figure 6 is a photograph that was taken in July 1982; it shows a white centerline still remaining after 12 years of use (left line of the figure). The other line is yellow paint. Figure 7 shows another road where the white centerline is still intact between the two yellow lines after 12 years in service. Figure 8 shows still another road, and again the white line is still visible. These photographs were taken in 1982, 12 years after the white stripe was applied.

North Carolina has been using the premixed dual system for more than 30 years. Numerous paint tests have proved that the premixed system has a longer life because of the small premixed glass spheres. These small glass spheres provide wear resistance and durability while also providing retroreflectivity down to the last speck of paint on the road surface. The longer life (reflectivity and durability) reduces the repainting cycle needed for an effective line. Thus safety is enhanced because (a) the motorist has continuous day and night visibility and (b) the time necessary for personnel and equipment to be exposed to the hazards of striping highways is reduced. The use of a premixed dual system in North Carolina saves the state money in materials and application costs and also saves the motoring public money by having safer highways.

Several years ago North Carolina found that in painting some 46,000 paved miles of highways and rural streets (12,000 miles of the primary and 34,000 miles of the secondary system), approximately 100 percent of the centerlines and edge lines on the primary system and 73 percent of the centerlines and 21 percent of the edge lines on the secondary system were painted each year. This painting program has been reduced by about 15 percent without an appreciable reduction in the quality of the painted line. For many years North Carolina found that repainting the same line during the same paint season because

Figure 3. Premixed line with no drop-on beads (left) and standard line (right): initially in June (top) and after 8 months in February (bottom).

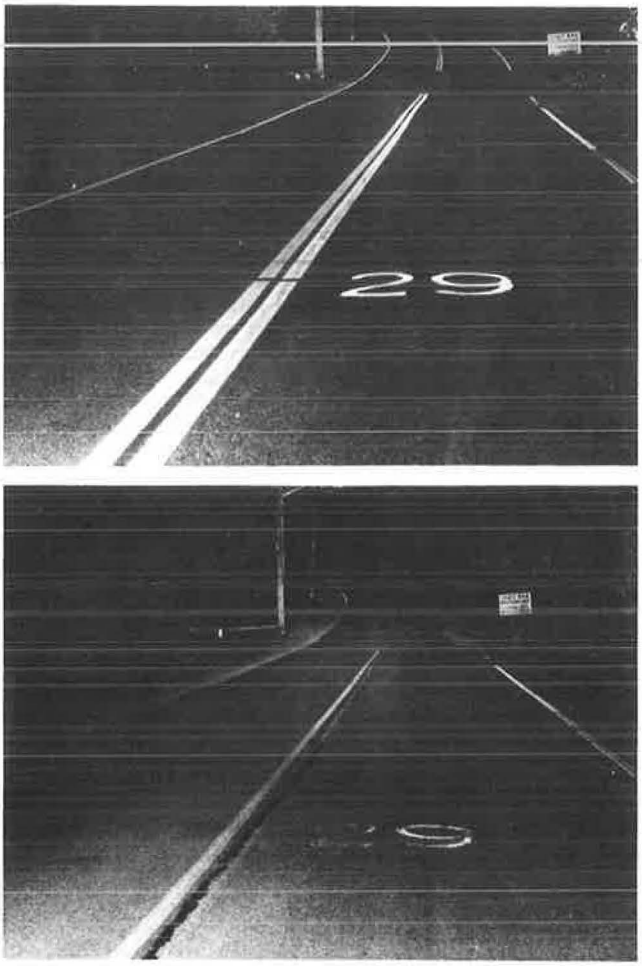
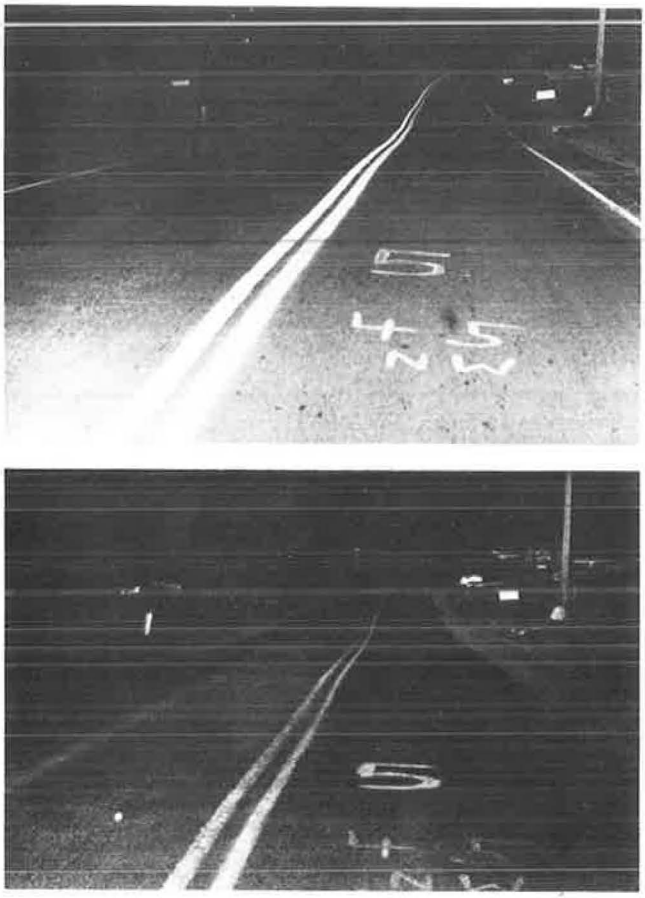


Figure 4. Condition of standard line (left) and premixed dual line with 2.5 lb of glass beads per gallon dropped on (right): initially in May (top) and after 8 months in January (bottom).



of heavy traffic volumes amounted to less than 1 percent during the same season.

By using North Carolina paint costs for plain paint plus 6 lb of drop-on glass spheres per gallon versus premixed paint plus 2.5 lb of drop-on glass spheres per gallon, the premixed system saved a considerable amount of money. Because North Carolina used 840,000 gal of paint during fiscal year 1982, the state saved $193,000 (see Figure 9). Studies in North Carolina indicated that the cost of a traffic painting operation is approximately 21 percent labor, 12 percent equipment, and 67 percent materials. Because of the longer durability of the premixed dual system, there is less need to repaint; therefore, there are lower costs for materials, labor, and equipment.

EQUIPMENT

With all the advantages that can be obtained with a premixed dual system, there are agencies that raise legitimate questions about the system. Based on more than 30 years of experience, the following comments are appropriate.

Generally, a premixed traffic paint must be manufactured by using better raw materials and must be formulated to closer tolerances. This also requires an understanding of the settling that can occur and methods to counteract this behavior. All paints, regardless of their intended use, will settle to some extent with time. Paints that contain a higher percentage of solids will settle more than those paints that contain a lower percentage of solids at the same viscosity. Traffic paints with premixed glass spheres have a tendency to settle a little more; hence there is the need for an antisettling agent to be formulated into the paint.

Any good painting operation, regardless of type, will have a means to agitate or tumble the paint before its use. Traffic painting is no different, and the paint should not be stored for any length of time without agitation. The paint should be used on a first-in, first-out basis and should be thoroughly mixed before and during application.

The equipment required to apply any traffic paint is specialized and expensive. It has to be designed and constructed for the particular operation by using the best materials and workmanship. Once the equipment is placed in operation, it must be well maintained. A major concern of nonusers of premixed paint is the wear on paint gun parts and pumps, and the downtime that would result from this wear. This wear and downtime have amounted to approximately 0.3 percent of the marking program costs in North Carolina. A majority of this expenditure would be required even with a plain paint system, considering that approximately 1 million gal of paint per year is applied on the highways through 28 machines (14 centerline and 14 edge line machines).

The experience in North Carolina has diminished many of the problems with equipment by specifying the following guidelines:

1. The equipment uses a traffic paint with glass beads mixed in the paint;
2. The paint storage tank should be fitted with a removable top, and the bottom should slope to allow drainage for each compartment;
3. A minimum of one hydraulic-driven material agitator that has speed control and a valve shutoff should be used; the props should be as large as practical and of sufficient size to keep the glass and paint pigments in suspension;
4. Air-operated diaphragm pumps should be equipped with Teflon ball valves and diaphragms; wetted parts should be made of stainless steel; and all material conductors, other than the pipes, should be nonmetallic and flexible and have a solvent-resistant nylon or Teflon base;

Figure 5. Condition of standard line (left) and commercial premixed paint with 2.5 lb of glass beads per gallon dropped on (right): initially in May (top) and after 9 months in February (bottom).

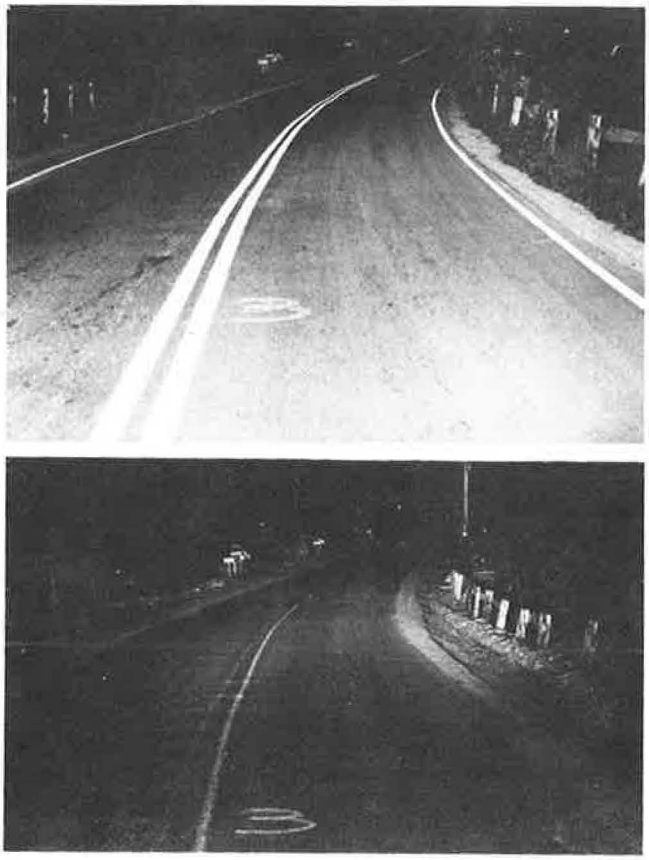


Figure 6. White premixed paint (centerline, upper left) after 12 years of service; rest of line painted over in yellow.

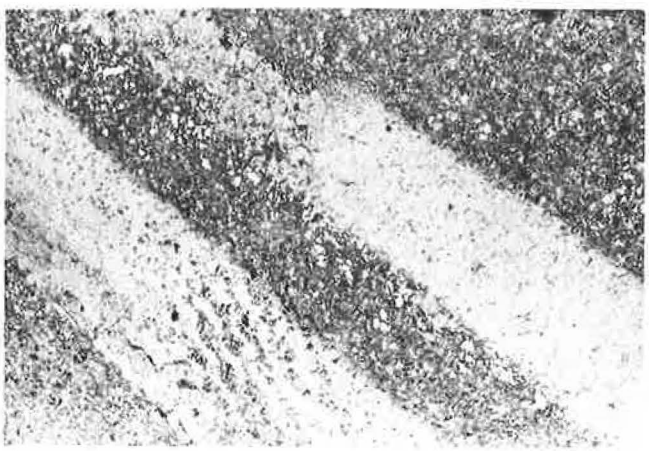


Figure 7. White premixed paint (centerline) after 12 years of service, shown between yellow lines.

Figure 8. White premixed paint (centerline) still visible after 12 years of service.

Figure 9. Cost savings.

PLAIN PAINT + 6#/GAL D.O.			P.M. + 2.5#/GAL D.O.	
WHITE -	$ 4.08		WHITE -	$ 4.69
GLASS 6# X $.23 =	$ 1.38		GLASS 2.5# X $.23 =	$ .575
	$ 5.46	DIFF. = $ .185		$ 5.275
		X 422,395 GALLONS		
		$ 78,143		
YELLOW	$ 4.26		YELLOW	$ 4.79
GLASS 6# X $.23 =	$ 1.38		GLASS 2.5# X $.23 =	.575
	$ 5.64	DIFF. = $ .275		$ 5,365
		X 417,525 GALLONS		
		$ 114,819		
			$ 78,143	
			$ 114,819	
ASSUME ANNUAL PAINTING			TOTAL $ 192,962	MATERIAL

ADDITIONAL SAVINGS IN LABOR AND EQUIPMENT RENTAL DUE TO NEED TO PAINT LESS OFTEN. ALSO LESS EXPOSURE OF PUBLIC TO PAINT EQUIPMENT ON HIGHWAY AND CONTINUOUS REFLECTORIZATION "REDUCES" ACCIDENTS.

5. The paint conductors, which are rigid paint lines and fittings, should be at least 2-in. standard weight pipe, and all valves in these lines should be of the full-throated ball-valve type with Teflon seats; and the nonrigid paint conductors should be flexible and made of a solvent-resistant material of at least 0.5-in. inside diameter;

6. The truck-mounted guns should be Binks 21 with brass bodies capable of processing premixed material in quantities that will yield a line of 15-mil wet film thickness and a sharp, clean 4-in.-wide line; and

7. Hand spray guns should be a Binks Model 69 equipped with a number 59A fluid nozzle, a number 242 air nozzle, and a number 559 needle.

Another concern of the nonusers of premixed paint is the attitude of the maintenance people. If this group is not fully trained and convinced that their effort is necessary, the best results will not be obtained. Placing a standard line alongside a premixed line in each district would illustrate the results of their care and concern.

Because a standard line has 6 lb of glass spheres per gallon on the surface of the line compared with 2.5 lb on the premixed line, the premixed line may not be as visible at night initially. If this is objectionable, it can easily be corrected by applying more drop-on glass spheres. This is shown in Figure 10, where a premixed paint line with 5 lb of glass spheres per gallon dropped on is shown on the left and a standard line with 6 lb of glass spheres per gallon dropped on is shown on the right. Nevertheless, as the line wears, the premixed line retains more visibility compared with the drop-on line, and it can be seen for a longer period because it is more durable, as shown in Figure 11.

Figure 10. Premixed line with 5 lb of glass beads per gallon dropped on (left) and standard line with 6 lb of glass beads per gallon dropped on (right).

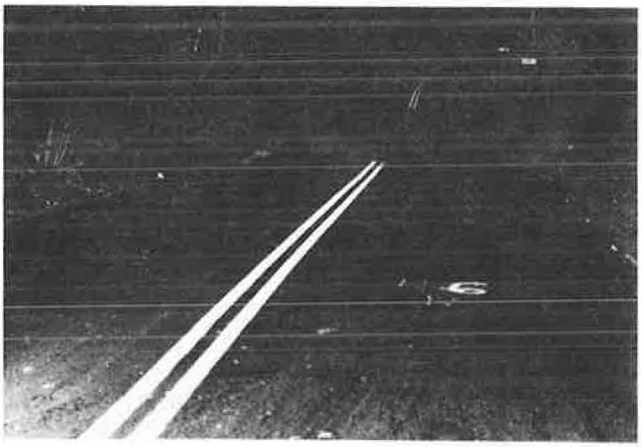
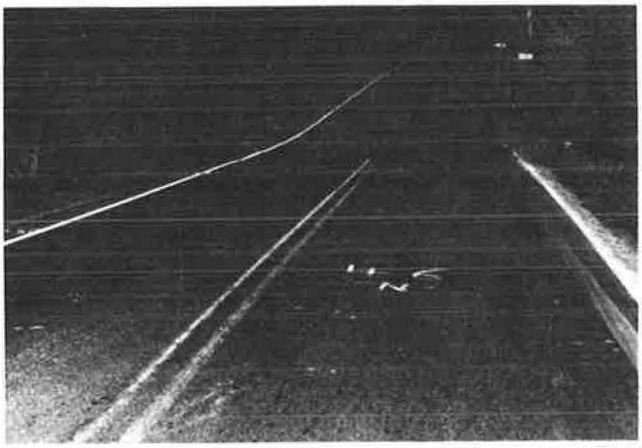


Figure 11. Same as Figure 10, but after being in service.



CONCLUSIONS

After more than 30 years of experience in North Carolina, the premixed dual system has proved to be a durable reflective system that saves the state money. North Carolina also uses a 3-min premixed dual system that has the same characteristics as the conventional drying premixed paint.

The North Carolina premixed dual system has the following advantages over other systems:

1. Increased service life,
2. Extended night visibility,
3. Rapid drying time,
4. Satisfactory and long-time visibility during the day, and
5. Lower cost.

The cost per foot of applied line per day of useful life should be the criterion for selecting the traffic paints for all agencies. All costs such as material, labor, and equipment must be considered as well as the wear characteristics. The life in terms of longer reflectivity and greater durability is the key to maximizing the traffic markings on streets and highways.

REFERENCES

1. G.W. Ashman. Present Preferences for Traffic Paint. HRB, Bull. 36, 1951, pp. 7-24.
2. A Study of Traffic Paint Specifications. HRB, Highway Research Correlation Service Circular 347, Oct. 1957, 10 pp.
3. 1965 Usage of Pavement Marking Materials by Government Agencies in the United States. HRB, Highway Research Circular 79, April 1968, 19 pp.
4. Glass Spheres, Retroreflective. North Carolina Department of Transportation, Raleigh, North Carolina Specification 8010-GS-1a, Aug. 1978.
5. F.L. Homan. Glass Beads for Traffic Marking Paint. Alabama Department of Highways, Montgomery, HRP Rept. 55, July 1971.
6. Pavement Traffic Marking--Materials and Application Affecting Serviceability. NCHRP, Synthesis of Highway Practice 17, 1973, 44 pp.
7. J.R. Ritter. Glass Beads for Highway Paint Stripes. FHWA, Rept. FHWA-TS-78-213, 1978, p. 8.

Publication of this paper sponsored by Committee on Traffic Safety in Maintenance and Construction Operations.