

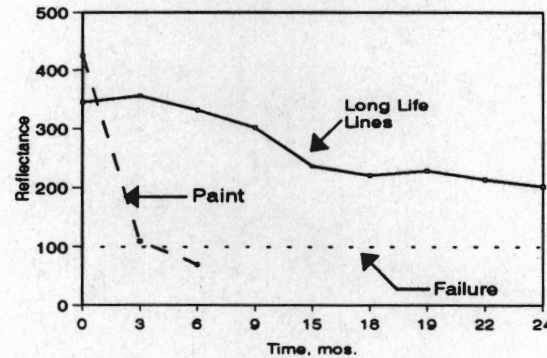


# EVALUATION OF LONG LIFE TRAFFIC LINES

Rt. I-280, Contract No. 1

## FINAL REPORT

### REFLECTIVITY



By

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16. Abstract  This report presents the results of a two-year evaluation of alternate long life traffic markings installed on Interstate Route I-280. Both epoxy and preformed tape markings performed satisfactorily through 24 months under severe exposure conditions (i.e., AADT >85,000). This result verifies that epoxy markings are cost-effective. A similar statement cannot be made about the preformed tape, since its break-even point occurs after 30 months in service. Based upon the observed condition of the markings at the time of restriping, it is estimated that both materials can provide satisfactory service for up to 36 months.  Epoxy markings are recommended for future projects satisfying the criteria outlined by the Department's Task Force on Long Life Lines (LLL). Revised LLL specifications are presented and recommended for future work.  It is also recommended that the Department continue to evaluate promising long life marking materials, particularly for high traffic and/or congested areas. In view of the encouraging performance of the preformed tape, a more comprehensive evaluation (including edge line and gore markings in high impact areas) is warranted to determine the cost-effectiveness of such material.			
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## **IMPLEMENTATION STATEMENT**

The researcher and the Task Force on Long Life Lines have utilized the study findings to revise the Department's initial specifications presented in Appendix A. The latter encompasses the three (3) major operations involved in this work; requirements relative to materials, removal of existing lines and application of new markings.

Based on the successful performance of epoxy markings in the study installation, the Department implemented the striping policy outlined in section 3.4 by letting five (5) Maintenance contracts in 1991. The revised specifications were also implemented on these projects.

## PART 1: CONCLUSIONS

- 1.1 The overall performance of the epoxy pavement markings is judged satisfactory after 24 months in service under severe exposure conditions (AADT >85,000). Accordingly, this material exceeds the criteria necessary to be cost-effective relative to New Jersey's conventional paint markings. The latter would have required restriping 4 to 5 times during this evaluation period.
- 1.2 Generally, epoxy material retention was very high, averaging 90 percent after 24 months. However, not unexpectedly, markings at several high-impact areas such as acceleration/deceleration lanes, gore and weaving areas exhibited considerably more wear (only 30 to 50 percent material retention).
- 1.3 Production rates of both the removal and striping operations were adversely affected by inadequate removal equipment and/or procedures employed as well as restrictions on working hours.
- 1.4 Dust created by removal equipment/operations was frequently disruptive to traffic and thus presented a potential safety hazard.
- 1.5 Removal will be substantially minimized on future contracts since new epoxy markings may be applied directly over existing epoxy striping.
- 1.6 The performance of preformed tape (lane line) markings is adequate after 24 months in service. However, at least a 30 - month period of satisfactory performance is required for this

material to be cost-effective relative to conventional paint markings.

## PART 2: RECOMMENDATIONS

- 2.1 Based on the results of this evaluation, epoxy markings have demonstrated their cost-effectiveness and thus are recommended for future projects satisfying the Department's criteria for use of long life lines (see Section 3.1.2)
- 2.2 Future installations should be governed by the revised specifications presented in Appendix A. The latter encompasses the three (3) major operations involved in this work; requirements for materials, removal of existing lines and application of new markings.
- 2.3 To minimize traffic delays and improve safety, the Department's specifications for removal of existing lines in high traffic areas should be modified to require equipment/methods capable of controlling the dust created during the removal process as contained in the revised specifications in Appendix A.
- 2.4 To ensure that cost-effective, year round striping is provided on our highways, the Department should continue to evaluate promising marking materials as warranted. For example, given the encouraging performance of studied preformed tape lane lines, it is recommended that a more comprehensive evaluation, including edge line and gore markings (not studied herein) be conducted to determine the cost-effectiveness of this material.

## PART 3: INTRODUCTION

### 3.1 Background

Recent striping practices in New Jersey required that lines be repainted twice yearly in highly urbanized and dense traffic areas. When subjected to adverse conditions (heavy traffic and/or winter weather), our conventional traffic paint is not sufficiently durable to provide adequate visibility throughout this (6 month) period. Under such conditions painted lines often wear out after about 4 1/2 months exposure or about 1 1/2 months less than the minimum stripe "design" life <sup>1</sup> .

In an effort to overcome the cited stripe durability/visibility problem, the Department has, in recent years placed (on a more or less an ad hoc basis) several experimental installations of durable materials (e.g., thermoplastic, tape) to improve overall performance.

To provide for more coordination in future installations of durable markings and to devise a Department striping policy, the Task Force on Long Life Lines (LLL) was formed about seven years ago. The basic charge of that unit was to determine what type of (LLL) material and raised pavement markers should be used and where. However, since the focus of this study was traffic striping only the findings and recommendations of the task force relative thereto have been summarized and will be presented in the following sections.

### **3.1.1 Findings - NJDOT Task Force**

- o On heavily travelled roads, conventional paint wears rapidly thus, frequent paintings are required to provide good quality markings year round.
- o The application of pavement markings is potentially hazardous to both traffic and marking crews.
- o Painting of crosswalks, stop lines, gores, words and symbols is very labor intensive and thus very costly.
- o Temperature restrictions prevent the application of paint during winter months. As a result, delineation on heavily travelled roads is often less than desirable.
- o Freeways and interstate highways are designed to the highest standards. Such roads should have "state-of-the-art" markings to complement their design features.
- o The Regional Maintenance Engineers have identified portions of State highways on which the markings wear off rapidly or the application of markings is particularly hazardous.

### **3.1.2 Recommendations - NJDOT Task Force**

In view of the above findings, the Department's Task Force established and recommended the following striping policy for long life markings on some 900 miles of New Jersey's total system of 2300 centerline miles. The decision as to the type of marking material to be used was determined from a review of the literature, our own experience <sup>2,3</sup>, and that of other using agencies <sup>4,5,6</sup> with various



types of alternative marking materials.

1. Long life markings are to be used:
  - a. On all freeways and interstate highways
  - b. On State highways with an AADT greater than 25,000
  - c. At locations suggested by the regional Maintenance Engineers
  - d. For crosswalks, stop lines, gores, words, symbols, etc. and on State highways not covered in item (a) above.
2. Materials to be used:
  - a. Longitudinal lines will be two-component epoxy resin.
  - b. Crosswalks, stop lines, gores, words and symbols will be epoxy, extruded thermoplastic or preformed tape.

Based on the recommendations of the (LLL) Task Force, the FHWA granted provisional approval, in late 1986, to implement a policy for the use of such markings on Federal Aid projects. That approval, and thus continued Federal participation, was conditional while the Department gained experience with and evaluated long life markings to confirm their cost-effectiveness. Thus, this two-year study was undertaken on the Department's first (LLL) installation (Rt. I-280, Long Life Lines, Contract No. 1) under the above policy.

This report presents the findings of that study and recommendations for future use of the studied materials.

### **3.2 Study Objectives**

The primary objective of this research was to confirm the cost-effectiveness of epoxy as a (LLL) material when subjected to New Jersey conditions. A secondary objective was to determine the cost-effectiveness of preformed tape (3M Stamark A350) as an alternate marking material for lane lines.

## **PART 4: NATURE OF THE INSTALLATION**

The following sections present an overview of the Rt. I-280 study installation which was completed in July 1988. This location was considered an excellent test site due to its high traffic volume and complex traffic patterns (e.g., numerous interchanges and connection to other heavily travelled routes). Initial specifications for the material (two-component epoxy) and its application as well as the removal of existing paint stripes were developed and implemented on the study project-- Long Life Pavement Markings - Including Experimental Sections, Contract No. 1 (Route 280); Federal Project IRG-280-6(77)51. Additional project details are provided in Appendix B.

### **4.1 Materials**

1. Two-component Epoxy --manufactured by Poly-Carb, Inc.
2. Preformed Tape --3M Stamark Series A350

### **4.2 Site Description**

The above materials were installed on a 13 mile section of Interstate Route 280 in the cities of Orange, East Orange and Newark. This is a heavily travelled, six lane, divided highway having an AADT of about 85,000. The epoxy and preformed tape markings under test were installed on both pavement types (i.e., PCC and bituminous concrete). Appendix C shows the total quantities of markings installed and their distribution among pavement types.

### **4.3 Removal of Existing Markings**

Existing painted and thermoplastic markings were removed by

grinding. Photos of the pavement surface after marking removal and the various types of equipment used are presented in Appendix D, while equipment removal rates are presented in Appendix C.

#### **4.3.1 Problems Encountered**

Although the existing painted lines were removed satisfactorily, the slowness of the initial operation (about 3,000 to 7,000 feet/day) adversely affected both traffic and new striping production. Long traffic delays were created as two and sometimes three lanes were closed to accommodate the slower removal equipment (combination grinder/blaster and manual units). As a result, the epoxy striper, capable of applying about 25 miles of new material per day, was limited to only 4 to 6 miles per day on this project. The above problems can be largely alleviated with the use of more efficient removal equipment such as the sometimes used truck-mounted grinding unit shown in Appendix D. This equipment essentially doubled the removal production (average 12,000 vs 7000 feet/day) and is capable of removing up to 20,000 feet of markings per day. Clearly, the appropriate use of several such units on a project can enhance production rates.

Without adequate dust control devices, the removal equipment produced dust clouds which inhibited driver visibility and traffic flow. Several near-accidents were observed when motorists made erratic maneuvers and/or sudden stops to avoid dust or other vehicles.

#### **4.4 Application**

The markings were successfully applied in accordance with

project specifications. Detailed application data is provided in Appendices B and C. Photos of the application equipment used and newly applied markings are shown in Appendix D.

#### **4.4.1 Problems Encountered**

Striper production was also hindered by restrictions on daily working hours. That is, due to high traffic volume (AADT >85,000) on the study project work was permitted only during the non-peak traffic hours (between 9 AM and 2 PM). The time consumed for daily start/stop activities, particularly placement and removal of safety devices, often resulted only about 2 (two) hours of actual material application on a given work day. This problem may be alleviated by permitting work during evening/early morning non-peak hours (e.g., 10 PM to 4 AM).



## PART 5: METHOD OF EVALUATION

Performance evaluations of study markings were conducted quarterly through the first 18 months in service. Subsequent thereto, evaluations were conducted at one month intervals in an effort to determine the endpoint of service life. The evaluation consisted of reflectance measurements with a portable retroreflectometer and subjective assessments of night visibility, durability and appearance. Wet night visibility was also evaluated, but covered under a separate study <sup>7</sup>. Findings from the latter study indicated that the wet night visibility of epoxy markings can be significantly improved with the use of Visibeads. The latter are basically larger diameter beads designed to provide greater retroreflectance and thus, improved wet night visibility of traffic markings. As a result, future installations of epoxy markings will require that a combination of the large and standard beads be used to provide optimum night/wet night visibility.

Reflectance measurements were taken at random locations throughout the project with a Mirolux 12 retroreflectometer. A minimum reflectance of 100 milli-candelas was used as the critical value based on research by the FHWA sponsored Regional Test Center at Pennsylvania State University and a 1990 NCHRP study <sup>8</sup>. Night visibility was rated from a passenger car traveling at speeds ranging from 40 to 50 mph. This subjective assessment of delineation provided to the driver was rated as adequate, marginally adequate or inadequate.

Durability was evaluated by estimating the percent of material retained using the Texas Transportation Institute Method ' .

The daytime appearance of the markings was evaluated taking into account color and cleanliness. Photographs of installation are presented in Appendix D.

## **PART 6: RESULTS AND DISCUSSION**

### **6.1 General**

While the level of epoxy marking performance -- reflectivity, night visibility and durability -- did, as with all marking materials, diminish with time, their general performance under severe exposure conditions (i.e., AADT greater than 85,000) in this two year study was very good.

Specific performance parameters are discussed in the following report sections.

### **6.2 Reflectivity**

Figure C-1 (Appendix C) graphically displays changes in reflectivity of the studied markings throughout this evaluation. As indicated in Figure C-1 and the following table, the average reflectivity of all epoxy markings declined only 35 percent over a two year period, still providing about twice the recommended <sup>8</sup> minimum acceptable reflectance (i.e. 215 vs 100 mcd/lum/m<sup>2</sup>). Not unexpectedly, the lanelines show a somewhat higher loss (about 40 percent) in reflectance than the edgelines since the former are typically subjected to more traffic impacts. While the preformed tape lane lines show more than a 50 percent decrease over the same period, they still exhibited a reflectance level comparable to that of the epoxy.

By comparison, a conventionally painted line --under similar exposure conditions-- typically loses about 75 percent of its initial reflectivity, falling below acceptable reflectivity in four to six months, and thus requiring replacement.

### AVERAGE CHANGE IN REFLECTIVITY

MARKING TYPE	COLOR	REFLECTANCE, (mcd/lum/m <sup>2</sup> ) <sup>a,b,c</sup>		PERCENT CHANGE FROM INITIAL
		Initial	24 Months	
Epoxy Edgelines	White Yellow	334	223	-33
		314 (n= 46; 92)	224 (n= 23; 52)	-29
Epoxy Lanelines	White	345 (n= 104)	203 (n= 56)	-41
Mean Values		331	215	-35
Preformed Tape (lanelines only)	White	441 (n= 32)	196 (n= 9)	-56

**Notes:**

<sup>a</sup> Measurements taken with a Mirolux 12 retroreflectometer

<sup>b</sup> Summary of data from Table 3 (Appendix C)

<sup>c</sup> A value less than 100 is considered inadequate <sup>8</sup>

### 6.3 Night Visibility

This visual assessment of delineation provided to the driver indicates that all markings were performed adequately, albeit with the aid of overhead lighting in some areas. All markings were judged to have shown good initial night visibility.

### 6.4 Durability

The durability of all markings was generally good after two years exposure. In fact, (overall) material retention for the installation was about 90 percent. However, the epoxy edge lines in some high impact areas (e.g., weaving areas and/or gores, acceleration/deceleration lanes) showed only 20 to 50 percent material retention. The affected areas ranged from 50 to 100 ft.

in length and abrasion was generally the failure mode. Photos showing typical wear are provided in Appendix D.

Minor chipping was observed in isolated areas -- traffic use notwithstanding -- particularly on the outer (slow lane) edge lines. This may have been the result of inadequate bond of epoxy material to polished pavement surfaces (i.e., the aggregate in some older PCC pavements was exposed). New York State DOT, one of the nation's heaviest users of epoxy, has experienced similar failure with epoxy on older ( more than 10 years) PCC pavements. NYDOT is currently working with an epoxy supplier to develop a special primer to alleviate this problem.

#### **6.5 Appearance**

The daytime appearance of the markings was fair after two years in service. Typically, appearance and marking visibility declined during winter months, then improved in the spring. The latter is largely attributed the cleansing action of spring rains. The white markings exhibited minor "yellowing" after about 6 months exposure, however, this condition was not progressive and thus had minimal affects on delineation.

## PART 7: COST ANALYSIS

### 7.1 Epoxy

Analysis of Department experience with traffic paint and the various costs involved indicated that the epoxy markings would have to provide about two years service to be cost-comparable to conventional traffic paint. Although this evaluation was formally closed-out after two years, the study installation easily exceeded this criteria based upon the observed condition of the markings after 36 months exposure.

While the unit cost for epoxy on this project was considerably higher (\$0.30 versus \$0.10) than our conventionally used traffic paint, the epoxy has provided more than a five-fold increase in service life. Conventional traffic paint -- under similar exposure conditions -- would be expected to provide only about 4-1/2 months service. As shown in the following table, even when costs for removal of existing lines and traffic control are considered, the study markings are still a viable alternate to conventional traffic paint after 2 years.

This table shows a comparison of markings on an annual cost basis with interest and inflation affects ignored. Apart from direct costs, use of a more durable marking material has the potential for improving safety. That is, decreasing the number of annual striping applications required (by about 5:1) reduces the time both striping crews and the public are exposed to hazardous conditions.

Assuming similar costs for future work, where removal will not typically be required, epoxy would be cost-effective in slightly over 1 year.

## 7.2 Preformed Tape

As shown in the table, the study tape (lane lines only) would have to provide 2 to 3 years of satisfactory service to be cost-effective. Since the tape lane lines proved generally, more durable than the epoxy lane lines, it is felt that a more comprehensive evaluation should be conducted to determine the cost-effectiveness of this material. Such an evaluation should certainly include edge lines and gore markings in high impact areas where epoxy did not perform as expected and therefore a viable alternate material is needed.

**COST OF MARKING MATERIALS**

MARKING TYPE	ESTIMATED ANNUAL COST, (\$)/lin ft		
	INSTALLED	SERVICE LIFE, yrs.	
		2	3
Epoxy	0.30	0.15	0.10
Epoxy <sup>a</sup>	0.55	0.28	0.18
Preformed Tape <sup>a</sup>	1.35	0.68	0.45
Conventional Traffic Paint by Contract <sup>b</sup>	0.27	0.53	0.81

**Notes:**

<sup>a</sup> Includes \$0.25/lin. ft. for removal of existing markings and traffic control

<sup>b</sup> Assumes worn out lines are repainted promptly (i.e., every 4½ mos.), thus cost to maintain year-round delineation





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**APPENDIX A**

Recommended NJDOT Specifications

Subsection 617.....	A1
Subsection 620.....	A9
Subsection 912.....	A11



## **Appendix A**

### **SECTION 617 - EPOXY TRAFFIC MARKINGS**

**617.01 DESCRIPTION.** THIS WORK SHALL CONSIST OF APPLYING WHITE OR YELLOW EPOXY RESIN TRAFFIC MARKINGS (STRIPES AND SPECIAL MARKINGS SUCH AS LETTERS OR SYMBOLS) AND GLASS BEADS TO PORTLAND CEMENT OR BITUMINOUS CONCRETE SURFACES.

REMOVAL SHALL CONSIST OF REMOVING EXISTING TRAFFIC STRIPES AND SPECIAL MARKINGS SUCH AS LETTERS OR SYMBOLS FROM PORTLAND CEMENT AND BITUMINOUS CONCRETE PAVEMENTS AND CURING COMPOUNDS FROM NEW PORTLAND CEMENT CONCRETE SURFACES PRIOR TO APPLICATION OF NEW EPOXY TRAFFIC MARKINGS.

#### **MATERIALS**

**617.02 MATERIALS.** MATERIALS SHALL CONFORM TO THE FOLLOWING SUBSECTIONS:

TRAFFIC MARKING MATERIALS.....	912.01
EPOXY RESIN TRAFFIC MARKING MATERIALS.....	912.34
LARGE GLASS BEADS.....	912.35

#### **EQUIPMENT**

**617.03 EQUIPMENT.** APPLICATING EQUIPMENT FOR THE PLACEMENT OF EPOXY TRAFFIC MARKINGS SHALL BE APPROVED PRIOR TO THE START OF WORK.

IN GENERAL, THE APPLICATING EQUIPMENT SHALL CONSIST OF ONE OR MORE MOBILE, TRUCK MOUNTED AND SELF CONTAINED PAVEMENT MARKING MACHINES, SPECIFICALLY DESIGNED TO APPLY EPOXY MATERIAL AND REFLECTIVE GLASS BEADS IN CONTINUOUS AND SKIP-LINE PATTERNS. THE APPLICATING EQUIPMENT SHALL BE CAPABLE OF APPLYING STRAIGHT AND CURVED LINES.

APPLICATION OF SPECIAL MARKINGS SHALL BE BY TRUCK MOUNTED UNITS EQUIPPED WITH NEEDED ACCESSORIES TO ALLOW FOR THE MARKING OF SOLID AREAS, LETTERS AND SYMBOLS. THE ENGINEER MAY APPROVE THE USE OF A PORTABLE APPLICATOR (IN LIEU OF TRUCK MOUNTED ACCESSORIES), FOR APPLYING SPECIAL MARKINGS ONLY, PROVIDED SUCH EQUIPMENT DEMONSTRATES IT IS CAPABLE OF PRODUCING SPECIAL MARKINGS WITH UNIFORM COLOR AND CRISP, WELL-DEFINED EDGES.

EACH APPLICATOR SHALL BE OPERATED BY A QUALIFIED OPERATOR WHO HAS THE NECESSARY CONTROL OF ALL EQUIPMENT.

TRUCK MOUNTED STRIPING APPLICATORS SHALL BE CAPABLE OF INSTALLING UP TO 50,000 LINEAL FEET OF EPOXY TRAFFIC MARKINGS IN AN 8-HOUR DAY. EACH APPLICATOR SHALL INCLUDE THE FOLLOWING FEATURES:

A. INDIVIDUAL MATERIAL RESERVOIRS FOR THE STORAGE OF PART A AND PART B OF THE EPOXY RESIN COMPOSITION AND FOR THE SEPARATE STORAGE OF EACH GRADATION OF REFLECTIVE GLASS BEADS SPECIFIED IN SUBSECTION 617.06.

B. HEATING EQUIPMENT OF SUFFICIENT CAPACITY TO MAINTAIN THE INDIVIDUAL EPOXY RESIN COMPONENTS AT THE MANUFACTURER'S RECOMMENDED TEMPERATURE FOR SPRAY APPLICATION.

C. TWO (2) GRAVITY TYPE GLASS BEAD DISPENSERS CAPABLE OF UNIFORMLY APPLYING GLASS BEADS TO EPOXY MARKINGS AT THE RATE SPECIFIED IN SUBSECTION 617.06. BOTH DISPENSERS SHALL BE EQUIPPED WITH A CUT-OFF CONTROL SYNCHRONIZED WITH THE CUT-OFF OF THE EPOXY RESIN MATERIAL.

D. ACCURATELY CALIBRATED, TAMPER-PROOF, METERING DEVICES THAT MEASURE AND RECORD THE GALLONAGE OF EPOXY MATERIAL USED AND THE LENGTH OF STRIPES APPLIED. THIS INFORMATION SHALL BE PROVIDED IN A FORMAT THAT PERMITS A DIRECT DETERMINATION OF THE YIELD (AVERAGE MIL THICKNESS) OF APPLIED MATERIALS.

E. ALL APPLICATOR GUNS ON THE SPRAY CARRIAGES SHALL BE IN FULL VIEW OF THE OPERATOR(S) DURING OPERATION.

EQUIPMENT FOR REMOVAL OF EXISTING TRAFFIC MARKINGS AND CURING COMPOUND IS OPTIONAL, HOWEVER, IT SHALL BE APPROPRIATE FOR THE PROPOSED WORK AND SUBJECT TO APPROVAL BY THE ENGINEER. THE EQUIPMENT SHALL CONFORM TO ALL APPLICABLE LOCAL, STATE AND FEDERAL LAW REGULATIONS OR CODES.

#### CONSTRUCTION

**617.04 GENERAL.** ALL PAVEMENT MARKINGS AND PATTERNS SHALL BE PLACED AS SHOWN ON THE PLANS AND IN ACCORDANCE WITH THE MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES FOR STREETS AND HIGHWAYS (MUTCD).

AT LEAST THIRTY (30) DAYS BEFORE ANY PAVEMENT MARKING WORK IS BEGUN, A COMPLETE SCHEDULE OF OPERATIONS, INCLUDING THE NUMBER AND TYPES OF EQUIPMENT AND PROCEDURES PROPOSED FOR THE PROJECT, SHALL BE SUBMITTED FOR APPROVAL.

AT LEAST FIVE (5) DAYS PRIOR TO STARTING STRIPING THE CONTRACTOR SHALL PROVIDE THE ENGINEER WITH THE EPOXY MANUFACTURER'S WRITTEN INSTRUCTIONS FOR PROPER USE OF THE MATERIAL. THESE INSTRUCTIONS SHALL INCLUDE BUT NOT BE LIMITED TO MIXING RATIOS AND APPLICATION TEMPERATURES.

THE EPOXY MANUFACTURER'S TECHNICAL REPRESENTATIVE SHALL BE ON THE SITE FOR THE FIRST FULL DAY OF STRIPING TO RECOMMEND METHODS OF SURFACE PREPARATION AND MARKING APPLICATION BASED ON EXISTING AND ANTICIPATED PROJECT CONDITIONS.

THE APPLICATION OF PAVEMENT MARKINGS SHALL ONLY BE PERMITTED IN THE DIRECTION OF TRAFFIC.

ANY TRACKING MARKS OR SPILLED EPOXY MATERIALS APPLIED IN UNAUTHORIZED AREAS SHALL BE COMPLETELY REMOVED.

WHEN NECESSARY FOR ACCURATE STRIPE INSTALLATION, MARKING LINE POINTS SHALL BE ESTABLISHED AT THIRTY (30) FOOT INTERVALS THROUGHOUT THE LENGTH OF THE PAVEMENT OR AS DIRECTED.

**617.05 THICKNESS.** THE EPOXY MARKING MATERIAL SHALL HAVE A WET FILM THICKNESS OF 20 MILS, WITH A TOLERANCE OF  $\pm 1$  MIL.

**617.06 GLASS BEADS.** GLASS BEADS SPECIFIED IN SUBSECTION 912.35 SHALL BE UNIFORMLY APPLIED AT THE RATE OF 27 LBS (15 LBS OF LARGE BEADS AND 12 LBS OF NJDOT STANDARD BEADS) PER GALLON OF EPOXY MATERIAL.

**617.07 LIMITATIONS.** EPOXY TRAFFIC MARKINGS SHALL ONLY BE APPLIED DURING CONDITIONS OF DRY WEATHER AND ON DRY PAVEMENT SURFACES. AT THE TIME OF INSTALLATION THE PAVEMENT SURFACE TEMPERATURE AND THE AMBIENT TEMPERATURE SHALL BE A MINIMUM OF 50°F AND RISING.

WHEN WATER BLASTING IS PERMITTED TO REMOVE EXISTING TRAFFIC MARKINGS IN ACCORDANCE WITH SUBSECTION 617.13, NEW PAVEMENT MARKINGS SHALL NOT BE APPLIED FOR AT LEAST 24 HOURS AFTER THE WATER BLASTING HAS BEEN COMPLETED. REMOVAL BY WATER BLASTING SHALL NOT BE ALLOWED WHEN MARKING REPLACEMENT IS REQUIRED WITHIN THE SAME DAY.

**617.08 SURFACE PREPARATION.** PRIOR TO THE APPLICATION OF NEW EPOXY MARKING MATERIAL, ALL EXISTING MARKINGS (STRIPES, LETTERS AND SYMBOLS, ETC.) AND THE CURING COMPOUND ON NEW PORTLAND CEMENT CONCRETE SURFACES SHALL BE REMOVED IN ACCORDANCE WITH SUBSECTION 617.13. THIS REQUIREMENT MAY BE WAIVED UNDER THE FOLLOWING CONDITIONS:

A. THE EXISTING MARKINGS ARE AN EPOXY COMPOSITION.

B. TEN DAYS PRIOR TO APPLICATION, THE NEW EPOXY MATERIAL MANUFACTURER SUBMITS A WRITTEN RECOMMENDATION TO THE ENGINEER STATING THAT THE CONDITION OF THE EXISTING EPOXY MARKINGS IS SUCH THAT LEAVING THEM IN PLACE WILL NOT ADVERSELY AFFECT THE PERFORMANCE OF THE NEW EPOXY MATERIAL.

SUBSEQUENT TO COMPLETION OF REQUIRED REMOVAL OPERATIONS IN ACCORDANCE WITH SUBSECTION 617.13 AND IMMEDIATELY PRIOR TO THE APPLICATION OF NEW EPOXY MARKING MATERIAL, THE SUBSTRATE ON WHICH EPOXY WILL BE APPLIED SHALL BE CLEANED SUCH THAT IT IS FREE OF OIL, DIRT, DUST, GREASE AND OTHER FOREIGN MATERIALS IN ACCORDANCE WITH THE NEW MATERIAL MANUFACTURER'S RECOMMENDATIONS. THIS SHALL BE ACCOMPLISHED BY A COMBINATION OF BROOMING AND COMPRESSED AIR.

SUBSTRATE CLEANING SHALL BE PERFORMED ONLY IN THE AREA ON WHICH THE NEW EPOXY TRAFFIC MARKINGS WILL BE APPLIED.

**617.09 APPLICATION.** APPLICATION OF NEW EPOXY TRAFFIC MARKINGS SHALL NOT BEGIN UNTIL THE APPLICABLE SURFACE PREPARATION WORK SPECIFIED IN SUBSECTION 617.08 IS COMPLETED AND APPROVED. EPOXY TRAFFIC MARKINGS SHALL BE PLACED AT THE LOCATIONS, DIMENSIONS, AND PATTERNS DESIGNATED ON THE CONTRACT PLANS.

A. **PROCEDURE.** THE GENERAL PROCEDURE FOR APPLYING EPOXY MARKINGS SHALL BE AS FOLLOWS:

1. THE PAVEMENT SUBSTRATE SHALL BE PREPARED IN ACCORDANCE WITH SUBSECTION 617.08.
2. IMMEDIATELY FOLLOWING CLEANING OF THE SUBSTRATE, THE MIXED EPOXY RESIN COMPOUND SHALL BE HOT-SPRAYED ONTO THE PAVEMENT AT THE WET FILM THICKNESS SPECIFIED IN SUBSECTION 617.05 AND AT A TEMPERATURE THAT WILL RESULT IN THE NO-TRACKING CONDITION DESCRIBED IN SUBSECTION 617.10. THE TEMPERATURE OF THE MIXED EPOXY COMPOUND SHALL BE ADJUSTED AS REQUIRED FOR PREVAILING CONDITIONS, INCLUDING THE AIR AND PAVEMENT TEMPERATURE, TO COMPLY WITH NO-TRACKING REQUIREMENTS.
3. IMMEDIATELY AFTER, OR IN CONJUNCTION WITH THE EPOXY RESIN APPLICATION, REFLECTIVE GLASS BEADS SHALL BE UNIFORMLY APPLIED TO THE EPOXY COMPOSITION AT THE SPECIFIED RATE IN SUBSECTION 617.06.

**B. TEST STRIP.** PRIOR TO THE START OF ROUTINE PROJECT STRIPING OPERATIONS ONE OR MORE TEST STRIPS SHALL BE CONSTRUCTED. EACH TEST STRIP SHALL CONSIST OF ABOUT 500 LINEAR FEET OF PAVEMENT WITH WHITE AND YELLOW STRIPING (LANE AND EDGELINES) AS SHOWN ON THE PLANS. THE PURPOSE OF THE TEST STRIP(S) IS TO DEMONSTRATE THE CAPABILITY OF THE PROPOSED EPOXY MATERIALS, EQUIPMENT AND PROCEDURES TO PLACE EPOXY STRIPING THAT COMPLIES WITH THESE SPECIFICATIONS INCLUDING DIMENSIONS, APPEARANCE (STRIPES HAVING UNIFORM COLOR AND CRISP, WELL DEFINED EDGES), WET FILM THICKNESS, DRYING TIME (FIELD), AND GLASS BEADS APPLICATION AND RETENTION. WHEN THE TEST STRIPES COMPLY WITH THESE SPECIFICATIONS, THE CONTRACTOR WILL BE PERMITTED TO PROCEED WITH ROUTINE PROJECT STRIPING OPERATIONS.

A TEST STRIP SHALL BE REQUIRED FOR EACH APPLYING MACHINE. ADDITIONAL TEST STRIPS MAY BE REQUIRED WHEN MAJOR EQUIPMENT REPAIRS OR ADJUSTMENTS ARE MADE OR SUBSEQUENT TO APPLICATION OF TRAFFIC MARKINGS THAT FAIL TO COMPLY WITH THESE SPECIFICATIONS.

**617.10 DRYING TIME (FIELD).** FOR THE APPLICATION CONDITIONS SPECIFIED IN SUBSECTION 617.07, THE NO-TRACK DRYING TIME SHALL NOT EXCEED 30 MINUTES. "NO-TRACK" DRYING TIME SHALL BE CONSIDERED AS THE CONDITION WHERE NO VISUAL DISPLACEMENT OF THE EPOXY MARKING IS OBSERVED AFTER A PASSENGER CAR HAS PASSED OVER THE LINE.

**617.11 DEFECTIVE EPOXY TRAFFIC MARKINGS.** ANY EPOXY TRAFFIC MARKINGS WHICH ARE DETERMINED NOT TO BE IN CONFORMANCE WITH THESE SPECIFICATIONS SHALL BE REPLACED. SOME SPECIFIC DEFICIENCIES ARE:

- A. DEFICIENT WET FILM THICKNESS, LINE DIMENSIONS, GLASS BEAD COVERAGE OR RETENTION.

WET FILM THICKNESS SHALL BE AS SPECIFIED IN SUBSECTION 617.05



AND LINE DIMENSIONS AS SHOWN ON THE PLANS.

DEFICIENT GLASS BEAD COVERAGE AND/OR RETENTION SHALL BE BASED ON YIELD DETERMINATIONS MADE DURING INSTALLATION AND VISUAL COMPARISON BY THE ENGINEER OF NEWLY APPLIED FIELD TRAFFIC MARKINGS TO STANDARD TEST PLATES MANUFACTURED IN ACCORDANCE WITH THESE SPECIFICATIONS.

REPLACEMENT METHOD. DEFECTIVE EPOXY MARKINGS SHALL BE PREPARED IN ACCORDANCE WITH THE REQUIREMENTS OF SUBSECTION 617.08 AND RESTRIPE IN ACCORDANCE WITH THESE SPECIFICATIONS.

B. DEFICIENT CURING, COLOR OR BOND TO SUBSTRATE. UNCURED EPOXY SHALL BE DEFINED AS APPLIED MATERIAL THAT FAILS TO CURE (DRY) IN ACCORDANCE WITH SUBSECTION 617.10.

DISCOLORATION SHALL BE DEFINED AS LOCALIZED AREAS OR PATCHES OF BROWN OR GRAYISH COLORED EPOXY MARKING MATERIAL. THESE AREAS OFTEN OCCUR IN A CYCLIC PATTERN AND, OFTEN ARE NOT VISIBLE UNTIL SEVERAL DAYS OR WEEKS AFTER MARKINGS ARE APPLIED.

DEFICIENT BOND SHALL BE DEFINED AS THE LACK OF ADHESION (E.G., SEPARATION, CHIPPING, CRACKING, ETC.) BETWEEN THE NEW EPOXY MATERIAL AND THE SUBSTRATE.

REPLACEMENT METHOD. DEFECTIVE EPOXY MARKINGS SHALL BE REMOVED IN ACCORDANCE WITH SUBSECTION 617.13 AND RESTRIPE IN ACCORDANCE WITH THESE SPECIFICATIONS.

**617.12 OPENING TO TRAFFIC.** TRAFFIC STRIPING AND SPECIAL MARKINGS SHALL BE COMPLETED AND THE EPOXY SHALL BE THOROUGHLY DRY BEFORE OPENING TO TRAFFIC.

**617.13 REMOVAL OF EXISTING TRAFFIC MARKINGS AND CURING COMPOUNDS.**

A PROPOSAL, DETAILING REMOVAL OPERATIONS, INCLUDING THE EQUIPMENT (TYPE AND NUMBER), PROCEDURES AND SCHEDULE TO BE EMPLOYED, SHALL BE SUBMITTED FOR APPROVAL AT LEAST 30 DAYS PRIOR TO THE START OF WORK. PRIOR TO THE START OF ROUTINE REMOVAL OPERATIONS, A FIELD DEMONSTRATION MAY BE REQUIRED TO VERIFY THE ADEQUACY OF THE PROPOSED EQUIPMENT AND PROCEDURES.

THE INTENT OF THESE REQUIREMENTS IS TO CONTROL THE DUST CREATED DURING THE MARKING REMOVAL PROCESS AND TO ACHIEVE A CLEAN, DRY PAVEMENT SURFACE FOR THE APPLICATION OF NEW PAVEMENT MARKINGS. THEREFORE THE EXISTING PAVEMENT MARKINGS SHALL BE REMOVED WITH MACHINERY DESIGNED WITH A SELF-CONTAINED DUST COLLECTION SYSTEM TO PREVENT AIRBORNE RESIDUE FROM ESCAPING INTO THE ATMOSPHERE. SPRAYING OF WATER ON GRINDING HEADS AS A MEANS OF DUST CONTROL WILL NOT BE PERMITTED.

A. LIMITS OF WORK. REMOVAL OPERATIONS SHALL BE CONFINED TO THE SURFACE AREA OF EXISTING PAVEMENT MARKINGS SPECIFIED FOR REMOVAL ON THE PLANS OR AS DIRECTED.

THE AREA OF STRIPE REMOVAL SHALL BE THE WIDTH OF THE EXISTING LINE, PLUS ONE (1) INCH ON EACH SIDE. FOR LETTERS AND SYMBOLS, THE REMOVAL AREA WILL BE SUFFICIENTLY LARGE TO COMPLETELY REMOVE THE EXISTING LETTER OR SYMBOL.

**B. REMOVAL OF CURING COMPOUND FROM NEW CONCRETE PAVEMENT.** THE CURING COMPOUND ON NEW PORTLAND CEMENT CONCRETE PAVEMENTS SHALL BE REMOVED. REMOVAL OPERATIONS SHALL NOT BEGIN UNTIL AT LEAST 30 DAYS AFTER PLACEMENT OF CONCRETE. WHEN WATER BLASTING IS PERMITTED, NEW PAVEMENT MARKINGS SHALL NOT BE APPLIED FOR AT LEAST 24 HOURS AFTER REMOVAL BY WATER BLASTING HAS BEEN COMPLETED.

SUBSEQUENT TO REMOVAL OPERATIONS, THERE SHALL BE NO VISIBLE EVIDENCE OF CURING COMPOUND ON THE PEAKS OF THE TEXTURED CONCRETE SURFACE. ALL LOOSE AND FLAKING MATERIAL SHALL HAVE BEEN REMOVED. REMAINING CURING COMPOUND, IF ANY, SHALL BE INTACT.

**C. REMOVAL OF EXISTING PAVEMENT MARKINGS.** THIS WORK SHALL BE CONDUCTED SO THAT ESSENTIALLY ALL OF THE EXISTING MARKINGS ARE REMOVED WITHOUT GOUGING OR CREATING RIDGES OR GROOVES IN THE EXISTING PAVEMENT. REMOVAL OPERATIONS SHALL BE CONDUCTED IN SUCH A MANNER THAT DAMAGE TO THE EXISTING PAVEMENT SURFACE IS MINIMAL AND RESULTS IN NO MORE THAN A MODERATE CHANGE IN COLOR AND/OR SURFACE TEXTURE. THE FINISHED SURFACE SHALL NOT BE LEFT IN A PATTERN THAT WILL MISLEAD OR MISDIRECT THE MOTORIST.

DURING REMOVAL OPERATIONS, CARE SHALL BE TAKEN TO PREVENT DAMAGE TO TRANSVERSE AND LONGITUDINAL JOINT SEALERS.

DURING AND/OR AT COMPLETION OF REMOVAL OPERATIONS, THE PAVEMENT SURFACE SHALL BE POWER BROOMED AND BLOWN OFF WITH COMPRESSED AIR TO REMOVE RESULTING RESIDUE AND DEBRIS. ALL SUCH DEBRIS SHALL BE REMOVED AND DISPOSED OF IN ACCORDANCE WITH SUBSECTION 201.09.

THE DETERMINATION OF ACCEPTABLE REMOVAL OF EXISTING LINES, LETTERS AND SYMBOLS WILL BE MADE BY THE ENGINEER AND WILL BE GUIDED BY THE DEPARTMENT'S PICTORIAL STANDARDS OF ACCEPTABLE MARKING REMOVAL. COPIES OF THESE PICTORIAL STANDARDS CAN BE OBTAINED FROM THE NJDOT MATERIALS BUREAU (TELEPHONE NO. 609-530-2317).

**617.14 WARRANTY.** THREE HUNDRED SIXTY-FIVE (365) CALENDAR DAYS AFTER RECEIPT OF WRITTEN NOTICE FROM THE CONTRACTOR (IN ACCORDANCE WITH SUBSECTION 105.23) THAT HE HAS FINISHED HIS WORK AND IS READY FOR FINAL INSPECTION AND ACCEPTANCE, THE EPOXY STRIPES AND SPECIAL MARKINGS SHALL BE INSPECTED BY THE NEW JERSEY DEPARTMENT OF TRANSPORTATION.

ACCEPTANCE OF EPOXY TRAFFIC STRIPES PLACED ON THIS PROJECT SHALL BE DETERMINED IN LOTS, EACH LOT BEING EQUAL TO THE TOTAL LINEAR FEET PLACED EACH PRODUCTION DAY. EACH LOT WILL BE ACCEPTED IF NO MORE THAN 100 LINEAR FEET OF THE STRIPES HAVE FAILED DUE TO

LOSS OF ADHESION, COMPLETE WEAR THROUGH, OR HAS A REFLECTANCE VALUE OF LESS THAN 100 MCD/LUM/M<sup>2</sup> AS MEASURED BY A MIROLUX 12 RETROREFLECTOMETER IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATION. WHEN MORE THAN 100 LINEAR FEET OF STRIPES IN THE LOT ARE JUDGED IN NONCONFORMANCE, ALL STRIPES FAILING TO COMPLY SHALL BE REPLACED IN ACCORDANCE WITH THESE SPECIFICATIONS AT THE CONTRACTOR'S EXPENSE. WHEN THERE IS MORE THAN ONE (1) LOCATION WITHIN A LOT THAT REQUIRES RESTRIPIING AND THE DISTANCE BETWEEN SUCH LOCATIONS IS EQUAL TO OR LESS THAN 100 LINEAR FEET, THE ENGINEER MAY, FOR UNIFORMITY, DIRECT RESTRIPIING BE CONTINUOUS THROUGHOUT THE ENTIRE AFFECTED AREA. ANY SPECIAL MARKINGS, SUCH AS WORDS AND SYMBOLS, JUDGED IN NONCOMPLIANCE WITH THE SPECIFIED ACCEPTANCE CRITERIA FOR STRIPING SHALL ALSO BE REPLACED IN ACCORDANCE WITH THESE REQUIREMENTS.

#### COMPENSATION

**617.15 METHOD OF MEASUREMENT.** TRAFFIC STRIPES (LONGITUDINAL LINES) WILL BE MEASURED BY THE LINEAR FOOT FOR EACH 4-INCH WIDTH OF STRIPE, DEDUCTING THE GAPS. MEASUREMENT FOR STRIPING WITH A WIDTH GREATER OR LESS THAN 4-INCHES, AS SHOWN ON THE PLANS OR DIRECTED BY THE ENGINEER, WILL BE MADE BY THE FOLLOWING METHOD:

$$\text{Pay Length} = \frac{\text{Plan Width of Striping (inches)} \times \text{Linear Feet}}{4 \text{ in.}}$$

SPECIAL MARKINGS SUCH AS LETTERS, ARROWS AND OTHER SYMBOLS WILL BE MEASURED BY THE NUMBER OF UNITS APPLIED.

REMOVAL OF EXISTING TRAFFIC STRIPES SHALL BE MEASURED IN LINEAR FEET IRRESPECTIVE OF THEIR WIDTH.

REMOVAL OF EXISTING SPECIAL TRAFFIC MARKINGS (LETTERS OR SYMBOLS) WILL BE MEASURED BY THE NUMBER OF UNITS REMOVED.

#### **617.16 BASIS OF PAYMENT.**

PAYMENT WILL BE MADE UNDER:

<u>PAY ITEM</u>	<u>PAY</u>
<u>UNIT</u>	
EPOXY TRAFFIC STRIPES.....	LINEAR FOOT
SPECIAL EPOXY MARKINGS.....	EACH UNIT
REMOVAL OF EXISTING TRAFFIC STRIPES.....	LINEAR FOOT
REMOVAL OF EXISTING SPECIAL TRAFFIC.....	EACH UNIT
MARKINGS	

SEPARATE PAYMENT SHALL NOT BE MADE FOR CLEANING THE SUBSTRATE IMMEDIATELY PRIOR TO THE APPLICATION OF NEW EPOXY MATERIALS.

SEPARATE PAYMENT WILL NOT BE MADE FOR REMOVAL OF CURING COMPOUND FROM NEW PORTLAND CEMENT CONCRETE SURFACES.

NO PAYMENT SHALL BE MADE FOR THE REPLACEMENT OF DEFECTIVE TRAFFIC MARKINGS.

NO ADDITIONAL PAYMENT WILL BE MADE FOR THE ADDITIONAL ONE (1)

INCH REMOVAL REQUIRED ON EACH SIDE OF EXISTING TRAFFIC LINES OR FOR  
DUST CONTROL AND DISPOSAL OF RESIDUE CREATED IN THE REMOVAL  
PROCESS.

**SECTION 620 - REMOVAL OF EXISTING TRAFFIC MARKINGS AND CURING COMPOUNDS**

**620.01 DESCRIPTION.** THIS WORK SHALL CONSIST OF REMOVING TRAFFIC MARKINGS (STRIPE AND SPECIAL MARKINGS SUCH AS LETTERS OR SYMBOLS) FROM PORTLAND CEMENT AND BITUMINOUS CONCRETE PAVEMENTS AND CURING COMPOUNDS FROM NEW PORTLAND CEMENT CONCRETE SURFACES PRIOR TO APPLICATION OF NEW TRAFFIC MARKINGS.

**EQUIPMENT**

**620.02 EQUIPMENT.** EQUIPMENT FOR THIS WORK MAY BE SELECTED BY THE CONTRACTOR, HOWEVER, IT SHALL BE APPROPRIATE FOR THE PROPOSED WORK AND SUBJECT TO APPROVAL BY THE ENGINEER. THE EQUIPMENT SHALL CONFORM TO ALL APPLICABLE LOCAL, STATE AND FEDERAL LAW REGULATIONS OR CODES.

**CONSTRUCTION**

**620.03 GENERAL.** A PROPOSAL, DETAILING REMOVAL OPERATIONS, INCLUDING THE EQUIPMENT (TYPE AND NUMBER), PROCEDURES AND SCHEDULE TO BE EMPLOYED, SHALL BE SUBMITTED FOR APPROVAL AT LEAST 30 DAYS PRIOR TO THE START OF WORK. PRIOR TO THE START OF ROUTINE REMOVAL OPERATIONS, A FIELD DEMONSTRATION MAY BE REQUIRED TO VERIFY THE ADEQUACY OF THE PROPOSED EQUIPMENT AND PROCEDURES FOR WORK ON THIS PROJECT.

THE INTENT OF THESE REQUIREMENTS IS TO CONTROL THE DUST CREATED DURING THE MARKING REMOVAL PROCESS AND TO ACHIEVE A CLEAN, DRY PAVEMENT SURFACE FOR THE APPLICATION OF NEW PAVEMENT MARKINGS. THEREFORE THE EXISTING PAVEMENT MARKINGS SHALL BE REMOVED WITH MACHINERY DESIGNED WITH A SELF-CONTAINED DUST COLLECTION SYSTEM TO PREVENT AIRBORNE RESIDUE FROM ESCAPING INTO THE ATMOSPHERE. SPRAYING OF WATER ON GRINDING HEADS AS A MEANS OF DUST CONTROL WILL NOT BE PERMITTED.

**620.04 LIMITS OF WORK.** REMOVAL OPERATIONS SHALL BE CONFINED TO THE SURFACE AREA OF EXISTING PAVEMENT MARKINGS SPECIFIED FOR REMOVAL ON THE PLANS OR AS DIRECTED.

THE AREA OF STRIPE REMOVAL SHALL BE THE WIDTH OF THE EXISTING LINE, PLUS ONE (1) INCH ON EACH SIDE. FOR LETTERS AND SYMBOLS, THE REMOVAL AREA WILL BE SUFFICIENTLY LARGE TO COMPLETELY REMOVE THE EXISTING LETTER OR SYMBOL.

**620.05 REMOVAL OF CURING COMPOUND FROM NEW CONCRETE PAVEMENT.** THE CURING COMPOUND ON NEW PORTLAND CEMENT CONCRETE PAVEMENTS SHALL BE REMOVED. REMOVAL OPERATIONS SHALL NOT BEGIN UNTIL AT LEAST 30 DAYS AFTER PLACEMENT OF CONCRETE. WHEN WATER BLASTING IS PERMITTED, NEW PAVEMENT MARKINGS SHALL NOT BE APPLIED FOR AT LEAST 24 HOURS AFTER REMOVAL BY WATER BLASTING HAS BEEN COMPLETED.

SUBSEQUENT TO REMOVAL OPERATIONS, THERE SHALL BE NO VISIBLE EVIDENCE OF CURING COMPOUND ON THE PEAKS OF THE TEXTURED CONCRETE SURFACE. ALL LOOSE AND FLAKING MATERIAL SHALL HAVE BEEN REMOVED. REMAINING CURING COMPOUND, IF ANY, SHALL BE INTACT.

**620.06 REMOVAL OF EXISTING PAVEMENT MARKINGS.** THIS WORK SHALL BE

CONDUCTED SO THAT ESSENTIALLY ALL OF THE EXISTING MARKINGS ARE REMOVED WITHOUT GOUGING OR CREATING RIDGES OR GROOVES IN THE EXISTING PAVEMENT. REMOVAL OPERATIONS SHALL BE CONDUCTED IN SUCH A MANNER THAT DAMAGE TO THE EXISTING PAVEMENT SURFACE IS MINIMAL AND RESULTS IN NO MORE THAN A MODERATE CHANGE IN COLOR AND/OR SURFACE TEXTURE. THE FINISHED SURFACE SHALL NOT BE LEFT IN A PATTERN THAT WILL MISLEAD OR MISDIRECT THE MOTORIST.

DURING REMOVAL OPERATIONS, CARE SHALL BE TAKEN TO PREVENT DAMAGE TO TRANSVERSE AND LONGITUDINAL JOINT SEALERS.

DURING AND/OR AT COMPLETION OF REMOVAL OPERATIONS, THE PAVEMENT SURFACE SHALL BE POWER BROOMED AND BLOWN OFF WITH COMPRESSED AIR TO REMOVE RESULTING RESIDUE AND DEBRIS. ALL SUCH DEBRIS SHALL BE REMOVED AND DISPOSED OF IN ACCORDANCE WITH SUBSECTION 201.09.

THE DETERMINATION OF ACCEPTABLE REMOVAL OF EXISTING LINES, LETTERS AND SYMBOLS WILL BE MADE BY THE ENGINEER AND WILL BE GUIDED BY THE DEPARTMENT'S PICTORIAL STANDARDS OF ACCEPTABLE MARKING REMOVAL. THESE PICTORIAL STANDARDS CAN BE OBTAINED FROM THE NJDOT MATERIALS BUREAU (TELEPHONE NO. 609-530-2317).

**620.07 METHOD OF MEASUREMENT.** REMOVAL OF EXISTING TRAFFIC STRIPES SHALL BE MEASURED IN LINEAR FEET IRRESPECTIVE OF THEIR WIDTH.

REMOVAL OF EXISTING SPECIAL TRAFFIC MARKINGS (LETTERS OR SYMBOLS) WILL BE MEASURED BY THE NUMBER OF UNITS REMOVED.

**620.08 BASIS OF PAYMENT**

PAYMENT WILL BE MADE UNDER:

<u>PAY ITEM</u>	<u>PAY UNIT</u>
REMOVAL OF EXISTING TRAFFIC STRIPES.....	LINEAR FOOT
REMOVAL OF EXISTING SPECIAL TRAFFIC.....	EACH UNIT
MARKINGS	

NO ADDITIONAL PAYMENT WILL BE MADE FOR THE ADDITIONAL ONE (1) INCH REMOVAL REQUIRED ON EACH SIDE OF EXISTING TRAFFIC LINES OR FOR DUST CONTROL AND DISPOSAL OF RESIDUE CREATED IN THE REMOVAL PROCESS.

SEPARATE PAYMENT WILL NOT BE MADE FOR REMOVAL OF CURING COMPOUND FROM NEW PORTLAND CEMENT CONCRETE SURFACES.

## SECTION 912 - PAINTS AND COATINGS

**912.01 TRAFFIC MARKING MATERIALS.** THE TRAFFIC MARKING MATERIAL SHALL BE AN EPOXY RESIN COMPOSITION SPECIFICALLY FORMULATED FOR USE AS A PAVEMENT MARKING MATERIAL AND FOR HOT-SPRAY APPLICATION AT ELEVATED TEMPERATURES.

THE PERCENTAGES OF ALL MATERIALS REQUIRED SHALL BE IN TERMS OF NET WEIGHT. THE MATERIALS SHALL CONFORM TO THE REQUIREMENTS HEREINAFTER SPECIFIED FOR EPOXY RESIN TRAFFIC MARKINGS.

- (A) METHODS OF TEST AND INSPECTION. THE EPOXY RESIN MARKING MATERIALS SHALL BE ANALYZED IN ACCORDANCE WITH SUBSECTION 912.34.
- (B) SAMPLES AND CERTIFIED ANALYSIS. THE EPOXY MANUFACTURER SHALL FURNISH CERTIFIED TEST RESULTS THAT EACH BATCH OF EPOXY MATERIALS USED ON THE PROJECT COMPLIES WITH THESE SPECIFICATIONS. IN ADDITION, ALL EPOXY COMPONENTS SHALL BE PRE-APPROVED FOR USE ON NJDOT PROJECTS. THEREFORE, SAMPLES OF THE EPOXY COMPONENTS SHALL BE SUBMITTED TO THE NJDOT LABORATORY FOR TESTING AT LEAST THIRTY (30) DAYS PRIOR TO THE NEEDED APPROVAL DATE.

TO VERIFY THAT THE EPOXY MATERIALS SUBSEQUENTLY USED ON THE PROJECT ARE OF AN IDENTICAL FORMULATION AS THOSE PRE-APPROVED, EPOXY COMPONENTS SHALL BE SAMPLED AT THE PROJECT AND SUBMITTED TO THE NJDOT LABORATORY. THESE SAMPLE COMPONENTS SHALL MATCH THEIR RESPECTIVE INFRA-RED SPECTRUMS IN THE PRE-APPROVED FILE IN THE NJDOT LABORATORY.

- (C) CONTAINERS AND SHIPMENT. THE EPOXY MATERIALS SHALL BE SHIPPED IN APPROPRIATE CONTAINERS PLAINLY MARKED WITH THE FOLLOWING INFORMATION:
  - 1. MANUFACTURER'S NAME AND ADDRESS
  - 2. NAME OF PRODUCT
  - 3. LOT/BATCH NUMBER
  - 4. COLOR
  - 5. NET WEIGHT AND VOLUME OF CONTENTS
  - 6. DATE OF MANUFACTURER
  - 7. DATE OF EXPIRATION
  - 8. STATEMENT OF CONTENTS (AS APPROPRIATE)
    - PART A - PIGMENT & EPOXY RESIN
    - PART B - CATALYST
  - 9. MIXING PROPORTIONS AND INSTRUCTIONS
  - 10. SAFETY INFORMATION



**912.34 EPOXY RESIN TRAFFIC MARKING MATERIALS.** THE EPOXY RESIN COMPOSITION SHALL BE SPECIFICALLY FORMULATED FOR USE AS A PAVEMENT MARKING MATERIAL AND FOR HOT-SPRAY APPLICATION AT ELEVATED TEMPERATURES. THE TYPE AND AMOUNTS OF EPOXY RESINS AND CURING AGENTS SHALL BE AT THE OPTION OF THE MATERIAL MANUFACTURER, PROVIDING THE COMPOSITION AND PHYSICAL REQUIREMENTS OF THIS SPECIFICATION ARE SATISFIED.

ANY PAVEMENT MARKINGS (STRIPES AND LETTERS OR SYMBOLS) PLACED ON THE PROJECT WITH MATERIAL THAT FAILS TO COMPLY WITH THIS REQUIREMENT SHALL BE REPLACED IN ACCORDANCE WITH THESE SPECIFICATIONS.

PHYSICAL PROPERTIES OF MIXED COMPOSITION. UNLESS OTHERWISE NOTED, ALL SAMPLES ARE TO BE PREPARED AND TESTED AT AN AMBIENT TEMPERATURE OF  $73 \pm 5^{\circ}\text{F}$ .

- COLOR. THE WHITE EPOXY COMPOSITION WHEN APPLIED TO A WET FILM THICKNESS OF 20 MILS  $\pm$  1 MIL AND ALLOWED TO CURE, SHALL BE A REASONABLE VISUAL MATCH TO #17778 OF FEDERAL STANDARD 595A DATED JANUARY 2, 1968.

THE YELLOW EPOXY COMPOSITION WHEN APPLIED TO A WET FILM THICKNESS OF 20 MILS  $\pm$  1 MIL AND ALLOWED TO CURE, SHALL BE A REASONABLE VISUAL MATCH TO #13538 OF FEDERAL STANDARD 595A DATED JANUARY 2, 1968.

- DIRECTIONAL REFLECTANCE. THE WHITE EPOXY COMPOSITION (WITHOUT GLASS BEADS) SHALL HAVE A DAYLIGHT DIRECTIONAL REFLECTANCE OF NOT LESS THAN 84 PERCENT RELATIVE TO A MAGNESIUM OXIDE STANDARD WHEN TESTED IN ACCORDANCE WITH METHOD 6121 OF FEDERAL TEST METHOD STANDARD NO. 141.

THE YELLOW EPOXY COMPOSITION (WITHOUT GLASS BEADS) SHALL HAVE A DAYLIGHT DIRECTIONAL REFLECTANCE OF NOT LESS THAN 55 PERCENT RELATIVE TO A MAGNESIUM OXIDE STANDARD WHEN TESTED IN ACCORDANCE WITH METHOD 6121 OF FEDERAL TEST METHOD STANDARD NO. 141.

- DRYING TIME (LABORATORY). THE EPOXY COMPOSITION, WHEN MIXED IN THE PROPER RATIO AND APPLIED IN ACCORDANCE WITH THE THICKNESS REQUIREMENTS HEREIN AND IMMEDIATELY DRESSED WITH GLASS BEADS AT THE RATE SPECIFIED IN SUBSECTION 617.06 SHALL EXHIBIT A NO-TRACK DRYING TIME OF 30 MINUTES OR LESS WHEN TESTED IN ACCORDANCE WITH ASTM D711. A BIRD APPLICATOR OR ANY OTHER DOCTOR BLADE SHALL BE USED TO PRODUCE A UNIFORM FILM THICKNESS.
- ABRASION RESISTANCE. WHEN THE EPOXY MATERIAL IS TESTED ACCORDING TO ASTM C501 WITH A CS-17 WHEEL UNDER A LOAD OF 1,000 GRAMS FOR 1,000 CYCLES, THE ABRASIVE WEAR INDEX SHALL BE NO GREATER THAN 82. THE ABRASIVE WEAR INDEX IS THE WEIGHT IN MILLIGRAMS THAT IS ABRADED FROM THE SAMPLE UNDER



THE SPECIFIED TEST CONDITIONS.

- HARDNESS. AFTER THE EPOXY MATERIAL HAS CURED FOR NOT LESS THAN 72 AND NOT MORE THAN 96 HOURS AT 70 DEGREES F, SHORE D HARDNESS OF THE MATERIAL SHALL BE NOT LESS THAN 75 NOR MORE THAN 100 WHEN TESTED IN ACCORDANCE WITH ASTM D2240.

EPOXY COMPOSITION THE EPOXY MARKING MATERIAL SHALL BE A TWO-COMPONENT (PART A AND PART B), 100 PERCENT SOLIDS TYPE SYSTEM FORMULATED AND DESIGNED TO PROVIDE A SIMPLE VOLUMETRIC MIXING RATIO (E.G., TWO VOLUMES OF PART A TO ONE VOLUME OF PART B).

Pigment Composition, % by weight	Minimum	Maximum
<u>WHITE:</u>		
Titanium Dioxide (ASTM D476, Type II)	20.0	---
Epoxy Resin	75.0	80.0
<u>YELLOW:</u>		
Chrome Yellow (ASTM D211, Type III)	23.0	---
Epoxy Resin	70.0	77.0

**NOTE:** THE ENTIRE PIGMENT COMPOSITION SHALL CONSIST OF EITHER TITANIUM DIOXIDE OR MEDIUM CHROME YELLOW. NO EXTENDER PIGMENTS ARE PERMITTED.

- EPOXY CONTENT-WPE (COMPONENT A) - THE EPOXY CONTENT OF THE EPOXY RESIN WILL BE TESTED IN ACCORDANCE WITH ASTM D1652 AND CALCULATED AS THE WEIGHT PER EPOXY EQUIVALENT (WPE) FOR BOTH WHITE AND YELLOW. THE EPOXY CONTENT WILL BE DETERMINED ON A PIGMENT FREE BASIS. THE EPOXY CONTENT (WPE) SHALL MEET THE TARGET VALUE PROVIDED BY THE MANUFACTURER AND APPROVED BY THE NJDOT BUREAU OF MATERIALS. A  $\pm 50$  TOLERANCE WILL BE APPLIED TO THE TARGET VALUE TO ESTABLISH THE ACCEPTANCE RANGE.
- AMINE VALUE (COMPONENT B) - THE AMINE VALUE OF THE CURING AGENT SHALL BE DETERMINED IN ACCORDANCE WITH ASTM D2074. THE TOTAL AMINE VALUE SHALL MEET A TARGET VALUE PROVIDED BY THE MANUFACTURER AND APPROVED BY THE NJDOT BUREAU OF MATERIALS. A  $\pm 50$  TOLERANCE WILL BE APPLIED TO THE TARGET VALUE TO ESTABLISH THE ACCEPTANCE RANGE. IF THE MANUFACTURER SPECIFIES AN ALTERNATE TEST METHOD FOR DETERMINING THE AMINE VALUE, THE ALTERNATE SHALL BE SUBJECT TO THE APPROVAL OF THE NJDOT BUREAU OF MATERIALS.
- TOXICITY - UPON HEATING TO APPLICATION TEMPERATURE, THE

MATERIAL SHALL NOT EXUDE FUMES WHICH ARE TOXIC OR INJURIOUS TO PERSONS OR PROPERTY.

**912.35 GLASS BEADS.** GLASS BEADS SHALL BE TRANSPARENT, CLEAN, COLORLESS GLASS; SMOOTH AND SPHERICALLY SHAPED; FREE OF MILKINESS, PITS, OR AIR BUBBLES. THE BEADS SHALL BE COATED WITH A TEMPERATURE RESISTANT, PREMIUM EMBEDMENT COATING HAVING HIGH ADHESION PROPERTIES, AS APPROVED BY THE BUREAU OF MATERIALS.

THE GLASS BEADS SHALL COMFORM TO THE FOLLOWING WHEN TESTED IN ACCORDANCE WITH SECTION 990 NJDOT P-2, AND WITH OTHER APPROPRIATE METHODS:

- (A) SPHERICAL PARTICLES. GLASS BEADS SHALL CONTAIN A MINIMUM OF 80% ROUNDS PER SCREEN FOR THE TWO HIGHEST SIEVE QUANTITIES. THE REMAINING SIEVE FRACTIONS SHALL CONTAIN NOT LESS THAN 75% ROUNDS. THERE SHALL BE NO MORE THAN 3 PERCENT SHARP ANGULAR PARTICLES PER SCREEN.
- (B) GRADATION. THE BEADS SHALL MEET THE FOLLOWING WHEN TESTED IN ACCORDANCE WITH ASTM D1214:

**LARGE BEADS**

SIEVE SIZE	PERCENT RETAINED BY WEIGHT
NO. 10.....	0
NO. 12.....	0-5
NO. 14.....	5-20
NO. 16.....	40-80
NO. 18.....	10-40
NO. 20.....	0-5
PAN.....	0-2

**SMALL BEADS**

NO. 20.....	0-5
NO. 30.....	5-20
NO. 50.....	30-75
NO. 80.....	9-32
NO. 100.....	0-5
PAN.....	0-2

- (C) INDEX OF REFRACTION. THE BEADS WHEN TESTED BY THE LIQUID IMMERSION METHOD SHALL SHOW AN INDEX OF REFRACTION WITHIN THE RANGE OF 1.50 TO 1.52.
- (D) CHEMICAL STABILITY. BEADS WHICH SHOW ANY TENDENCY TOWARD DECOMPOSITION, INCLUDING SURFACE ETCHING, WHEN EXPOSED TO ATMOSPHERIC CONDITIONS, MOISTURE, DILUTE ACIDS OR ALKALIES OR PAINT FILM CONSTITUENTS, SHALL BE REJECTED.

(E) PACKAGING. THE BEADS SHALL BE PACKAGED IN 50-POUND MOISTURE-RESISTANT BAGS CONFORMING TO THE PACKAGING AND MARKING REQUIREMENTS OF AASHTO M247.

**912.36 SAMPLING AND TESTING.** SAMPLING AND TESTING WILL BE PERFORMED IN ACCORDANCE WITH SUBSECTIONS 912.01, 912.34, 912.35, AND THE FOLLOWING:

EPOXY COMPONENTS

PART A

2 QUARTS FROM EACH BATCH

PART B

1 QUART FROM EACH BATCH



**APPENDIX B**

Detailed Project Data



APPENDIX B

NEW JERSEY DEPARTMENT OF TRANSPORTATION

LONG LIFE TRAFFIC LINES PROJECT DATA

Detailed Information

Date August 16, 1988

I. Project

- Long Life  
Pavt. Markings
- A. Route & Section: Contract 1 Federal Aid No. IRG-280-6(77)51
- B. Region 2 County/Municipality Essex & Hudson Counties
- C. Total Length: 13 miles. Limits: Milepost 4.00 to Milepost 17.00  
PCC 4.00 to 13.00
- D. Pavement Type: MABC/PCC (if combined, state limits of @ type) MABC 13.00 to 17.00
- E. Overhead Lighting: YES/NO Limits (M.P.) Yes
- F. Number of Lanes 3 Limits (if variable)                      AADT
- G. Resident Engineer Garrett L. Van Vliet Telephone No. (201) 673-0430
- H. Contractor(s) Denville Line Painting Inc.

II. Material

- A. Type of material(s) Epoxy Resin Quantity 557,045 <sup>1,072 s.f.</sup> 1.0 Bid Items(s) Item # 26  
Item # 25
- B. Manufacturer/Supplier Poly-Carb
- C. Contractor/Applicator Denville Line Painting Inc.
- D. Check Samples Yes Certifications Yes

III. Costs (Attach itemized summary if available.)

- A. Unit cost of material(s) installed: \$0.30 \$/linear ft.
- B. Unit cost of striping related activities (itemized):  
Item # 24 Removal of Traffic Stripes \$0.19 per l.f.  
Items #11 Thru 21 Traffic Control \$0.06 per l.f.
- C. Total Project Cost: \$417,661.92

(continued on reverse side)

IV. Application

- A. Date(s) of Installation: Start 6/16/88 Completed 7/28/88
- B. Temperatures: Air 70-100°F; Pavement 80-110°F; Material 120°F
- C. Surface Preparation: Method Air Blasting Bid Item N/A
- D. Traffic Control/Protection (i.e., cones X; moving vehicle w/arrowboard X); other Signs - Impact Attenuators - Arrow Boards - Drums - Lights
- E. Process: Sprayed/~~Extruded~~
- F. Measured Material Thickness: Wet 20 mils; dry      mils.
- G. Drying Time (no track) 6 to 8 min.
- H. Total material applied (lin. ft.; gallons):  
skip or lane-lines X yellow, X white; 557,045 l.f. 4" width lines  
edgelines X yellow, X white; 1,072 s.f. pavement markings  
centerlines N/A yellow, N/A white.
- I. Special Markings/Symbols (type and quantity) Arrows - "ONLY" - "EXIT"
- J. Measured Bead Application Rate: 25 lbs/gal.

- V. Equipment (Description of striper, make of vehicle, material capacity, number in crew, etc.) Truck mounted mobile self contained line striper truck capable of applying 2 component epoxy resin material. Meets supplementary specifications for Epoxy Application Equipment. Custom manufactured and outfitted. 200 gallon capacity of Part A and Part B components ( total 400 gallons). Two (2) crew members required for operation. Video equiped for precise control.

VI. General Appearance

- A. Markings Very Good (Some edge oversplatter)
- B. Beads Excellent ( excellent retention in epoxy material)
- C. Color Good ( Some yellowing of white material)
- D. Other

VII. Problems Encountered (Attach additional page if necessary.)

1) High traffic volume made traffic control difficult - some damage to stripes occurred when traffic broke through barriers.

2) Heavy tracking of existing joint sealer has diminished visibility of some lines.

VIII. Additional Comments, Suggestions (Attach additional page if necessary):

Removal of existing stripes slowed operation. A better method of removal should be explored to facilitate traffic control and provide a higher volume of work for the epoxy striper.

Form completed by: Garrett L. Van Vliet

Title: Resident Engineer



## APPENDIX C

### Tables & Figures

Table 1: Markings Quantities and Distribution

Table 2: Stripe Removal Data

Figure 1: Average Reflectivity

Table 3: Summary of Reflectivity Data



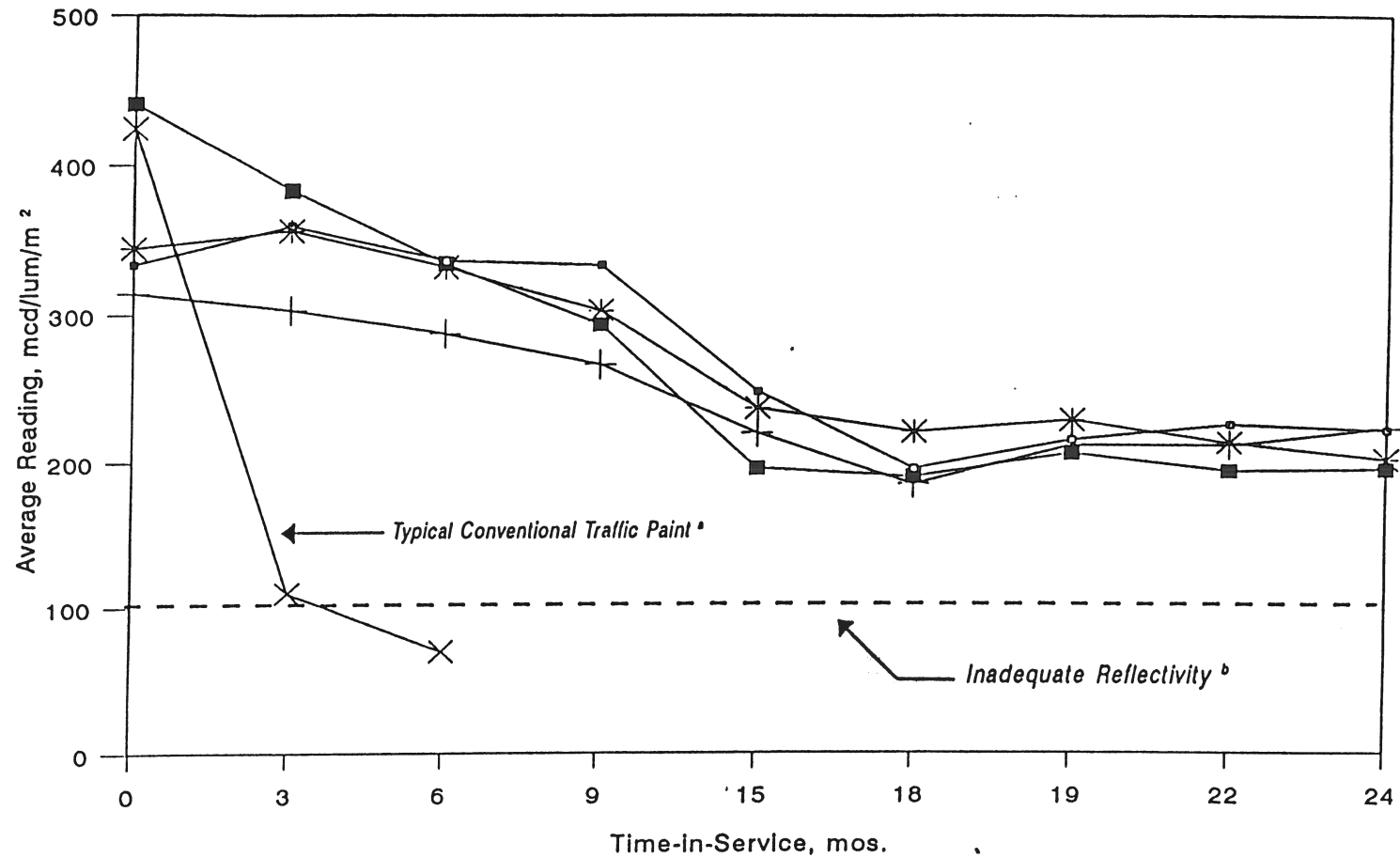
**TABLE 1: PAVEMENT MARKING QUANTITY DISTRIBUTION**

Material	Pavement Type	Approximate Section Length (miles)	Approximate Quantity Applied (lin. ft.)
Epoxy	PCC	9.5	541,000
	MABC	1.5	16,000
Preformed Tape	MABC	2.0	4,500

**TABLE 2: STRIPE REMOVAL DATA**

Type Equipment	Description		
Truck-mounted Grinder	Average Production Rate (ft/day)	Grinding Path/Width Used (in)	Remarks
	12,000	16	Used primarily on edge-lines
Combination Grinder/Blaster	3,000	7	Used on lanelines; self-contained vacuum to collect dust
Manually-operated, (walk-behind) Grinder	7,000	8	Used on areas missed by grinder/blaster and on gores.

**FIGURE C-1: REFLECTIVITY READINGS**  
Rt. I-280, Long Life Pavement Markings



Legend:

— Epoxy Edge, white    + Epoxy Edge, yellow    \* Epoxy Lane, white    ■ Tape Lane, white    X Paint

<sup>a</sup> Based on NJDOT Research <sup>1</sup>

<sup>b</sup> Based on criteria from NCHRP Study No. 416, "Service Life and Cost of Pavement Marking Materials", March 1990.

TABLE 3: SUMMARY OF REFLECTIVITY DATA  
Rt. I-280 Long Life Traffic Lines

MARKING TYPE	TIME IN SERVICE, mos.-->	0	3	6	9	15	18	19	22	24
Epoxy: Edgelines, white	$\bar{X}$	334	359	336	333	248	196	216	226	223
	$\sigma$	75.89	36.92	54.25	42.37	53.38	50.82	52.45	57.93	57.86
	Min	141	259	153	253	153	71	40	89	142
	Max	448	414	430	420	372	269	300	314	323
	n	46	44	46	32	35	25	31	27	23
Epoxy Edgelines, yellow	$\bar{X}$	314	303	287	266	---	185	212	---	224
	$\sigma$	33.08	31.51	23.85	32.02	---	16.39	28.15	---	22.17
	Min	191	173	224	180	---	157	135	---	181
	Max	440	352	327	336	---	218	259	---	262
	n	92	68	61	48	---	21	22	---	52
Epoxy Lanelines, white	$\bar{X}$	345	356	332	303	237	221	229	214	203
	$\sigma$	55.75	31.73	32.98	22.49	21.98	33.06	37.28	29.27	36.73
	Min	173	245	127	252	200	131	159	152	136
	Max	423	416	418	348	275	271	307	267	269
	n	104	77	72	54	25	24	30	21	56
Preformed Tape Lanelines, white	$\bar{X}$	441	383	334	293	196	190	207	195	196
	$\sigma$	60.86	49.53	50.96	60.37	41.10	17.62	18.21	9.84	26.28
	Min	299	190	230	222	129	151	174	178	114
	Max	550	475	442	422	256	215	236	207	245
	n	32	32	32	19	22	23	16	6	29

Note: measurements taken with a Mirolux 12 retroreflectometer; units are mcd/lum/m<sup>2</sup>



## **APPENDIX D**

### **Photographs**

- Figure 1: Truck-Mounted Grinder
- Figure 2: Grinder/Blaster
- Figure 3: Manually-Operated Grinder
- Figure 4: Epoxy Striper
- Figure 5: 3M Tape Applicator
- Figure 6: Typical PCC Surface After Grinding
- Figure 7: Typical Epoxy Laneline
- Figure 8: Typical Epoxy Edgeline (white)
- Figure 9: Typical Epoxy Edgeline (yellow)
- Figure 10: Typical Preformed Tape Laneline  
(white)
- Figure 11: Typical Epoxy Gore





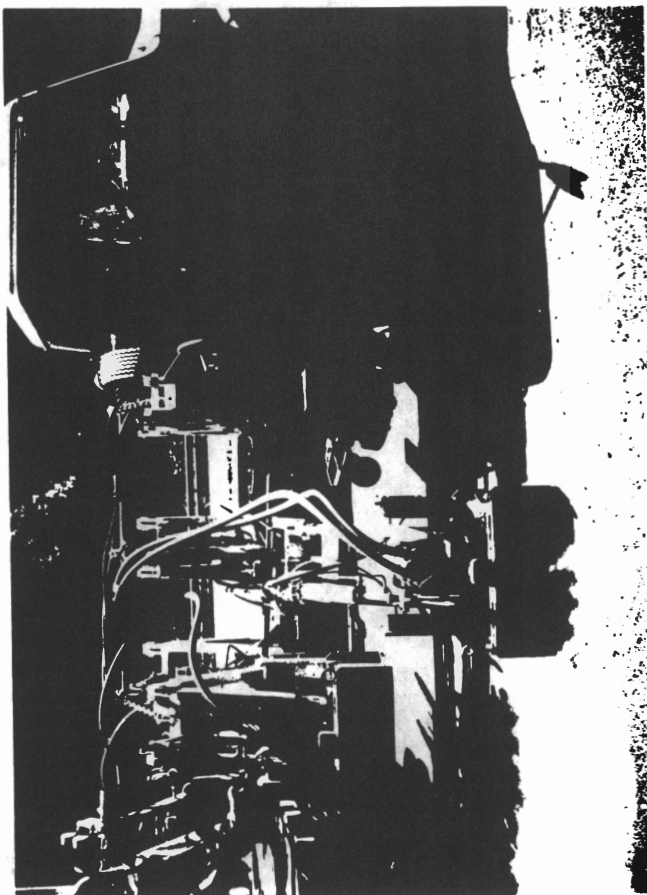
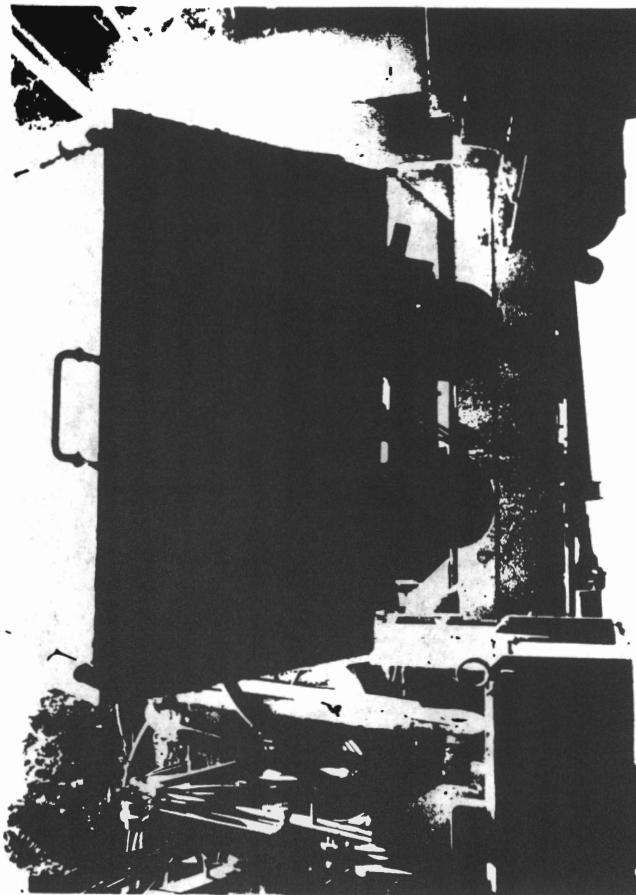


Figure 1: Truck-Mounted Grinder

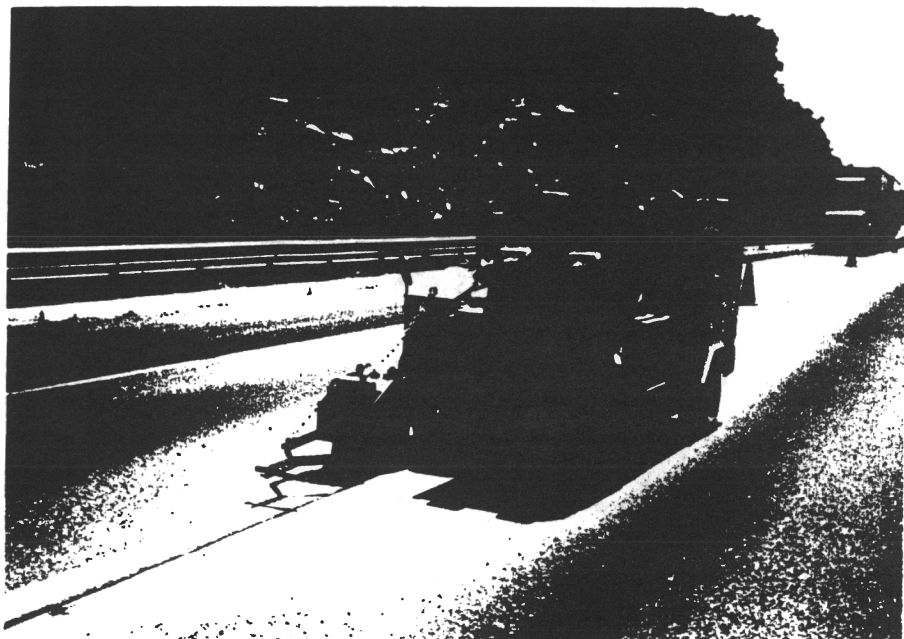


Figure 2: Combination Grinder/Blaster

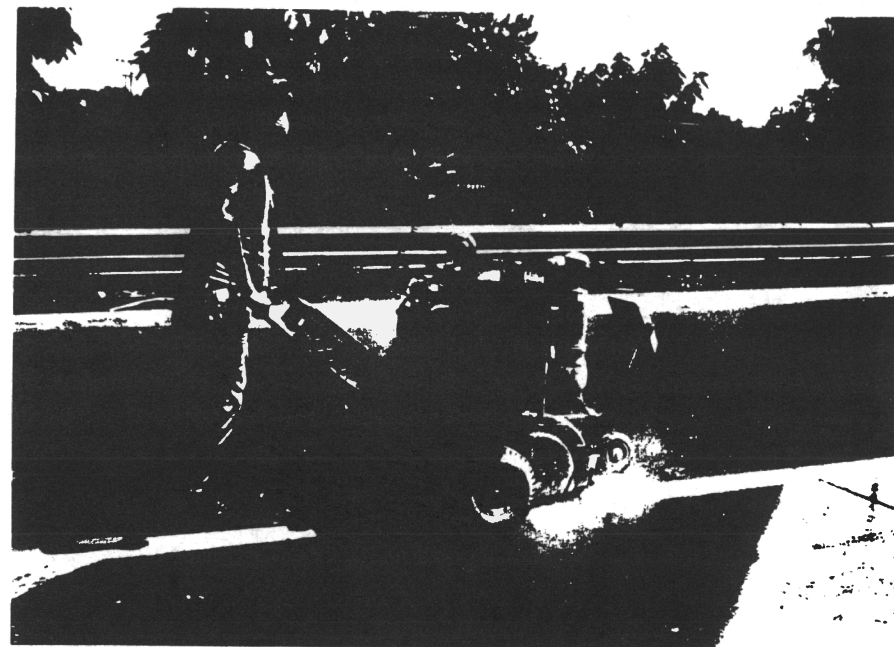


Figure 3: Manually-Operated, Gas-Powered Grinder



Figure 4: Epoxy Striper

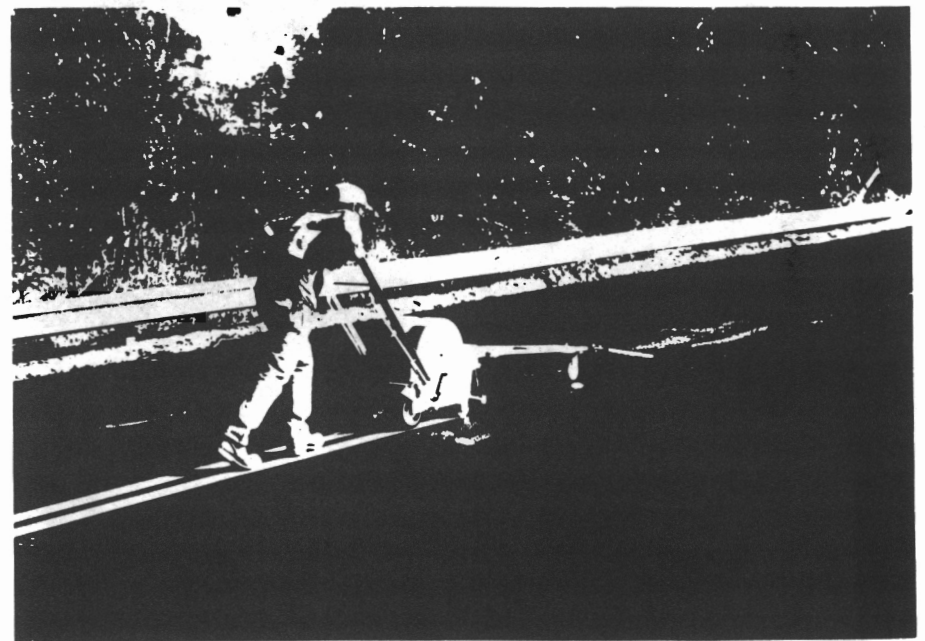


Figure 5: 3M Tape Applicator

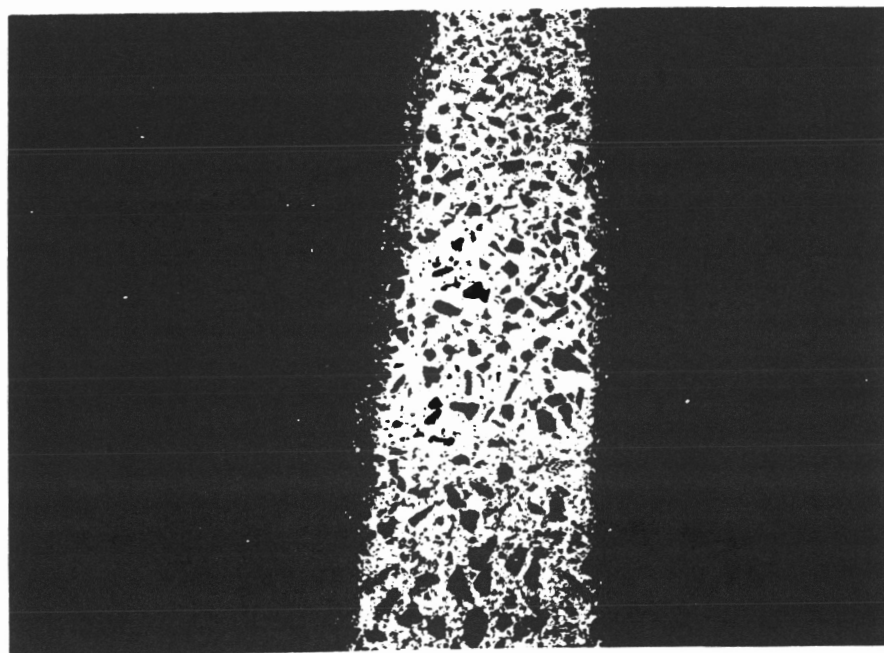


Figure 6: Typical PCC Pavement Surface After Removal of Existing Markings

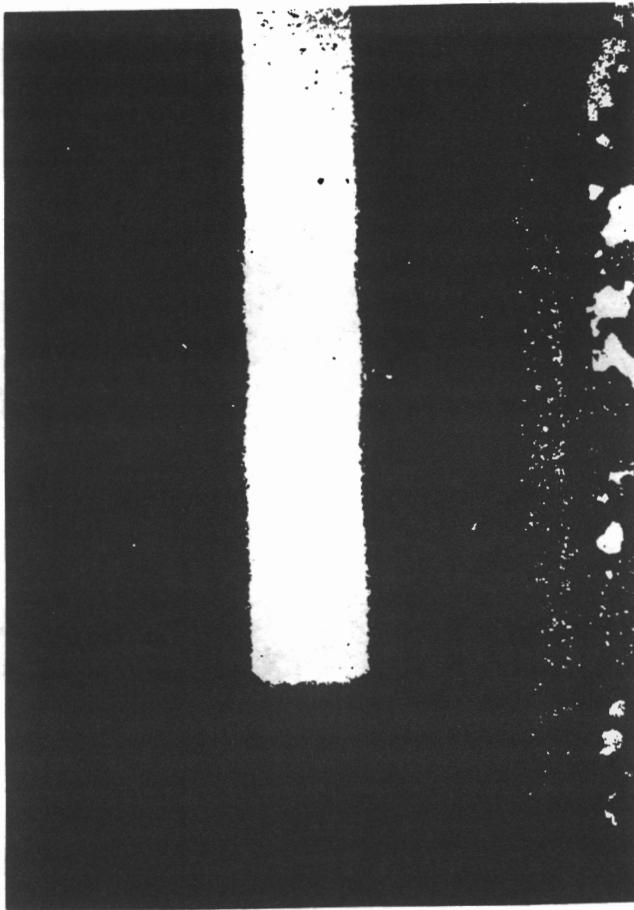


Figure 7A: New Line

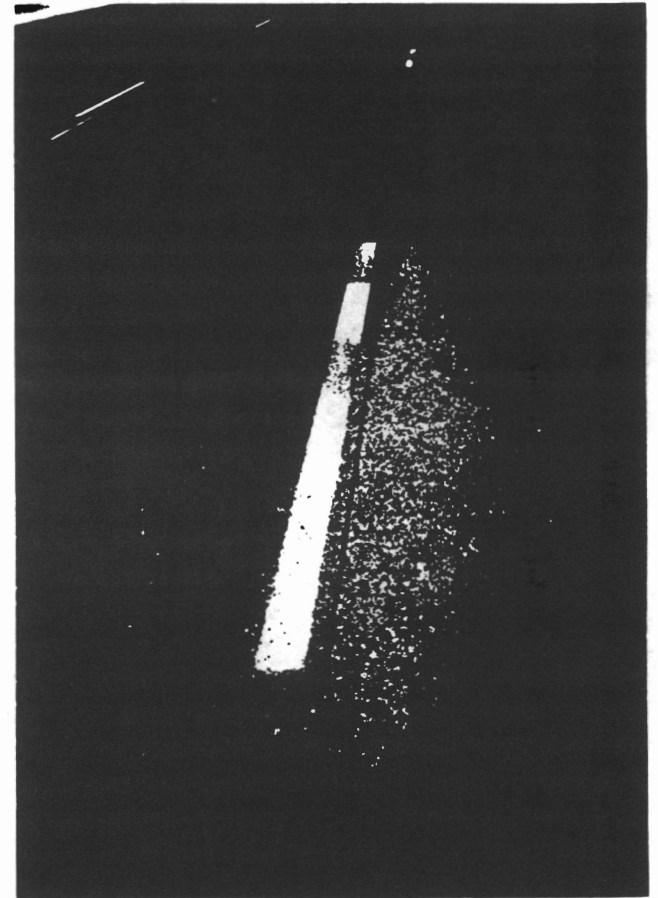


Figure 7B: 24 Months in Service

Figure 7: Typical Epoxy Laneline on PCC Pavement

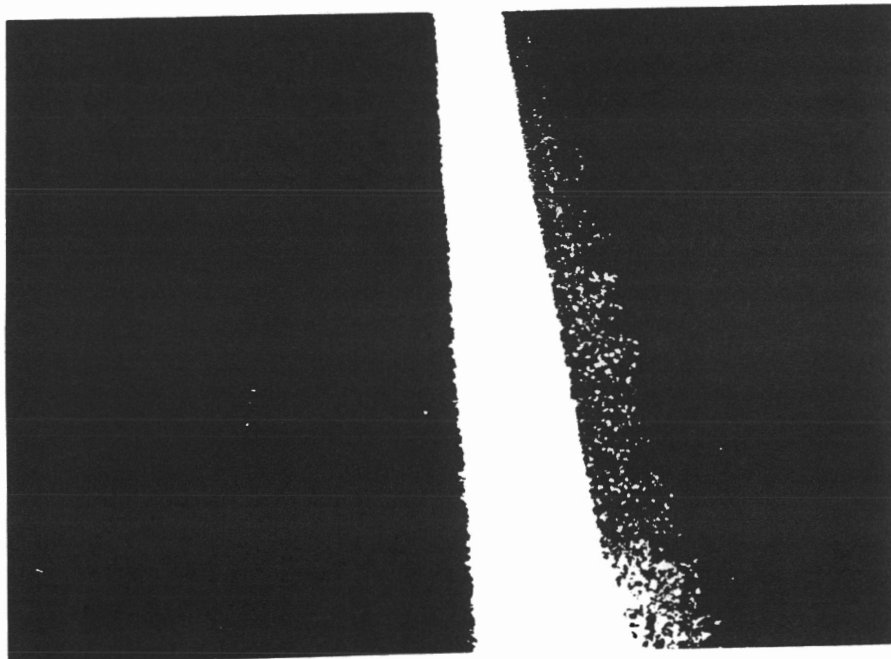


Figure 8A: New Line

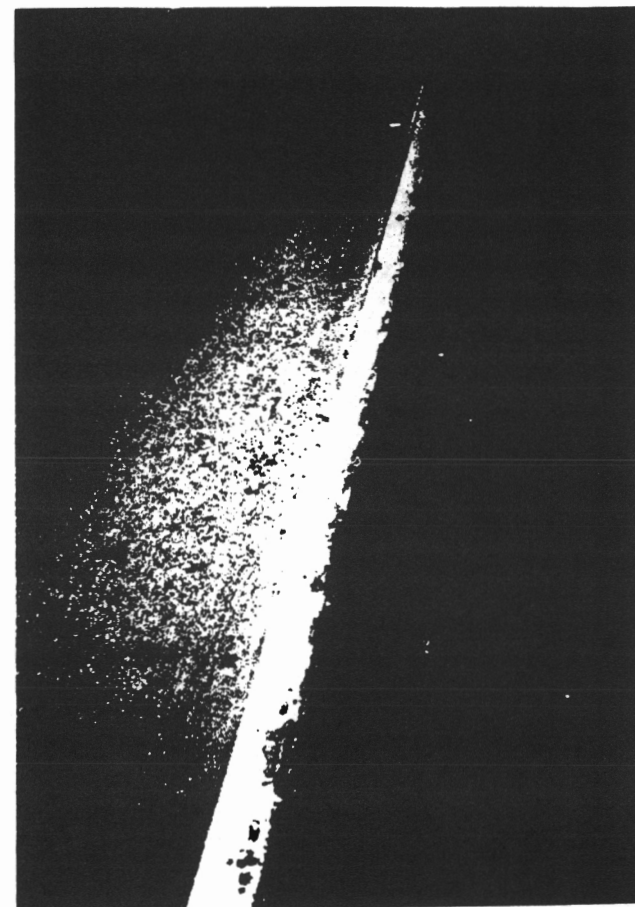


Figure 8B: 24 Months in Service

Figure 8: Typical Epoxy Edgeline (white) on PCC Pavement

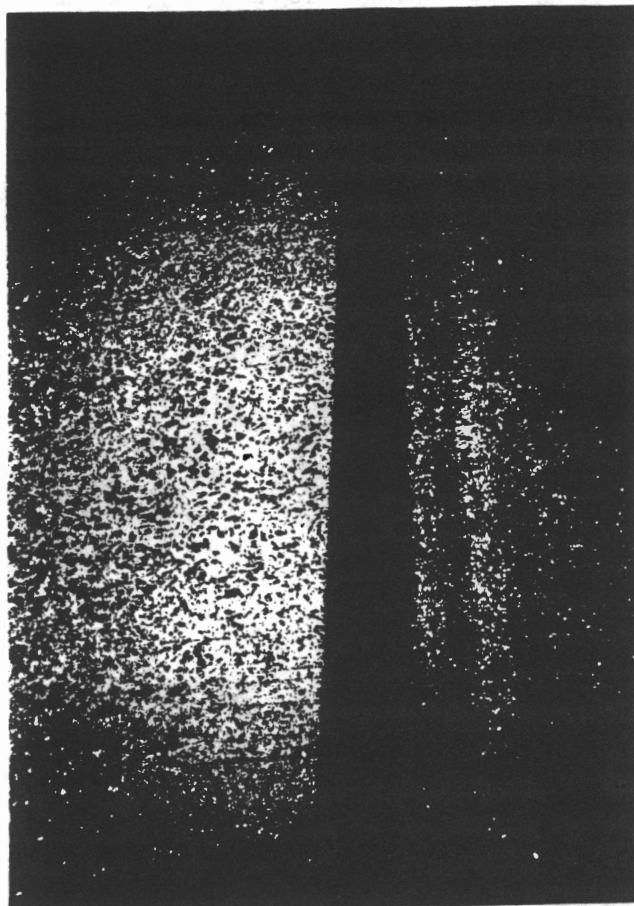


Figure 9A: New Line

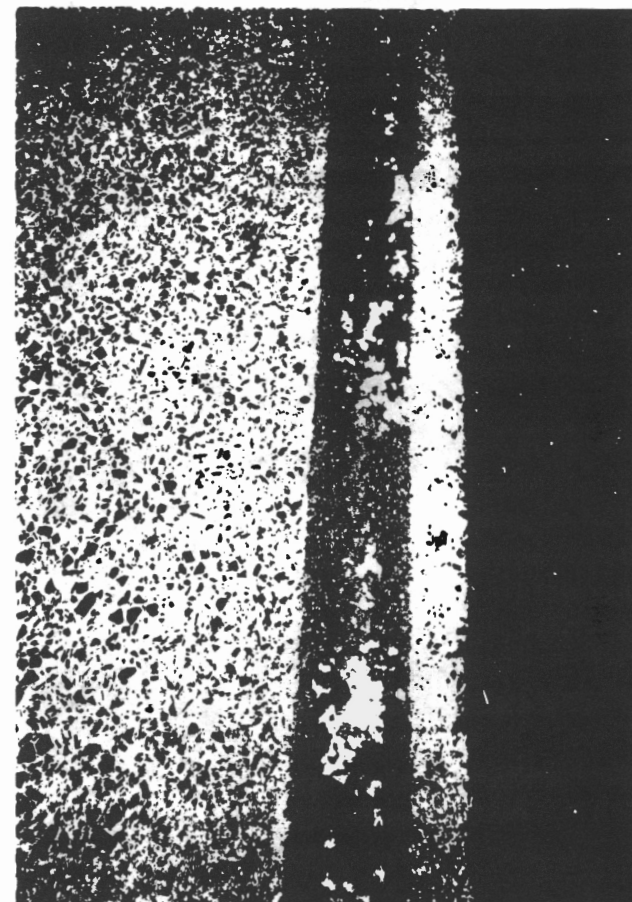


Figure 9B: 24 Months in Service

Figure 9: Typical Epoxy Edgeline (Yellow) on PCC Pavement



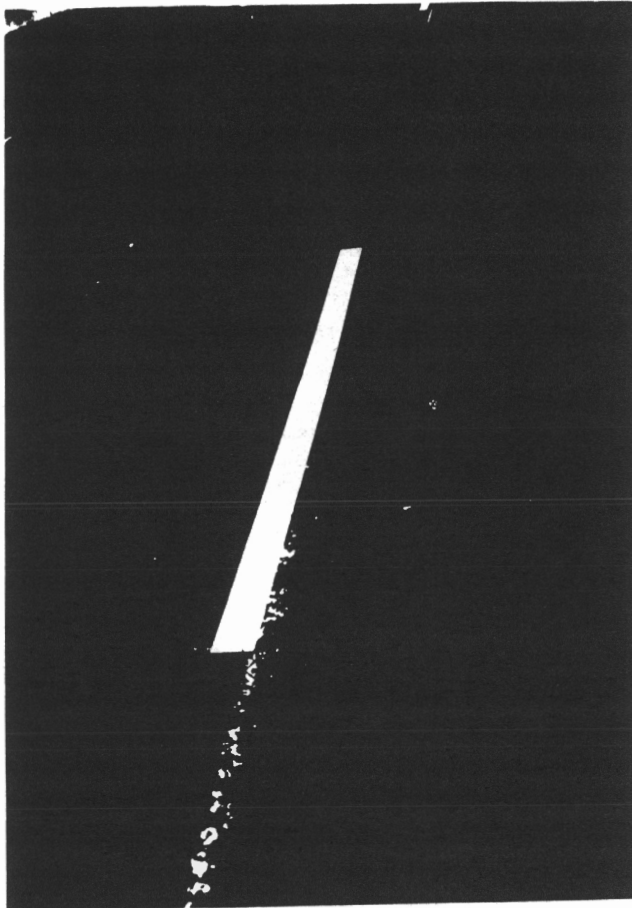


Figure 10A: New Line

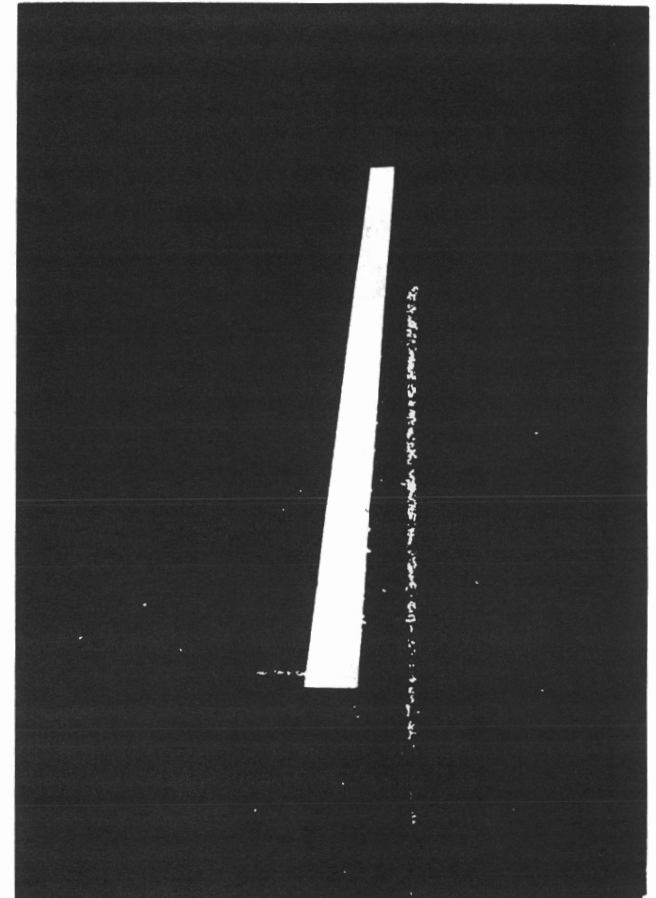


Figure 10B: 24 Months in Service

Figure 10: Typical Preformed Tape (3M Stamark 350A) Laneline on Bituminous Concrete Pavement



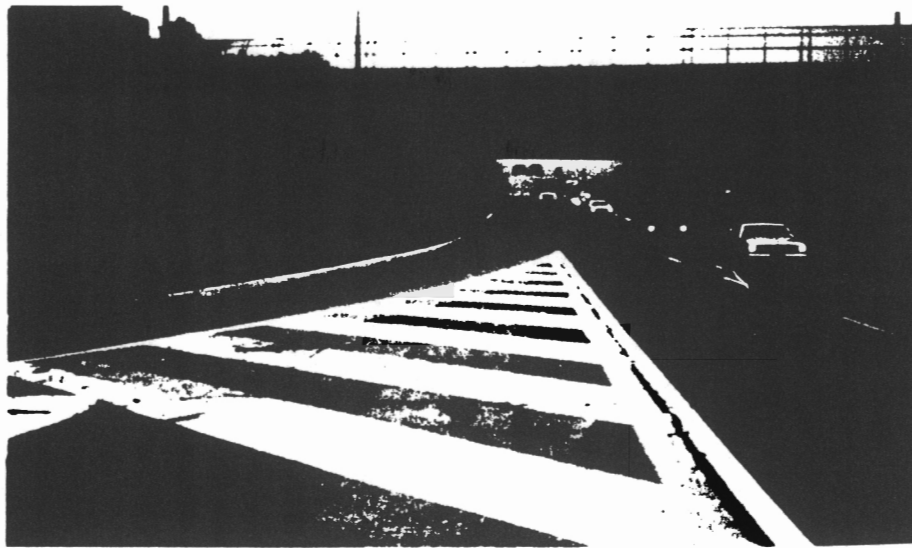


Figure 11A: New Gore

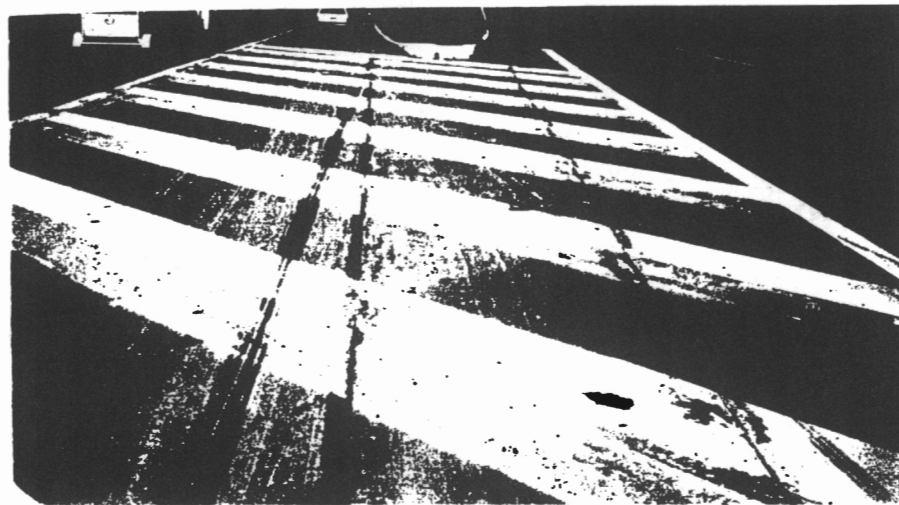


Figure 11B: 24 Month in Service (normal wear)

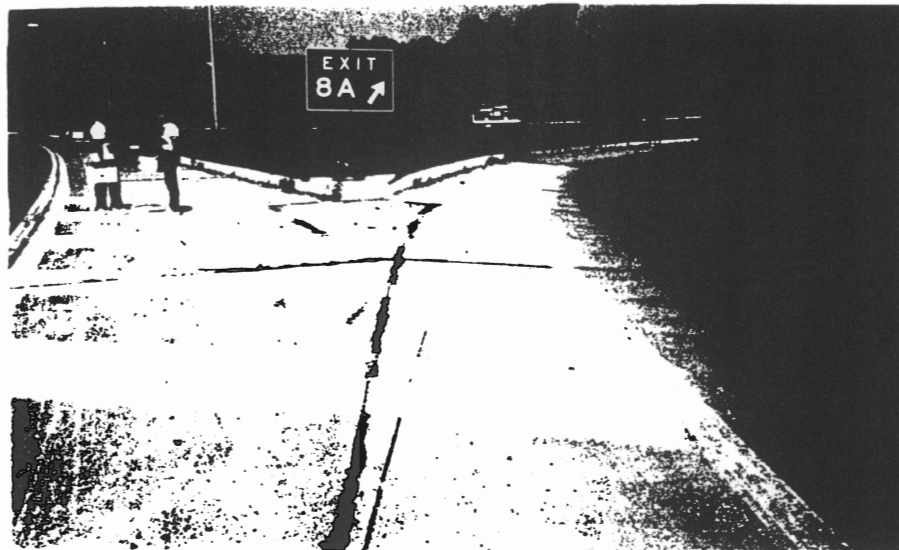


Figure 11C: 24 Months in Service (high impact area)

Figure 11: Typical Epoxy Gore Area





