

EPOXY THERMOPLASTIC PAVEMENT MARKING MATERIAL

A Final Report

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By

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16. Abstract <p>The results of a two-year field evaluation of ETP, an epoxy resin based thermoplastic pavement marking material, are presented. The study, conducted as a part of FHWA Demonstration Project No. 60, compared the performance of the white ETP lane and edgelines to that of a control (conventional traffic paint) on moderately trafficked bituminous and portland cement concrete pavements.</p> <p>The markings were inspected seven times during the evaluation period and at each inspection were subjectively rated for appearance, durability, and night visibility. Additionally, photographic documentation was made of representative sections of the striping during the day at several inspections.</p> <p>Application of the ETP marking material was initially hindered by equipment problems, but they were not believed to have adversely affected the material's performance.</p> <p>ETP pavement marking material was not cost-effective in this installation since it failed to provide the expected two years of useful service life.</p>			
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CONCLUSIONS

The principal conclusions from this evaluation are as follows:

1. While ETP generally outperformed the control in terms of drying time, appearance, and durability, its overall performance was disappointing in that it failed to provide the anticipated two years of useful service life.
2. Night visibility, considered the most critical parameter in this evaluation, was judged inadequate on both pavement types by the end of the first year of service (actually, between 6 and 12 months) . This finding renders the ETP material not cost-effective since it costs from four to six times more than conventional traffic paint.

RECOMMENDATION

Based on the findings of this study, further use of ETP by the Department is not recommended.

PART ONE: INTRODUCTION

1.1 Objective

The primary objective of this research was to compare the performance and cost-effectiveness of ETP marking material to that of New Jersey's conventional traffic paint.

1.2 Background

In April 1983, the Federal Highway Administration launched Demonstration Project No. 60 to promote the benefits and application of a promising new epoxy resin based thermoplastic pavement marking material known as ETP (or EPOFLEX). This material was jointly developed by the FHWA's Office of Research and the Southwest Research Institute of Texas.

At that time, ETP had been field tested around the country for more than two years and experience had shown it to be superior in several aspects to most other currently available durable marking materials (e.g., thermoplastics, two-component epoxy and polyester). Reported benefits of ETP were:

- good durability and night visibility on both bituminous and portland cement concrete surfaces (i.e., a minimum of two years' service under moderate to heavy traffic conditions)¹
- fast drying time (can be exposed to traffic in less than six seconds),
- application versatility (can be applied over a wide range of air temperatures), and
- a reduction in overall life-cycle costs compared to conventional traffic paint.

New Jersey considered this demonstration project to be particularly timely, since the development of a more durable pavement marking material for

high-volume roadways was deemed a critical need in our state. Indeed, at about the same time the demonstration project began, the Department formed a task force on long-life lines to address this specific problem. Accordingly, in April 1984, a trial installation of ETP was made to determine its performance under New Jersey conditions.

PART TWO: TEST INSTALLATION

2.1 Test Site Description

The following portions of the northbound roadway of Alternate Route U.S.1 in the City of Trenton, and Lawrence Township was selected for the ETP trial installations:

<u>Location</u>	<u>Pavement Type</u>	<u>One-Way AADT</u>
Milepoint 2.30 to 4.00; S of Olden Avenue to N of Whitehead Road	Portland Cement Concrete	9,000
Milepoint 4.00 to 5.50; N of Whitehead Road to Vicinity of Carnegie Road	Bituminous Concrete	14,400

This section of Route 1 is a four-lane divided facility with traffic volumes which would be considered moderate for New Jersey.

Although in service for some 32 years, the portland cement concrete surface was in fair to good condition. The existing traffic markings (paint) were also in reasonably good condition.

The ten-year old bituminous surface was also in fair to good condition except for a continuous, narrow longitudinal joint separation at the centerline and along the outer pavement edge. This condition intermittently passed through both the lane-line and edgeline markings. Although the existing markings were in good condition, some were partially covered by an excess of recently applied rubberized sealant material.

2.2 Materials

ETP is a 100 percent solid formulation (containing no solvents or other volatile components) and is a generic material consisting of a blend of two epoxy resins, pigment, filler, and glass beads in the following proportions:

Solid resin: 30 parts by weight solid epoxy resin,
Liquid resin: 20 parts by weight liquid epoxy resin,
Pigment: 10 parts by weight titanium dioxide, (white formulation)
or 9.26 parts by weight silica-encapsulated lead chromate,
medium yellow pigment (yellow formulation)
Filler: 10 parts by weight calcium carbonate
Beads: 14 parts by weight standard premixed glass beads

According to Niessner (1982) the above components have equivalents readily available from several manufacturers.

ETP is sometimes confused with epoxy paints (resin systems) because both materials contain epoxy resins. However, ETP is quite different in that it is manufactured in a homogeneous block which must be heated to about 460^oF prior to application. With the two-component epoxy paints, the resin is heated separately, then blended with a hardener prior to application.

Approximately 63 gallons of the white ETP formulation was used on the subject project. Time and manpower restrictions prevented application of the yellow striping.

Application of the control material consisting of conventional New Jersey Type IV white traffic paint was delayed due to equipment problems.

2.3 Equipment

The striping equipment used on this project was built by the Redland Prismo Corporation. The basic vehicle was a 1982 Ford truck Model F-900. The general configuration was similar to the Illinois striper described in Reference 1 except for two notable features.

First, the ETP striper employed an atomized spray system as opposed to the Southwest Research Institute (SWRI) recommended low-pressure airless (nonatomized) spray process. Use of an atomized system was encouraged by the striping industry who contended it would enhance stripe uniformity. That is, the atomized system increases spray velocity which should eliminate/alleviate the "fluttery" pattern (characterized by void spots within the center portion of a stripe) frequently encountered with the airless system.

The second major difference between the two stripers was in the melter volume. The FHWA striper was modified (elongated) to accommodate the second melter tank. The two melter tanks had a total capacity equivalent to about twice that of the Illinois striper.

The ETP unit also differs from a conventional paint striper in that it requires the following components:

- melting equipment - melter tanks (with a 1-inch oil jacket on the - sides and bottom), heating furnace, oil transfer pumps and plumbing, and a small gasoline driven motor-generator,
- jacketed pressurized application tank,
- surge tank,
- temperature indicator, and
- ETP thermostats.

Like most conventional stripers, the ETP striper is equipped with a center control console (at the rear of the vehicle) with carriage operator seats and a steering wheel on either side. Vertically telescoping right and left gun carriages (power-steered horizontally) are located just behind the rear truck wheels. Access steps are provided at the rear portion of the platform and on either side. A metal shade canopy covers the rear facing, lighted flashing arrow-board which pointer/stripping guide castoring wheel attached to the front bumper.

More detailed equipment information, including schematics and major component/manufacturer data, is provided in Reference 1.

2.4 Construction

2.4.1 Surface Preparation

About 24 hours prior to the ETP application, all pavement surfaces were cleaned with compressed air to remove dirt, dust, and loose foreign materials.

It should be noted here that since the successful application and long-term performance of ETP is dependent upon the bond between the marking material and the pavement surface, the FHWA recommends that ETP not be applied over existing markings that exhibit chipping or delamination. Since the existing markings on the study test site were in good condition (i.e., no indication of bond failure), their removal was not considered necessary.

2.4.2 Application

Experimental Striping (ETP)

The subject striping installation employed a three-man striping crew from the FHWA Demonstration project staff. The crew included a driver, operator and a third member who assisted in the equipment preparation and monitoring the operation of various components of the application system. Although the striper is designed/equipped to simultaneously apply edgelines and skip-lines of the same color, equipment problems (i.e., clogged spray gun nozzles) precluded this type of operation. As a result, two passes were required to complete the installation.

ETP exhibited an almost instantaneous (4-6 seconds) "no track" drying time. This eliminated the necessity for coning and the related traffic control costs.

The observed line thicknesses were generally satisfactory (i.e., minimum 15 mils, dry) throughout the range of standard applying speeds. However, travel speed was observed to effect thickness. For example, a measured line thickness of 13 to 15 mils was achieved at a striper speed of about 7 mph, while 18-20 mil thicknesses were observed at the speed of about 4.5 mph. Drop-on glass beads were applied at the desired rate of approximately 6 lbs. per gallon of ETP. Pertinent ETP application data are presented in Appendix A.

Control Striping (NJ Traffic Paint, Type IV)

The control striping was applied within five inches of and parallel to the ETP edgelines (pavement side) from milepost 3.0 to 5.0. Lane-line control markings were similarly applied adjacent to the first ten lines of ETP on the portland cement concrete site and between the first ten lines on the bituminous section.

PART THREE: PROBLEMS ENCOUNTERED

3.1 ETP

The start of the actual striping operation was delayed due to a minor equipment problem (i.e., a defective drive belt) on the generator supplying power to the pumps, valves, tank agitators and controls. A spare drive belt was not immediately available and subsequent replacement efforts resulted in about 1½ hours downtime. Once a new belt was installed, the pre-heating (melting) function was resumed.

When the material was reheated to the recommended application temperature of 460°F, efforts to begin striping were interrupted by clogged spray gun nozzles. The striping crew chief suggested that this may have been caused by partially polymerized material. This situation was remedied by disassembling and cleaning the nozzles and the ETP striping installation was accomplished without further problems.

3.2 Control Striping

Unfortunately, due to problems with Department's striping equipment, the control striping was not applied until some three months after the ETP installation.

PART FOUR: MONITORING PROGRAM

In accordance with the guidelines provided in the Demonstration Project prospectus, the evaluation of the ETP installation included the following:

1. The placement and performance of ETP installations was monitored and compared to that of a control consisting of conventional traffic paint over a 2-year period on both bituminous and portland cement concrete pavement surfaces.
2. The project was inspected seven times (after an initial assessment) during the evaluation period at intervals of 1, 3, 6, 12, 18, and 24 months.*
3. At each inspection, the markings were subjectively rated on the basis of the following performance criteria:
 - a. appearance (including color and cleanliness)
 - b. durability (material retention)
 - c. night visibility

As shown in Appendix B, for each of the above criteria, the lines were rated numerically from unsatisfactory to excellent on a 10-point scale, with a rating of 10 indicating a perfect condition and 0, complete failure. A rating below 4 indicates inadequate performance.

4. Photographic documentation of representative sections of ETP and the control material (conventional traffic paint) were made at the 1, 3, 6, 12 and 24 month inspections (see Exhibits 1 and 2).

*This schedule conforms to that shown on the Demonstration Project Evaluation Form. As it turned out, the use of closer inspection intervals (e.g., bi-monthly), after the 6-month evaluation would have allowed for a more accurate determination of the point of failure.

PART FIVE: STUDY FINDINGS

The performance ratings for the test and control lines at each of the seven inspections are presented in Appendices C & D. As noted in the appendices, the control striping behaved, generally, as expected. That is, night visibility had reached a terminal level after about 6 months in service. Accordingly, it was restriped twice during the evaluation period.

A summary analysis of the tabulated performance information for ETP is as follows:

5.1 Appearance

Although the ETP markings exhibited some discoloration (yellowing) which lowered the rating after only 3 month's service, adequate daytime delineation was provided for 18 and 24 months, respectively, on bituminous and portland cement concrete pavements.

5.2 Durability

5.2.1 Portland Cement Concrete Pavement

Generally poor material retention was observed. That is, about a 30 percent average material loss was observed at 12 months and 50 percent at 18 months at which time it was judged inadequate.

Basically, this was attributed to chipping and delamination of the underlying (paint) markings, a condition which was not apparent at the the time of ETP installation. This also adversely affected the general appearance.

5.2.2 Bituminous Concrete Pavement

Good to excellent durability was observed throughout the 24-month evaluation period.

5.3 Night Visibility

On both pavement types, night visibility was judged to be adequate at the 6 month inspection and inadequate at the 12 month inspection. Visibility failure was attributed to poor bead retention.

5.4 Equipment

a. Clogging of the spray gun nozzles occurred following reheating of the material. This is believed to have been caused by partially polymerized material lodged in the nozzles. This problem was similar to that encountered in an earlier New Jersey study.² The recommendation in that study (use of an additional spray gun with line filters to facilitate cleaning) may well be applicable to the ETP system.

b. A substantial deposit of partially polymerized flakes were observed in the bottom of the melter tank after unused material was disposed of following the striping installation. This polymerization was probably the result of reheating the material following an inadvertent shutdown. Although the tank deposits are not unusual and have no apparent adverse affect on the material's performance, repeated heating and cooling (more than two cycles) reportedly causes the material to fully polymerize, making it almost impossible to remove from the equipment (see Reference 1).

PART SIX: COSTS

Since the study striping was installed by FHWA Demonstration Project personnel, no material and/or labor costs per se were incurred by the Department. However, if this ETP installation had been made at FHWA estimated/average unit prices of \$0.12 (1984) to \$0.18 (1985) per lineal foot, the striping would have to provide a useful service life of 1.5 to 2.25 years to be equivalent, in terms of annual costs to our conventionally used traffic paint.* On this basis, having provided a useful service life of only 6 to 12 months, this ETP installation was not cost-effective.

It is important to note that New Jersey is apparently not alone in finding ETP not cost-effective. That is, in spite of initial reports citing an ETP service life of two years or more, recent experience with ETP by others (e.g., Pennsylvania and Delaware), reportedly has been equally as disappointing as that in New Jersey.

*The estimated annual cost of traffic paint is \$0.08 per foot based on a typical installation price of \$0.03 per foot (by Department forces) and an average life of 4.5 months.

PART SEVEN: REFERENCES

1. Niessner, Charles W. "Epoxy Thermoplastic Traffic Marking Material, Report No. FHWA-IP-82-14, July 1982.
2. Younger, C. L., "Evaluation of An Epoxy Resin Pavement Marking System", A Final Report, Report No. FHWA/NJ-84-004, December, 1985.

APPENDIX A: SUMMARY OF APPLICATION DATA

MARKING	DATE APPLIED	DESCRIPTION	APPROX. LINEAR FT. APPLIED	START STOP	TEMPERATURE °F			APPROX. MAT'L APPL. RATE (ft/gal)	APPROX. BEAD APPL. RATE (lbs/gal)	DRYING TIME No Track	FILM THICKNESS (mils)	LINE APPEARANCE
					AIR	PAV'T	(appl) MAT'L					
ETP	4-4-84	4" Solid 4" Lane (White)	16,900 2,130	11 am 2 pm	65	68	460	343 254	6	4-6 (secs)	13-15 18-20	Very good; extremely bright during the daytime and very good initial nighttime reflectivity as determined by visual observation.
CONTROL (NJ Type Iv Traffic Paint)	7-16-84	4" Solid 4" Lane (White)	16,900 250	-- --	75	80	---	330	5	4 (min)	15-17	Very good; good initial nighttime reflectivity.

APPENDIX B: SUMMARY OF PERFORMANCE DATA ON PORTLAND CEMENT CONCRETE PAVEMENTS

Factors: Each factor shall be averaged over the project site for that material.		Initial		1 MONTH		3 MONTH ^a		6 MONTH		12 MONTH ^b		18 MONTH ^b		24 MONTH ^b	
		LANE	EDGE	LANE	EDGE	LANE	EDGE	LANE	EDGE	LANE	EDGE	LANE	EDGE	LANE	EDGE
		ETP		CONTROL		ETP		CONTROL		ETP		CONTROL		ETP	
I. Appearance (daytime; to include color and cleanliness) 10 = Excellent 7 = Good (Minor distress, appearance unaffected) 5 = Fair (Detracts from appearance up close) 3 = Poor (Visibility Suffers)	ETP	10	10	8	8	5	7	5	5	4	4	3	4	3	3
	CONTROL	10	10	6	7	7	7	7	7						
II. DURABILITY (daytime; material retention) 10 = 100% intact 7 = 70% intact 5 = 50% intact 3 = 30% intact 0 = all gone	ETP	10	10	8	8	7	7	7	7	7	7	4	6	3	4
	CONTROL	10	10	10	10	9	9	10	10						
III. NIGHT VISION 10 = Excellent (Clearly visible some distance ahead) 7 = Good (More than 7 stripes or equivalent distance visible) 5 = Fair (4 to 7 Stripes or equivalent distance visible) 3 = Poor (3 or less stripes or equivalent distance visible) 0 = Unsatisfactory (invisible)	ETP	10	10	8	8	5	5	5	5	3	3	3	3	3	3
	CONTROL	7	10	5	5	5	5	5	5						
IV. TOTAL RATING (20*I + 30*II + 50*III)/100	ETP	10	10	8	8	5.6	6	5.6	5.8	4	4	3.3	4	3	3
	CONTROL	8.5	10	6.7	6.9	6.6	6.6	6.9	6.9						

Notes:

^a Control in service 4.5 months at this inspection.

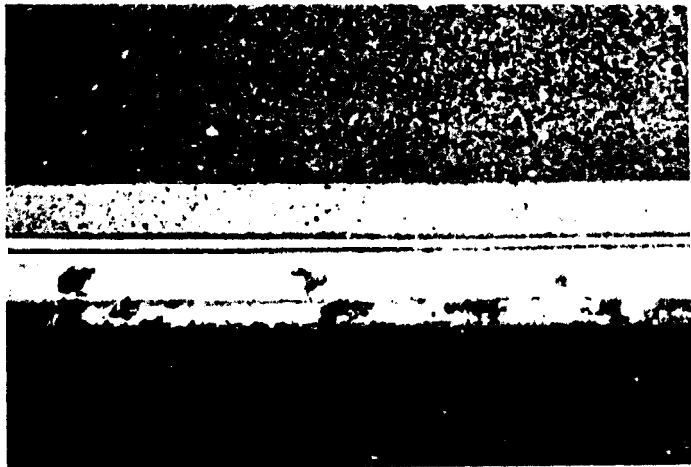
^b No control evaluation at these inspections due to restriping.

APPENDIX C: SUMMARY OF PERFORMANCE DATA ON BITUMINOUS CONCRETE PAVEMENT

Factors: Each factor shall be averaged over the project site for that material.		Initial		1 MONTH		^a 3 MONTH		6 MONTH		^b 12 MONTH		^b 18 MONTH		^b 24 MONTH		
		LANE	EDGE	LANE	EDGE	LANE	EDGE	LANE	EDGE	LANE	EDGE	LANE	EDGE	LANE	EDGE	
		E T P		C O N T R O L												
I. Appearance (daytime; to include color and cleanliness) 10 = Excellent 7 = Good (Minor distress, appearance unaffected) 5 = Fair (Detracts from appearance up close) 3 = Poor (Visibility Suffers)	E T P		10	10	7	7	5	5	5	5	5	5	4	4	4	3
	C O N T R O L		10	10	7	7	7	7	7	7						
II. DURABILITY (daytime; material retention) 10 = 100% intact 7 = 70% intact 5 = 50% intact 3 = 30% intact 0 = all gone	E T P		10	10	10	10	10	10	10	10	10	10	10	10	9	9
	C O N T R O L		10	10	10	10	9	9	10	10						
III. NIGHT VISION 10 = Excellent (Clearly visible some distance ahead) 7 = Good (More than 7 stripes or equivalent distance visible) 5 = Fair (4 to 7 Stripes or equivalent distance visible) 3 = Poor (3 or less stripes or equivalent distance visible) 0 = Unsatisfactory (invisible)	E T P		10	10	7	7	5	5	3	5	3	3	3	3	2	3
	C O N T R O L		10	10	4	5	5	5	5	5						
IV. TOTAL RATING (20*I + 30*II + 50*III)/100	E T P		10	10	8	8	6.5	6.1	5.5	6.1	5.5	5.5	5.3	5.3	4.5	4.8
	C O N T R O L		10	10	6.4	6.9	6.6	6.6	6.9	6.9						

Notes:

- ^a Control in service 4.5 months at this inspection.
- ^b No control evaluation at these inspections due to restriping.



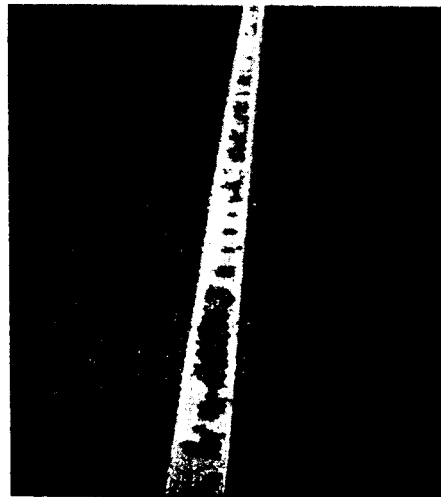
1 Month



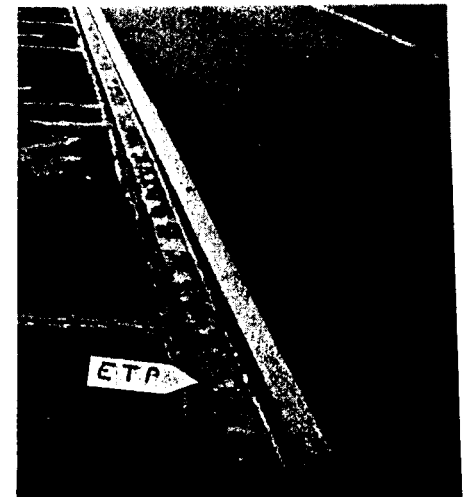
3 Months
(Control 4.5 Months)



6 Months

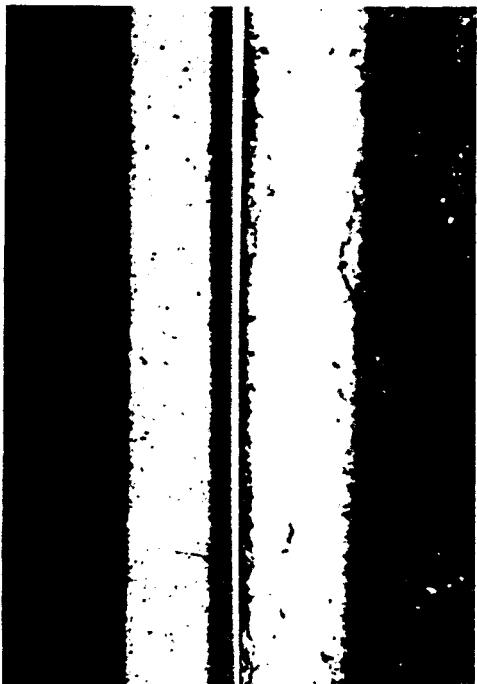


12 Months

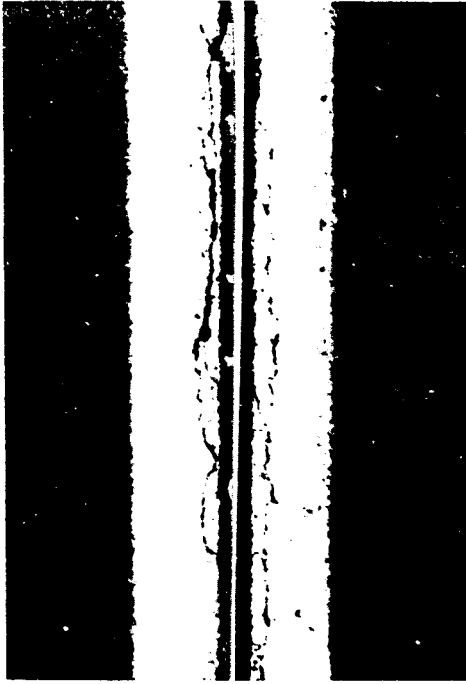


24 Months

EXHIBIT 1: Typical condition of ETP edge lines on portland cement concrete pavement (ETP - Bottom Stripe; Control - Top Stripe in 1, 3 and 6 month photos).



1 Month



3 Months
(Control 4.5 Months)



6 Months

No Control Photo



12 Months



24 Months

EXHIBIT 2: Typical condition of ETP edge lines on bituminous concrete pavement (ETP - Bottom Stripe; Control - Top Stripe in 1, 3 and 6 month photos).