Research Report
UKTRP-88-10

EVALUATION OF EXTRUDED THERMOPLASTICS AS LANE DELINEATION

by

Kenneth R. Agent
Research Engineer

and

Jerry G. Pigman
Research Engineer

July 1988

COMMONWEALTH OF KENTUCKY
TRANSPORTATION CABINET
FRANKFORT, KENTUCKY 40622

MILO D. BRYANT
SECRETARY
AND
COMMISSIONER OF HIGHWAYS

WALLACE G. WILKINSON
GOVERNOR

August 1, 1988

Mr. Robert E. Johnson
Division Administrator
Federal Highway Administration
330 West Broadway
Frankfort, Kentucky 40602-0536

SUBJECT: IMPLEMENTATION STATEMENT
Federal Aid Research Task 25
UKTRP 88-10, "Evaluation of Hydrocarbon and Alkyd Thermoplastics on Open-Graded Pavement"

Dear Mr. Johnson:

As a result of the information contained in the subject study, the Department of Highways has developed a new Pavement Marking Policy.

The new Pavement Marking Policy was submitted to you and was approved with minor changes September 22, 1987. This policy revision has been included in the Department's Traffic Division Guidance Manual.

Sincerely,

O. G. Newman, P. E.
State Highway Engineer

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Kentucky Transportation Research Program
College of Engineering
University of Kentucky
Lexington, Kentucky

in cooperation with
Transportation Cabinet
Commonwealth of Kentucky

and

Federal Highway Administration
US Department of Transportation

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16. Abstract

This study involved an evaluation of large-scale installations of both hydrocarbon and alkyd extruded thermoplastics as lane delineation on sections of interstate highways having open-graded surfaces. The objective of the study was to evaluate the performance of thermoplastics as lane delineation and to compare the performance of hydrocarbon versus alkyd formulations.

Data were collected on a periodic basis over an 18-month period. Data collection consisted of daytime observations of the appearance and durability of the thermoplastic material along with reflectivity measurements using a portable retroreflectometer.

The evaluation revealed that both the hydrocarbon and alkyd extruded thermoplastic material maintained their appearance, durability, and reflectivity over the 18-month study period. It was found that the alkyd formulation maintained a higher level of reflectivity than the hydrocarbon formulations.

Based on performance, it was recommended that extruded thermoplastic continue to be used as a lane delineation material, and its use be expanded to other bituminous pavements on high volume roadways. Either formulation could be used, but it was recommended that the installations on the open-graded pavements continue to be monitored to determine if either formulation performs substantially better on a long-term basis.

17. Key Words		18. Distribution Statement
Extruded Thermoplastic	Durability	Unlimited with approval of Kentucky Transportation Cabinet
Hydrocarbon	Reflectivity	
Alkyd		
Open-Graded Pavement		
Appearance		

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TABLE OF CONTENTS

INTRODUCTION

Traffic paints, typically an alkyd formulation, have been used as lane delineation on Kentucky highways for decades. In the past few years, more durable marking materials have been developed. These include thermoplastics, preformed tapes, and epoxy and polyester paints. Each material has advantages and disadvantages in the areas of cost, durability, visibility, and ease of application.

A specific problem area has been determination of the best marking material to use on open-graded pavement surfaces. Due to the porous nature of these pavements, the durability of typical traffic paint has been poor. Several applications of a typical traffic paint would not result in a durable line. A review of practices in other states has revealed that thermoplastics have been used frequently. Both a hydrocarbon and an alkyd formulation have been used with no consensus of opinion concerning the formulation that provided the best performance.

This study involved an evaluation of large-scale installations of both hydrocarbon and alkyd extruded thermoplastics as lane delineation on sections of interstate highways having open-graded surfaces. The objectives of the study were to evaluate the performance of thermoplastics as lane delineation and to compare the performance of hydrocarbon versus alkyd formulations. The evaluation dealt specifically with application on open-graded surfaces but could be applied to the use of thermoplastics statewide.

INSTALLATIONS

Four separate contracts were awarded (two for the alkyd and two for the hydrocarbon formulation). All installations were on interstate highways having open-graded asphalt surfaces. All contracts involved extruding the thermoplastic. A listing of the sections of interstate included in the four contracts is given in Table 1. The cost per linear foot for a four-inch line

varied from approximately 19 to 22 cents for the alkyd and 18 to 20 cents for the hydrocarbon formulation. The total quantities for the four contracts were approximately five million linear feet of four-inch line for white lane lines and yellow edge lines and 76,000 linear feet of eight-inch white line for gore markings. The quantities for the alkyd formulation were about 2.8 million linear feet of four-inch line and 47,000 linear feet of eight-inch lines. The quantities for the hydrocarbon formulation were about 2.2 million linear feet of four-inch line and 29,000 linear feet of eight-inch line. The projects covered about 214 miles on five different interstates with 115 miles of alkyd formulation and 99 miles of hydrocarbon formulation.

In each contract, it was stated that the material must conform to AASHTO Designation: M249-79. The yellow pigment contained a minimum of four percent encapsulated, heat resistant lead chromate. The application of glass beads was at a minimum rate of four pounds per one hundred square feet of line applied at the time of line placement. The specification for the alkyd formulation differed from the hydrocarbon formulation in that it had a section dealing with binder composition. This specification stated that: "The solid resin shall comprise a minimum of eight percent by weight of the entire material formulation which shall only consist of one hundred percent maleic modified glycerol ester of wood rosin with no tall oil derivative. Properly formulated maleic modified glycerol ester of wood rosin alkyd thermoplastic will, when one hundred grams of the sample is melted and mixed thoroughly with ten grams of Quaker State non-detergent thirty weight motor oil to approximately 425 degrees F., remain hard after pouring into a shallow lid or a thin patty and upon cooling shows a definite separation of the oil as a distinct layer on top of cool thermoplastic".

The thermoplastic material was extruded using a shaping die and placed at a minimum thickness of 90 mils. It was not applied when the pavement

temperature was below 50 degrees Fahrenheit or when the surface of the pavement contained evidence of moisture. On portland cement concrete pavements (bridges), a binder/sealer was applied to the area where the thermoplastic marking materials were placed. If it was felt that the existing pavement marking was loose and flaky, this material was removed by grinding or sand-blasting. This was not a problem on the open-graded pavement but was a consideration on the concrete bridges.

A copy of the installation specifications for one of the alkyd formulation contracts is included in Appendix A. The only difference between these specifications and those for the hydrocarbon formulation is the addition of the paragraph pertaining to "binder composition" in the material specifications section.

Lane lines and edge lines were four-inch lines and gore markings were eight-inch lines. Lane lines were installed as a ten-foot segment of material with a 30-foot gap. Due to the possibility that water may be retained on the roadway by the edge lines, a one-foot gap was placed every 20 feet.

Installations under the various contracts were monitored during the summer and fall of 1986 and discussions were held with both the state inspectors and contractor. The thermoplastic material was placed using a four-vehicle caravan, including the striper, with all vehicles equipped with an arrow board. No coning was required. There was a 30 second to one minute no-track time and no problems occurred with tracking. It was noted that the bead application rate was higher than required to increase reflectivity. Two bead guns were used with the beads sprayed under pressure. It was noted that if the temperature of the material was too high the beads would sink but if it was too low, the beads would not embed properly and would be knocked off by traffic. Checks at several locations revealed that bead embedment was good.

The inspectors noted that stripe thickness was monitored with the 90 mil minimum thickness maintained in most instances. The contractor noted that the hydrocarbon formulation material was easier to work with than the alkyd formulation. On the concrete bridges, the old paint was removed by grinding and a primer was used, but no surface preparation was necessary on the open-graded pavement since very little paint remained. Care had to be taken in the screening process to insure that clumps of material would not be placed. On a newly resurfaced open-graded surface, more thermoplastic material was required to obtain the 90 mil thickness since the aggregate had not been worn down and more voids had to be filled. On a section of pavement which had been resurfaced only about two weeks before placement of the thermoplastic, oil from the pavement was drawn through the thermoplastic to the top resulting in a number of small oil spots on the surface. While this did not present an appearance problem while driving down the roadway, the contractor noted that this problem could be solved by paint striping to seal the oil before placing the thermoplastic.

DATA COLLECTION

Data were collected periodically over 18 months. Data were collected shortly after installation to provide initial data. Additional data were collected approximately 3 months, 6 months, 9 months, 12 months, and 18 months after installation. This allowed data to be collected over two winters after installation in the summer and the fall of 1986. The initial data were collected in September 1986 with the 18-month data collected in March 1988.

Data collected consisted of daytime observations of the appearance and durability of the thermoplastic material along with reflectivity measurements using a portable retroreflectometer (PRR). The Mirolux 12 PRR was used to collect the reflectivity data. In early 1987, the Mirolux 12 was adapted

so that measurements were in terms of millicandelas per square foot per foot-candle (millicandelas). This resulted in four sets of data in these units with the first two sets of data in no units. Nighttime observations also were conducted. Both daytime and nighttime photographs were obtained to document the durability, reflectivity, and appearance evaluations.

Data were collected on eight sections of roadway (although data were not collected for each section during each of the six sets of data). There were five sections with hydrocarbon formulation and three with the alkyd formulation. Several measurements and observations were made on each section. The PRR data presented are an average of the data collected on each roadway section.

RESULTS

Appearance

During each inspection, the appearance of the thermoplastic stripes was evaluated while driving down the roadway as well as when viewed standing a few feet from the stripes. The appearance evaluation considered color of the white or yellow lines as compared to their original color and as compared to desirable colors. The appearance evaluation also concerned cleanliness of the stripe.

During each inspection, the daytime appearance of both the white and yellow stripes was found to be very good while driving down the roadway. When viewed from a few feet, some of the white stripes did not retain a bright white color but any appearance of a gray color was not readily observable while driving. The yellow stripes maintained a bright yellow color.

The inspections revealed that, while the white stripes did not retain a bright white color, the appearance of the thermoplastic lines was maintained well after the 18-month evaluation period.

Durability

The durability evaluation related to the ability of the material to remain on the surface. Observations were made during each inspection to determine if there were adhesive problems resulting in a loss in bond between the thermoplastic material and the roadway surface. The evaluation period allowed the material to be exposed to the use of snowplows during two winters. Inspections were made to determine if the 90-mil thick stripes had sustained any snowplow damage. Durability of the material on the concrete (Portland Cement Concrete (PCC)) bridges was also investigated.

After the 18-month evaluation period, it was determined that the thermoplastic material had not had any significant durability problems. Although the two winters since installation did not have substantial amounts of snowfall, the material had been subjected to snowplows. Some scraping of the top of the stripes were observed in isolated locations; however, the observations indicated that snowplow operations had not damaged the material. The only substantial loss noted was on some concrete bridges where there were sections with a loss in bond between the material and the concrete pavement. The durability of the material on the concrete bridges was inconsistent and verifies previous evaluations which revealed problems where thermoplastic material was placed on concrete pavement. No other significant durability problems were observed. At a few isolated locations, some loss was noted at the edges of some lines. In general, the inspections revealed that the thermoplastic material had maintained its durability quite well over the 18-month evaluation period.

The average daily traffic (ADT) at most of the inspection locations was in the range of 20,000 to 30,000. There were some locations having an ADT of 10,000 to 15,000 and observations were made at locations having an ADT as high as 90,000. The material remained durable on all roadways regardless of ADT.

Reflectivity

While the appearance and durability evaluations were generally subjective, the reflectivity evaluation was accomplished with a portable retroreflectometer (PRR) (the Mirolux 12) which allowed measurements in terms of millicandelas per square foot per foot-candle (millicandelas). Nighttime observations were conducted to supplement the PRR measurements. Data were collected on eight roadway sections (five with a hydrocarbon formulation and three with an alkyd formulation). Measurements were taken separately for the white edge lines, lane lines, and gore markings on the mainline and the yellow edge line on both the mainline and the ramp. Several measurements were taken on each type of line at each location to obtain an average. Also, measurements were taken at several locations on each roadway to obtain an average for that roadway section. The data for each of the roadway sections are summarized in Appendix B.

Data from the various roadway sections were combined into the summary contained in Table 2. The roadway sections with hydrocarbon and alkyd formulations were summarized separately for the time periods of 6, 12, and 18 months after installation. This allowed for all the data presented to be listed in millicandelas. The major types of stripes (white and yellow mainline edge line, white lane lines, and white gore markings) were summarized separately. For some time periods, all of the highway sections did not have data for a given type of stripe. The PRR data show that the reflectivity of the stripes had been maintained adequately over the 18-month evaluation period. This was confirmed by nighttime observations. The lowest readings were for the yellow edge line while the highest readings were for the gore markings. The readings for the alkyd formulation were consistently higher than for the hydrocarbon formulation. While the PRR measurements for the

hydrocarbon formulation has decreased during the study period, the measurements for the alkyd formulation have remained steady. All of the measurements have remained well above what would be considered a minimum acceptable value in the range of 80-100 millicandelas.

RECOMMENDATION

Based on performance (appearance, durability, and reflectivity), it is recommended that extruded thermoplastic continue to be used as a lane delineation material. While this evaluation dealt with open-graded pavements, use of extruded thermoplastics should be expanded to other bituminous pavements; however, it should not be used on concrete (PCC) pavements. The cost of approximately 20 cents per linear foot for four-inch lines would limit its use to higher volume highways. Both the hydrocarbon and alkyd formulation performed well but the alkyd formulation maintained a higher reflectivity. Either formulation could be used, but it is recommended that the installations on the open-graded pavements continue to be monitored to determine if either formulation performs substantially better on a long-term basis.

TABLE 1. LIST OF INSTALLATION LOCATIONS

PROJECT NUMBER	FORMULATION	COUNTY	ROUTE	MILE MARKER LIMITS		
IRG 00S(28)	Alkyd	Hart	I- 65	61.260	to	74.622
		Larue	I- 65	74.622	to	78.661
		Hardin	I- 65	78.661	to	90.000
IRG 00S(29)	Hydrocarbon	Jefferson	I- 64	5.500	to	8.200
			I- 64	18.830	to	23.970
			I-264	20.200	to	22.650
		Shelby	I- 64	23.970	to	38.180
		Jefferson	I- 71	5.440	to	11.320
		Oldham	I- 71	11.320	to	21.650
			I- 71	21.650	to	24.730
		Henry	I- 71	24.730	to	37.000
			I- 71	37.000	to	38.090
		Trimble	I- 71	38.090	to	38.810
IRG 00S(30)	Alkyd	Carroll	I- 71	38.810	to	53.430
		Gallatin	I- 71	53.430	to	69.890
		Boone	I- 71	69.890	to	77.720
		Grant	I- 75	143.239	to	166.263
		Kenton	I- 75	166.263	to	169.439
			I- 75	183.312	to	190.630
		Boone	I- 75	169.439	to	183.312
IRG 00S(31)	Hydrocarbon	Clark	I- 64	89.480	to	104.260
		Montgomery	I- 64	104.260	to	112.300
		Madison	I- 75	87.322	to	97.545
		Fayette	I- 75	97.545	to	100.320
		Scott	I- 75	138.051	to	143.237

TABLE 2. PORTABLE RETROREFLECTOMETER DATA

TIME IN SERVICE	PRR MEASUREMENT*							
	TYPE OF STRIPE							
	LANE LINE		WHITE EDGE LINE		GORE		YELLOW EDGE LINE	
	H**	A***	H	A	H	A	H	A
6 Months	290	390	310	420	370	490	180	210
12 Months	240	390	260	420	320	430	170	220
18 Months	220	400	200	420	280	460	160	230

* Data collected with a Mirolux 12 PRR in units of millicandelas per square foot per foot-candle.
** Hydrocarbon formulation.
*** Alkyd formulation.

APPENDIX A

Thermoplastic Specifications

INSTALLATION OF 90 MIL HOT SCREED EXTRUDED THERMOPLASTIC PAVEMENT MARKING MATERIAL

SPECIFICATIONS

GENERAL SPECIFICATIONS

Work performed under this contract shall be in conformance with Commonwealth of Kentucky, Transportation Cabinet, Department of Highways' Standard Specifications for Road and Bridge Construction 1985 Edition, applicable Special Provisions and general specifications included in this proposal or described in the plans. In the case of any discrepancy between the Standard Specifications, Special Provisions or other specifications and provisions contained in this contract, the Engineer shall be the sole authority as to the proper procedure to follow. The U. S. Department of Transportation's Manual on Uniform Traffic Control Devices, 1978 Edition, with all approved changes and additions shall also apply to this contract and hereafter will be referred to as the MUTCD.

SCOPE OF WORK

The work under this project shall consist of furnishing and installing machine applied screed extruded hot thermoplastic pavement marking material conforming to the specifications listed in this proposal to sections of the Interstate System which have been resurfaced with Open-graded surface. The use of spray or ribbon gun applications are unacceptable. The thermoplastic material must be applied through a shaping die that simultaneously deposits and shapes lines on the pavement surface.

This work shall consist of applying lane lines, edge lines and gore markings on the main line within the limits of roadway sections listed elsewhere in this proposal. The contractor shall furnish all material, services, labor and equipment necessary for the required pavement preparation, layout, and completion of the pavement marking installation.

APPLICATION

All pavement marking material installed under this contract shall generally be placed in the same locations where the old pavement markings existed. Naturally, any misalignment of existing pavement marking shall be corrected. If the existing pavement markings are not visible or no existing markings are in place, the Contractor shall be required to pre-mark each location prior to the application of the thermoplastic material. The thermoplastic material shall not be placed until the Engineer has approved the proposed location alignment as indicated by the control guides set by the contractor.

Application equipment for lane lines and edge lines shall be motorized and capable of applying thermoplastic pavement marking material at a minimum rate of three (3) miles per hour. All application equipment shall be so constructed as to assure continuous uniformity in the thickness and width of the pavement marking, and shall be equipped with a cut-off device remotely controlled, to provide clean, square stripe ends. The application equipment shall also be capable of applying glass beads at the time of line placement. Longitudinal lines shall be off-set at least two inches (2") from longitudinal pavement construction joints. All pavement marking lines shall be applied

with one pass of the pavement marking equipment.

If, in the opinion of the Engineer, the existing pavement marking is loose and flaky, the Engineer shall direct the Contractor to remove the loose and flaky material in an approved grinding or sand-blasting manner which will not materially damage the surface or the texture of the pavement prior to installing the thermoplastic material. The cost of this pavement marking removal shall be paid at the unit bid price for Paint Stripe Removal. In addition any pavement surface upon which the pavement markings are to be placed shall be properly cleaned of grease, oil, mud, dust, dirt, grass, loose gravel and other deleterious material prior to the application of the thermoplastic pavement marking material.

On all Portland Cement concrete pavement (for this project this shall occur on bridges) binder/sealer shall be applied to the area where thermoplastic pavement marking materials are to be placed. The binder/sealer shall be that recommended by the manufacturer of the thermoplastic material, and approved by the Engineer. The material shall form a continuous film which shall dry rapidly and adhere to the pavement. The material shall not discolor nor cause any noticeable change in the appearance of the pavement outside of the finished pavement marking. All solvents shall have evaporated from the binder/sealer prior to the application of the molten thermoplastic material. A sample of the binder/sealer and the recommended method of application must be submitted to the Engineer, and shall have been approved in writing by the Engineer and the manufacturer of the thermoplastic material before application.

No direct payment will be made for this surface preparation (pavement cleaning and application of binder/sealer) as such work will be considered incidental to the work being paid for the thermoplastic pavement marking material application in this contract.

All pavement markings shall be installed in accordance with Part III of the MUTCD and the following specifications at a minimum thickness of 90 mils. Lane lines and edge lines shall be four-inch (4") lines. Lines for gore markings shall be eight-inch (8") lines. Lane lines shall be installed as a ten-foot (10') segment of material with a thirty-foot (30') gap. Gore markings shall be installed as shown in Figures 3-11 and 3-12 of the MUTCD. The optional markings shown (transverse lines in the neutral area and dotted extension of the right edge line) shall not be used. Due to the possibility water may be retained on the roadway by the edge lines, a one-foot (1') gap shall be placed every twenty feet (20') of all edge lines.

The thermoplastic pavement marking material shall not be applied when pavement temperatures are below 50 degrees F. or when the surface of the pavement contains evidence of moisture. This moisture can be caused by heavy dew or very humid nights. A test to determine the presence of moisture is to lay some roofing tar paper on the road surface to be striped. Install a line of the thermoplastic material on this tar paper. Wait 30 seconds and pick up the paper. If the surface underneath is wet, the pavement should be dried with heat or the application of the thermoplastic material should wait until later in the day when natural evaporation has taken place. The Contractor shall be prepared to perform this test at the request of the Engineer at no additional expense to the Department.

PROVING PERIOD

A 90-day proving period shall follow the completion of the placement of the thermoplastic pavement marking placed during each calendar month under this contract. During this period the Engineer will make such observations as are necessary to determine failure of the material. If more than 10% of the pavement marking material within anyone mile section fails during the proving period for any reason, the material within that section shall be repaired or replaced at the Contractor's expense prior to final acceptance. Each edge line, lane line and gore markings shall be considered separately. This evaluation shall apply to material thickness, color, reflectivity and adhesion to the pavement surface.

CONFLICTS WITH OTHER PROJECTS

Roadway construction projects, not known by the Division of Traffic at the time these plans were developed, may be underway within the limits of the designated work areas when this project is under construction. It will be the responsibility of the Engineer to notify the Contractor of such roadway projects. No thermoplastic material shall be installed which will be removed or damaged by immediate subsequent roadway construction. It would be desirable to schedule thermoplastic material installation in order that the thermoplastic material could be installed upon completion of roadway construction. If this would be impossible or work an undue hardship on the Contractor, the roadway construction site should be eliminated from this project.

CERTIFICATION AND INSPECTION

Acceptance of the material to be used under this contract shall be based upon a certified report containing test data indicating compliance with the listed specification requirements. This certified report shall be delivered to the Engineer upon delivery of each shipment of material. At that time, a five (5) pound sample of each color shall be taken by the Engineer in a manner prescribed by the Division of Materials. Upon receipt of the certified report and sampling of the material, the shipped material may be used for this project.

COMPLETION TIME

The time allotted for this project is 80 working days.

PAYMENT

Payment will be made on a per unit basis for items listed in the Quantity Summary, which payment shall be full compensation for all labor, equipment, materials, transportation and all other costs to the Contractor. Contrary to Section 104.02 of the Standard Specifications, payment for all units will be at the contract unit price, and no adjustment in the price will be allowed because of overruns or underruns exceeding 25 percent.

MATERIAL SPECIFICATIONS

A. GENERAL

The pavement marking material applied under this contract shall conform to AASHTO Specification Designation: M-249-79 as published in 1982 and to other requirements listed below.

B. BINDER COMPOSITION

The solid resin shall comprise a minimum of eight percent (8%) by weight of the entire material formulation which shall only consist of one hundred percent (100%) maleic modified glycerol ester of wood rosin with no tall oil derivative. Properly formulated maleic modified glycerol ester of wood rosin alkyd thermoplastic will, when one hundred (100) grams of the sample is melted and mixed thoroughly with ten (10) grams of Quaker State non-detergent thirty (30) weight motor oil to approximately 425 degrees F., remain hard after pouring into a shallow lid or a thin patty and upon cooling shows a definite separation of the oil as a distinct layer on top of the cool thermoplastic.

C. YELLOW PIGMENT

The yellow pigment shall contain a minimal of four percent (4%) encapsulated, heat resistant lead chromate.

D. GLASS BEADS

The application of additional glass beads shall be at a minimum rate of four (4) pounds per one hundred (100) square feet to be applied at the time of line placement.

E. PACKAGING AND MARKINGS

The thermoplastic material shall be delivered to the Contractor in a suitable container to which it will not adhere during shipment or storage. The label shall warn the user that the material shall be heated in the range of 204-226 degrees C. (400-440 degrees F.) during application.

MAINTENANCE OF TRAFFIC

All traffic control devices required for this project shall be provided by the Contractor and approved by the Engineer. The cost of providing, installing, and maintaining all traffic control for this project shall be paid under the lump sum bid item of Maintain and Control Traffic. All traffic control devices shall conform to the requirements of the MUTCD and Standard Drawing Nos. TSC 260-05, TSC 261-02 and TSC 270-01. Normal lane closures shall be signed in accordance with Standard Drawing No. TSC 210-03 or TSC 215-02. Alternate traffic control schemes may be used if submitted in writing by the Contractor and approved in writing by the Engineer, Division of Traffic, Division of COnstruction, Division of Design and Federal Highway Administration.

No more than one lane of traffic plus two feet of only one adjacent lane shall be closed per direction of travel. There shall be only one lane closure per

direction of travel and the length of a lane closure shall not exceed three miles in urban areas nor five miles in rural areas. Egress or ingress shall be provided to all ramps at all times.

Working hours shall be scheduled as to avoid interference with normal traffic movement during the morning and evening hours of peak traffic flow. There shall be no lane closures or interference with normal traffic movement between the hours 6:30 AM to 9:00 AM and 3:00 PM to 7:00 PM on normal weekdays. There shall be not lane closures or interference with southbound traffic from 2:00 PM Friday until 2:00 AM Sunday and with northbound traffic from 2:00 PM Sunday until 2:00 AM Monday. This same type lane closure prohibition shall apply for days preceding national holidays or special events.

The national holidays mentioned in the preceding paragraph include, but are not necessarily limited to, Easter, Memorial Day, Independence Day (July 4), Labor Day, and Thanksgiving Day. Due to unforeseen special events, unusual traffic volumes may develop. In such cases, the above notes on lane closures shall not apply. In this case, lanes shall be closed only as directed by the Engineer.

Placement of all devices for lane closures shall start and proceed in the direction of traffic flow. Removal of devices shall start at the end of construction area and proceed toward oncoming traffic. The Contractor shall provide for the installation of all necessary traffic control devices before beginning work and their immediate removal as soon as work is suspended or completed and the pavement marking material is completely bonded to the pavement.

During non-working hours of each day, all equipment and signing devices required during the working hours shall be placed behind the ditchline at locations approved by the Engineer so as not to interfere with normal traffic flow. All signs shall be covered or stored so as to be obscured from all traffic. The Contractor's vehicles shall always move with and not across or against the flow of traffic. These vehicles will not be permitted to make U-turns on the median at any location. Vehicles shall enter or leave work areas in a manner which will not be hazardous to, or interfere with, normal traffic flow. Vehicles shall not park or stop except within designated work areas. Personal vehicles will not be permitted to park within the right-of-way except in specific areas designated by the Engineer.

APPENDIX B

REFLECTIVITY MEASUREMENTS

TABLE B1. PRR DATA FOR I75 IN MADISON COUNTY
(HYDROCARBON FORMULATION)
(AADT RANGE 18,600 - 34,100)

	PRR MEASUREMENTS				
	WHITE				YELLOW
DATE	EDGE	LANE	BOTH*	GORE	MAINLINE
September 1986			300		150
December 1986	270	140			140
April 1987**	340	140			120
September 1987**	230	130		220	140
March 1988**	170	180		200	110

* Both represents a combination of lane line and white edge line data.
** Millicandelas per square foot per footcandle.

TABLE B2. PRR DATA FOR I64 IN SHELBY COUNTY
(HYDROCARBON FORMULATION)
(AADT RANGE 18,900 - 21,300)

	PRR MEASUREMENTS					
	WHITE				YELLOW EDGE	
DATE	EDGE	LANE	BOTH*	GORE	MAINLINE	RAMP
September 1986			250		110	
December 1986			260		110	
April 1987**			330		150	
June 1987**	310	410		440	180	220
September 1987**	280	370		430	190	220
March 1988**	190	300		410	180	220

* Both represents a combination of lane line and white edge line data.
** Millicandelas per square foot per footcandle.

TABLE B3. PRR DATA FOR I75 IN SCOTT COUNTY
(HYDROCARBON FORMULATION)
(AADT RANGE 18,300 - 23,300)

	PRR MEASUREMENTS			
	WHITE			YELLOW
DATE	EDGE	LANE	BOTH*	MAINLINE
September 1986			240	120
December 1986	240	210		100
April 1987**	370	300		150
September 1987**	320	200		160
March 1988**	230	190		160

* Both represents a combination of lane line and white edge line data.

** Millicandelas per square foot per footcandle.

TABLE B4. PRR DATA FOR I71 (HYDROCARBON FORMULATION)
(AADT RANGE 13,800 - 17,100)

	PRR MEASUREMENTS*				
	WHITE			YELLOW EDGE	
DATE	EDGE	LANE	GORE	MAINLINE	RAMP
April 1987	400	380	380	230	
September 1987	320	300	360	200	240
March 1988	250	220	290	180	300

* Millicandelas per square foot per footcandle. No data was collected at this location before June 1987.

TABLE B5. PRR DATA FOR I64 IN CLARK AND MONTGOMERY COUNTIES (HYDROCARBON FORMULATION) (AADT RANGE 10,100 - 23,900)

	PRR MEASUREMENTS*			
	WHITE			YELLOW
DATE	EDGE	LANE	GORE	MAINLINE
April 1987	140	230	280	200
September 1987	160	190	250	180
March 1988	150	190	230	160

* Millicandelas per square foot per footcandle. No data was collected at this location before June 1987.

TABLE B6. PRR DATA FOR I75 IN GRANT COUNTY (ALKYD FORMULATION) (AADT RANGE 18,300 - 29,400)

	PRR MEASUREMENTS					
	WHITE				YELLOW EDGE	
DATE	EDGE	LANE	BOTH*	GORE	MAINLINE	RAMP
September 1986			270		130	
December 1986	200	200			90	
April 1987**	400	390			200	
September 1987**	390	390		430	220	230
March 1988**	390	430		400	220	210

* Both represents a combination of lane line and white edge line data.

** Millicandelas per square foot per footcandle.

TABLE B7. PRR DATA FOR I65 IN HARDIN COUNTY
(ALKYD FORMULATION)
(AADT RANGE 18,700 - 25,300)

	PRR MEASUREMENTS					
	WHITE				YELLOW EDGE	
DATE	EDGE	LANE	BOTH*	GORE	MAINLINE	RAMP
September 1986			290		140	
December 1986			250		120	
April 1987**			300		170	
June 1987**	420	340			190	
September 1987**	390	330		390	190	220
March 1988**	390	280		400	200	

* Both represents a combination of lane line and white edge line data.
** Millicandelas per square foot per footcandle.

TABLE B8. PRR DATA FOR I71 (ALKYD FORMULATION)
(AADT RANGE 13,800 - 17,100)

	PRR MEASUREMENTS*				
	WHITE			YELLOW EDGE	
DATE	EDGE	LANE	GORE	MAINLINE	RAMP
December 1986	230	220		120	
April 1987**	410	400		220	
June 1987**	440	470	490	250	250
September 1987**	470	440	460	250	220
March 1988**	470	480	570	260	360

* Millicandelas per square foot per footcandle. No data was collected at this location before December 1986.