

VERMONT AGENCY OF TRANSPORTATION

**Research and Development Section
Research Report**



EPOPLEX GLOMARC 90 POLYUREA PAVEMENT MARKING

Report 2015 – 02

January 2015

**EPOPLEX GLOMARC 90 POLYUREA
PAVEMENT MARKING**

Final Report 2015 – 02

January 2015

Reporting on Work Plan 2009-R-03

STATE OF VERMONT
AGENCY OF TRANSPORTATION

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16. Abstract <p>Pavement markings provide an important means of communication for all roadway users and must be capable of conveying information during inclement weather and evening hours when there may be little to no contribution from overhead lighting. Recently the Agency has been applying recessed polyurea markings on most interstate rehabilitation projects. Recessing has proven effective in extending the service life of pavement markings by protecting them from wear induced by tire abrasion and shearing effects generated by snow plows. This research was conducted to evaluate the application of an experimental pavement marking, known as Epoplex Glomarc 90 Polyurea, with respect to long line application.</p> <p>The Epoplex Glomarc 90 Polyurea was applied on the Derby IM 091-3(46) project, located along I-91 northbound and southbound between mile marker (MM) 169.8 and 177.4. Five test sites were established in the southbound lanes of the project, all of which were experimental. Following the placement of the markings, retroreflectivity and wear readings were collected using uniform methods. Retroreflectivity readings were taken on each line (white edge, white skip, yellow edge) within the southbound test site limits using the LTL 2000 Retroreflectometer. Each test site is 40 feet in length, with readings sampled every 10 linear feet. White skip lines that coincide transversely with any sample point were also tested.</p> <p>All markings were found to be in compliance with FHWA recommended minimum Retroreflective values, and above the Agency's required initial retroreflective values of 500 mcdl/m²/lx for white, and 400 mcdl/m²/lx for yellow. The most notable observation during the site visit was that on average, the yellow markings were presenting higher retroreflective values than the white lines. Research personnel will continue to monitor and collect additional information concerning the overall durability and retroreflectivity of all test sites in accordance with the work plan.</p>					
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ABSTRACT

Pavement markings provide an important means of communication for all roadway users and must be capable of conveying information during inclement weather and evening hours when there may be little to no contribution from overhead lighting. Recently the Agency has been applying recessed polyurea markings on most interstate rehabilitation projects. Recessing has proven effective in extending the service life of pavement markings by protecting them from wear induced by tire abrasion and shearing effects generated by snow plows. This research was conducted to evaluate the application of an experimental pavement marking, known as Epoplex Glomarc 90 Polyurea, with respect to long line application.

The Epoplex Glomarc 90 Polyurea was applied on the Derby IM 091-3(46) project, located along I-91 northbound and southbound between mile marker (MM) 169.8 and 177.4. Five test sites were established in the southbound lanes of the project, all of which were experimental. Following the placement of the markings, retroreflectivity and wear readings were collected using uniform methods. Retroreflectivity readings were taken on each line (white edge, white skip, yellow edge) within the southbound test site limits using the LTL 2000 Retroreflectometer. Each test site is 40 feet in length, with readings sampled every 10 linear feet. White skip lines that coincide transversely with any sample point were also tested.

All markings were found to be in compliance with FHWA recommended minimum Retroreflective values, and above the Agency's required initial retroreflective values of 500 mcdl/m²/lx for white, and 400 mcdl/m²/lx for yellow. The most notable observation during the site visit was that on average, the yellow markings were presenting higher retroreflective values than the white lines. Research personnel will continue to monitor and collect additional information concerning the overall durability and retroreflectivity of all test sites in accordance with the work plan (1).

INTRODUCTION

Pavement markings provide an important means of communication for all roadway users and must be capable of conveying information during inclement weather and evening hours when there may be little to no contribution from overhead lighting. However, traffic markings are often subject to abrasion from vehicle tires and winter maintenance practices as well as ultraviolet sunlight and fading pigments following application. These deterioration mechanisms result in a loss of binder and reflective elements. Durable markings are often applied to newly constructed pavements in the state of Vermont and restriped with waterborne paint when markings no longer adequately delineate the roadway. In accordance with “2006 Standard Specification for Construction”, “durable pavement markings are classified as pavement marking tape, epoxy paint, thermoplastic markings, polyurea paint, and methyl-methacrylate.” Each of the referenced markings, comprised of various elements, has displayed unique characteristics and varying life cycles.

Recently the Agency has been applying recessed polyurea markings on most interstate rehabilitation projects. The process of recessing includes the removal of a small portion of the surface of the wearing course prior to the application of permanent markings. Recessing has proven effective in extending the service life of pavement markings by protecting them from wear induced by tire abrasion and shearing effects generated by snow plows.

The following report outlines the final observations concerning the application of an experimental (to Vermont) pavement marking, known as Epoplex Glomarc 90 Polyurea, with respect to long line application. In addition, the report contains information pertaining to field data collection to assess the luminance, durability, and the ability to uphold the retroreflectivity requirements over time.

PROJECT LOCATION SUMMARY

The Epoplex Glomarc 90 Polyurea was applied on the Derby project, IM 091-3(46), located along I-91 northbound and southbound between mile marker (MM) 169.8 and 177.4 by L&D Safety Markings Corporation (See Figure 1). According to the project plans, work to be performed included cold planing and resurfacing of the northbound and southbound travel and passing lanes, interchange 27, 28, and 29 ramps, maintenance u-turns, and the welcome center with a leveling course, wearing course, milled rumble strips, new pavement markings, guardrail improvements, signs, and other incidental items. The average annual daily traffic (AADT) ranges from 5,200 at the start of the project to 3,000 at the end of the project as of 2012. These are considered moderate to low AADTs for Vermont.

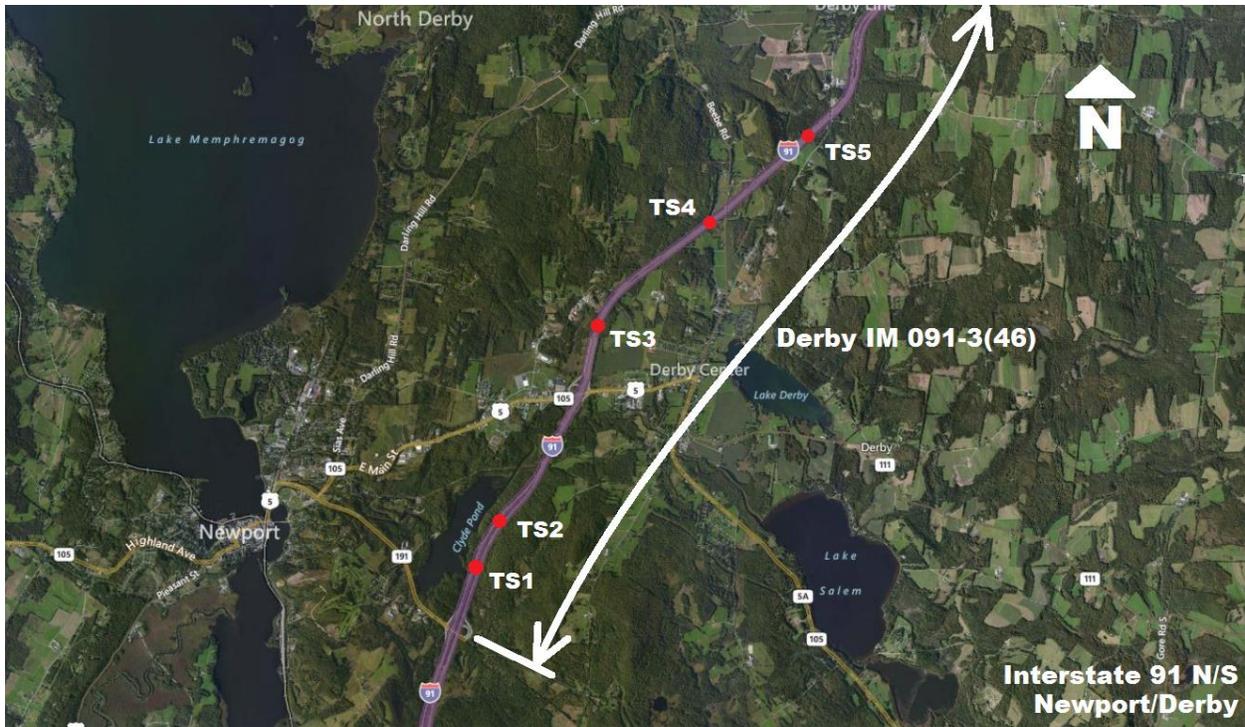


Figure 1 Project Location - I91 in Derby

Five test sites were established, all of which were experimental. All test site locations are summarized in Table 2 and shown in Figure 1. Each test site was 40 feet in length, with readings sampled every 10 linear feet for a total of five readings per line. White skip lines that coincide transversely with any sample point are also tested. Each test site had five white edge line readings, 5 yellow edge line readings, and two white skip line readings.

Table 2: Test Site Location Summary

Test Site	Mile Marker (MM)	AADT
TS 1	MM 170.80	5,200
TS 2	MM 171.30	5,200
TS 3	MM 172.95	3,000
TS 4	MM 174.30	3,000
TS 5	MM 175.45	3,000

MATERIAL DESCRIPTION

According to the manufacturer, Epoplex of Maple Shade, NJ, Epoplex Glomarc 90 is a highly reflective pavement marking system designed for use on concrete or bituminous concrete roadways and highways as a long-lasting striping material for both edging and centerline markings, as well as all intersection markings. The product consists of a two-component polyurea based durable highway marking system that provides superior reflectivity during both day and night under both dry and wet weather conditions. The first component is Epoplex LS90 polyurea binder, which is formulated to provide a simple volumetric mixing ratio of two volumes of Component A (amine) to one volume of Component B (isocyanate). The second component of the marking system is the VISIMAX™ Bead System, which is designed to achieve superior wet night reflective characteristics. According to the manufacturer, VISIMAX™ is a VISIBead core with High-Index beads on the coated exterior shell (2).

In accordance with the manufacturer's specifications, Glomarc 90 should be applied only when atmospheric and surface temperatures are 32°F or higher using mobile, truck mounted and self-contained equipment. The equipment shall be capable of spraying both white and yellow polyurea through an airless static tube or impingement mixing guns to accommodate a volumetric ratio of two to one to satisfy manufacturer recommendations. The applicator must be of sufficient size and stability with adequate hydraulic and air power supplies to produce uniform line dimensions and have a high-pressure air blast cleaning system capable of cleaning the pavement surface immediately prior to applying the markings.

At the time of installation, the Vermont General Special Provisions required that polyurea pavement markings be recessed whenever applied to provide longevity of the marking. This specification required that polyurea be applied to create a uniform wet film thickness of 22 mils (+/- 2 mils). The recessing specification for polyurea markings required that the recess be 60 mils (+/- 2 mils) in depth. These specifications have since been updated (3). For all recessed markings, the markings must not be applied for a minimum of 24 hours after the recess is completed.

PERFORMANCE AND OBSERVATIONS

Details of the application of the lines and initial readings are documented in the initial report 2014-6 (4). During the length of the study, the yellow markings, on average, registered higher retroreflective values than the white. This is not typical with line striping. White markings typically provide higher retroreflective values due to the nature of pigments in white paint as compared to yellow. Table 2 displays the average retroreflectivity value over all test

sites for each type of marking during each site visit, while Figure 2 illustrates the values over time. Retroreflectivity values were measured according to ASTM E 1710-97: Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer (5).

Table 2: Project Average Retroreflectivity Readings

	Date	Yellow Edgeline	White Skipline	White Edgeline
Average of All Test Sections	Sep-10	726	569	730
	Jan-11	364	165	247
	Mar-11	226	123	141
	Jul-11	442	136	138
	Oct-11	414	133	141
	Dec-11	79	60	50
	Mar-12	204	93	106
	Jul-12	292	136	137
	Oct-12	274	138	132
	Jan-13	199	135	134
	Apr-13	186	115	121
	Jul-13	186	118	119

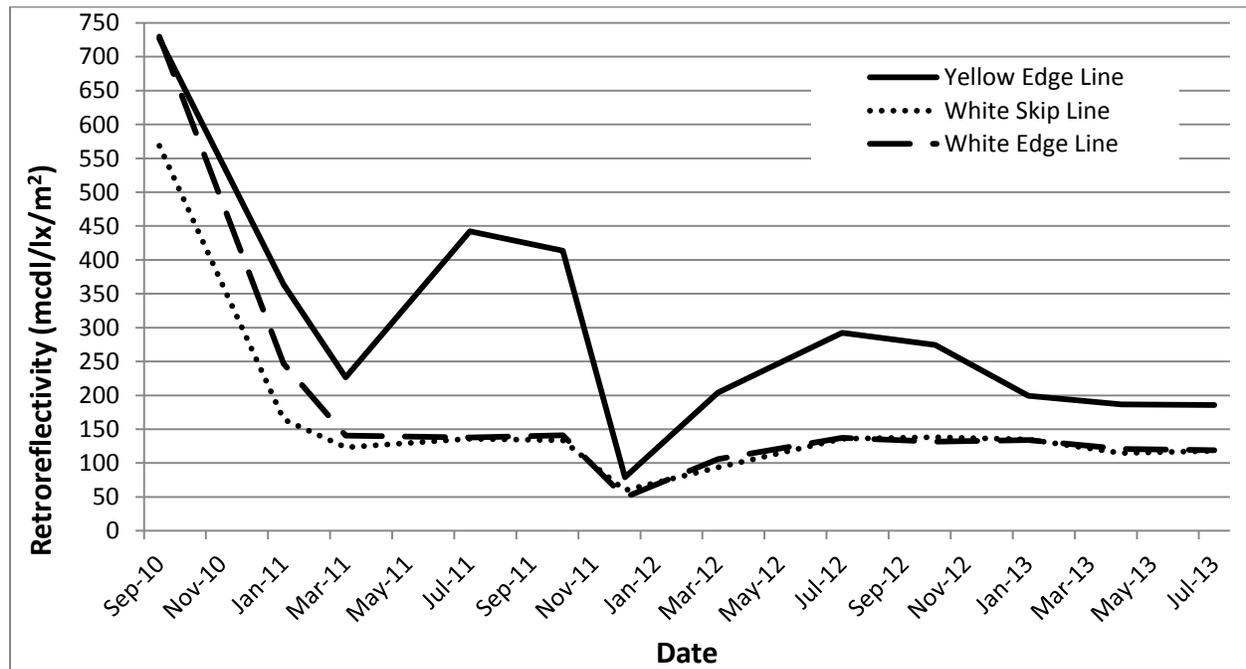


Figure 2. Average retroreflectivity values for each site visit.

All markings started well above the required initial retroreflective values of 500 mcd/m²/lx for white and 400 mcd/m²/lx for yellow as specified in the contract. The large dips in values occurring during winter readings (March 2011, January 2012) are most likely due to – low damage, excessive salt, sand and other contaminants on the lines along with the cold temperatures, and must be expected when attempting to perform retroreflectivity measurements during the winter in Vermont. To date, the Federal Highway Administration, or FHWA, and other federal and state authorities have not established a minimum requirement for retroreflectivity of pavement markings over their lifetimes. However, FHWA has compiled recommended retroreflectivity guidelines for white and yellow pavement marking for different classes of roads as shown in Table 3. As I-91 is classified as a freeway with a posted speed limit of 65 mph, the recommended minimum retroreflectivity for white markings is 150 mcd/m²/lx and 100 mcd/m²/lx for the yellow markings. Any readings that fall below the FHWA recommendations are bolded and italicized in the retroreflectivity tables. The average of all white readings, for both edge line and skip lines, fell below the recommended minimum of 150 following the first winter of service. Yellow readings, on the other hand, remained well above the minimum of 100 through the study period, with the exception of one mid-winter reading, likely due to excessive salt or contaminants on the lines at the time. Although the markings contained wet-night elements, wet readings could not be taken during the study, as a retrometer that can perform wet readings was not available.

Table 3. 1998 FHWA recommended retroreflectivity minimums.

Type	Non-Frwy	Non-Frwy	Freeway
Option 1	<= 40 mph	>= 45 mph	>= 55 mph
Option 2	<= 40 mph	>= 45 mph	>= 60 mph, >10K ADT
Option 3	<= 40 mph	45-55 mph	>= 60 mph
White	85	100	150
Yellow	55	65	100

Typical images of each marking are displayed in Figure 3. The top set represent images at the time of installation and the bottom at three years of age. The difference in radiance and the amount of wear are evident, but the overall durability (product remaining on the roadway) was sufficient given the age and wear they receive.

All test sites were rated using ASTM D 913-03: Standard Test Method for Evaluating Degree of Resistance to Wear of Traffic Paint (6). At the time of placement, all markings averaged a rating of 97% intact. A value of 97% suggests the marking is fully intact. At the

final, three year evaluation the markings were given an average value of 90%, as some areas exhibited substantial wear, Figure 4, while some as in Figure 3 had normal expected wear.

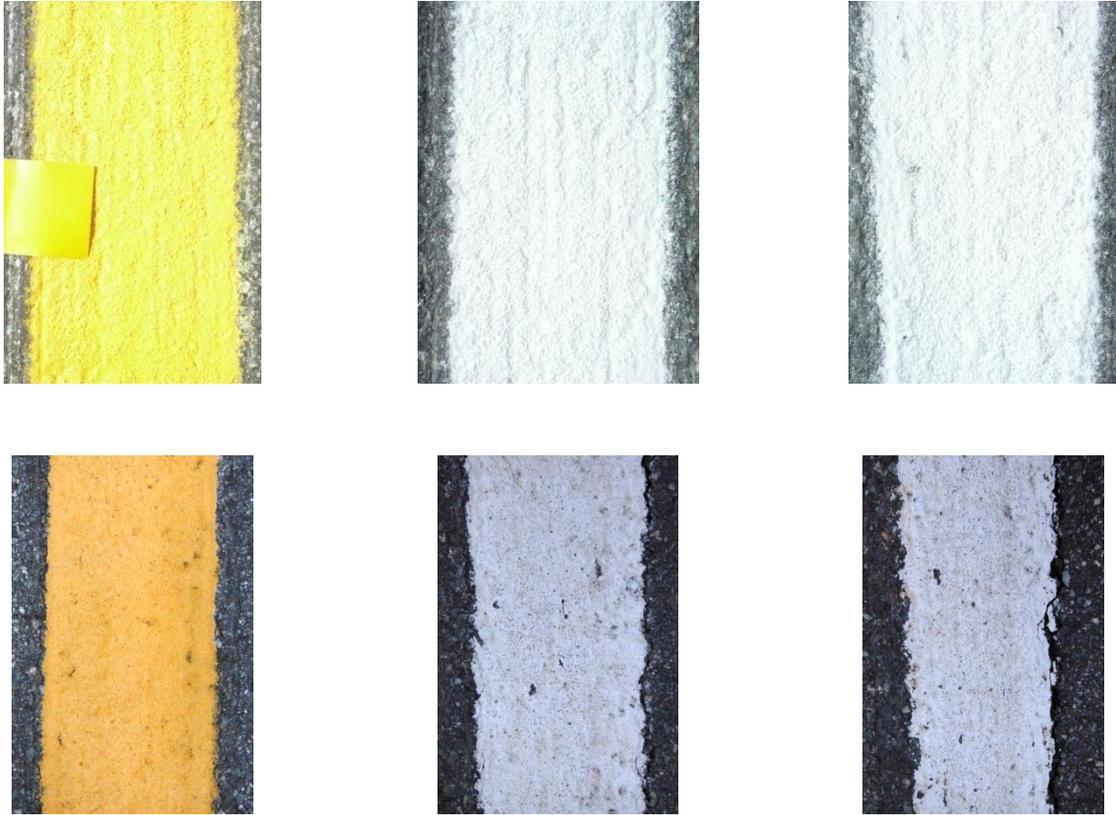


Figure 3. Visual comparison of markings (yellow edge, white skip, white edge) between installation (top) and final (bottom) site visit at three years of age.

COST ANALYSIS

The reported cost of Epoplex Glomarc 90 polyurea binder is \$65 per gallon. One gallon at 22 mils thick and 6 inch wide would extend 145.83 linear feet. The VISIMAX™ beads are \$6.00 per pound. The Type I beads are \$0.31 per pound. According to the manufacturers' specified application rates the polyurea binder is \$0.45 per linear foot, the VISIMAX™ beads are \$0.21 per linear foot, and the Type I beads are \$0.03 per linear foot for material costs, totaling \$0.69 per linear 6 inch line, installed.



Figure 4. Wear on some of the markings.

SUMMARY AND RECOMMENDATIONS

In an effort to explore the durable and retroreflective capabilities of Epoplex Glomarc 90 with VISIMAX™ Beads, the Vermont Agency of Transportation applied the product to a newly surfaced Interstate Highway 91 in the town of Derby.

Following the placement of the markings, retroreflectivity and wear readings were collected using uniform methods. All markings were found to be above the Agency's required initial retroreflective values of 500 mcdl/m²/lx for white and 400 mcdl/m²/lx for yellow. The white markings rapidly fell below FHWA recommended minimums for white markings on the interstate, 150 mcdl/m²/lx, falling below during the first winter season and remaining below for the three-year study length, with a final average value of 119. Yellow markings stayed above the 100 mcdl/m²/lx recommended minimum, and above the level of white markings, for the duration of the study, ending at an average value of 186. Although the white markings showed drastically lowered retroreflectivity readings, all markings proved to be durable, with only limited wear in general. After three winter-plowing seasons, the line stripes have held up well, with only a few areas experiencing moderate wear. When taking into account the climate and plowing conditions of the northern I-91 corridor, three years of durability out of markings is a recognized success.

The findings that showed the long-term white markings having significantly lower retroreflectivity readings than the yellow markings was unexpected. Yellow markings performed admirably while the white performed less well than previous studies suggested. Retroreflectivity

values for the white marking fell to approximately 90% of the minimum after one year, and culminated at 80% of the minimum at three years. Both the manufacturer and applicator representatives were made aware of this issue and asked for input; neither were able to provide any possible explanation. It is possible that the white markings, due to roadway geometry, may be subject to more force and wear from snow plowing activities, thereby scraping a greater amount of beads off; this is unconfirmed, however.

Based on the success of the yellow marking in regards to retroreflectivity and the durability of both colors, it is apparent that the Glomarc 90 binder with Visimax optics can be a satisfactory marking system for the Agency, albeit with possible drawbacks with unknown application and/or material issues that may provide less than desired retroreflectivity values under certain circumstances.

It is recommended that the agency deploy this material in all circumstances in which it is economically competitive as evidenced by the high performance demonstrated. It is further recommended that VTrans examine the performance of this product as it compares to the performance of other Polyurea markings for potential incentive-based payment. Additionally, a Research initiative to establish a pavement marking database is appropriate to help examine the cost benefit and life cycle determinations of not only Polyurea pavement marking products, but all other pavement marking types as well.

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5. ASTM E 1710-97, “Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer,” ASTM International, West Conshohocken, PA, <www.astm.org>.
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STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS AND RESEARCH SECTION

WORK PLAN FOR
RESEARCH INVESTIGATION
Epoplex Glomarc 90 Polyurea Pavement Marking
Work Plan No. WP 2009-3

OBJECTIVE OF STUDY:

Pavement markings provide an important means of communication for all roadway users and must be capable of conveying information during inclement weather and evening hours when there may be little to no contribution from overhead lighting. However, traffic markings are often subject to abrasion from vehicle tires and winter maintenance practices as well as ultraviolet sunlight and fading pigments following application. These deterioration mechanisms result in a loss of binder and reflective elements. Durable markings are often applied to newly constructed pavements in the state of Vermont and restriped with waterborne paint when markings no longer adequately delineate the roadway. In accordance with “2006 Standard Specification for Construction”, “durable pavement markings are classified as pavement marking tape, epoxy paint, thermoplastic markings, polyurea paint, and methyl-methacrylate.” Each of the referenced markings, comprised of various elements, has been shown to display unique characteristics and varying life cycles.

Over the past few years, the Agency has been applying recessed polyurea markings on most interstate rehabilitation projects. The process of recessing includes the removal of a small portion of the surface of the wearing course prior to the application of permanent markings. Recessing has proved effective in extending the service life of our pavement markings by protecting them from wear induced by tire abrasion and shearing effects generated by snow plows. However, there have been some complaints during rain events as water ponds over the marking materials causing a change in the indices of refraction between the optical elements and surrounding medium thereby reducing retroreflective properties. In an effort to enhance visibility during evening rain events, the Agency is interested in evaluating traffic markings with “wet night” properties.

The purpose of this study is to examine and evaluate the wet-night reflective capability of recessed Epoplex Glomarc 90 Polyurea pavement markings. Research personnel will also assess the product's durability and ability to uphold the retroreflectivity requirements. Efforts will be made to provide a comparative analysis with regards to standard polyurea recessed markings without wet reflective elements.

LOCATION:

The Epoplex Glomarc 90 Polyurea will be applied on the Derby project, IM 091-3(46), located along I-91 northbound and southbound between mile marker (MM) 169.8 to 177.4. According to the project plans, work to be performed includes cold planing and resurfacing of the northbound and southbound travel and passing lanes, interchange 27, 28, and 29 ramps, maintenance u-turns, and the welcome center with a leveling course, wearing course, milled rumble strips, new pavement markings, guardrail improvements, signs, and other incidental items. The average annual daily traffic (AADT) ranges from 5,000 from the start of the project to 2,100 at the end of the project. These are considered moderate to low AADTs for Vermont.

MATERIAL:

According to the manufacturer, Epoplex of Maple Shade, NJ, Epoplex Glomarc 90 is a highly reflective pavement marking system designed for use on concrete or bituminous concrete roadways and highways as a long-lasting striping material for both edging and centerline markings, as well as all intersection markings. The product consists of a two component polyurea based durable highway marking system that provides superior reflectivity during both day and night under both dry and wet weather conditions. The first component is Epoplex LS90 polyurea binder which is formulated to provide a simple volumetric mixing ratio of two volumes of Component A (amine) to one volume of Component B (isocyanate). The second component of the marking system is the VISIMAX™ Bead System which is designed to achieve superior wet night reflective characteristics.

In accordance with the manufacturer's specifications, Glomarc 90 should be applied only when atmospheric and surface temperatures at 32°F or higher using a mobile, truck mounted self contained, capable of spraying both white and yellow polyurea through an airless static tube or impingement mixing guns to accommodate a volumetric ratio of two to one according to manufacturer recommended proportions. The applicator must be of sufficient size and stability with adequate hydraulic and air power supplies to produce uniform line dimensions and have a high-pressure air blast cleaning system capable of cleaning the pavement surface immediately prior to applying the markings.

RETROREFLECTIVITY REQUIREMENTS

According to the Agency's special provisions, polyurea markings shall have a minimum retroreflectivity of 500 and 400 mc dl/m²/lx for white and yellow markings, respectively when tested in accordance with ASTM D 6359-99, "Specification for Minimum Retroreflectance of Newly Applied Pavement Marking Using Portable Hand-Operated Instruments."

COST:

The reported cost of Epoplex Glomarc 90 polyurea binder is \$65 per gallon. At 22 mils thick and 6 inch wide, this is equivalent to 145.83 linear feet. The VISIMAX™ beads are \$6.00 per pound. The Type I beads are \$0.31 per pound. According to the manufacturers' specified application rates the polyurea binder is \$0.45 per linear foot, the VISIMAX™ beads are \$0.21 per linear foot, and the Type I beads are \$0.03 per linear foot. The quantities in the project plans specify that 117,000 linear feet of 6" white polyurea, 95,000 linear feet of 6" yellow polyurea, and 5,200 linear feet of 12" white polyurea be used on the project. For this amount of material needed, at \$0.69 per linear foot, the total estimated material cost for the project is \$151,232.00. Please note that this cost does not include recessing the markings or application costs.

SURVEILLANCE AND TESTING:

The experimental durable marking will be monitored during placement in accordance with our Standard Specifications as well as with the manufacturer's specifications. Designated test sections will be visually inspected and tested on a periodic basis throughout the duration of the study. The evaluation shall include the following:

1. At the time of the application, temperature, relative humidity, precipitation/cloud cover, wind condition, ambient air, and pavement temperatures will be recorded. The roughness of the recess will be measured and recorded prior to placement of the pavement marking.
2. A minimum of three, forty foot test sites will be established from MM 169.8 to MM 177.432 in both the north and southbound lanes. Data collection will be conducted along prescribed intervals for ease of future duplication. The test sites will be established as according to mile marker for easy identification purposes. Each data collection location will be marked with white marking paint along the shoulder of the driving lane and freshened as appropriate.
3. Retroreflectivity measurements, in accordance with ASTM E 1710-97, "Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer," and durability, in accordance with ASTM D 913-03, "Evaluating Degree of Resistance to Wear of Traffic Paint" will be collected at the following times:

- a) Immediately following installation.
 - b) One month after installation.
 - c) Bimonthly for the remainder of the evaluation.
4. Retention of elements will also be documented by the use of photographic methods at sufficient resolution to observe the elements and their condition. Photographs of each test site will be gathered during each site visit. Additional observations regarding the inspection including marking variability or changes in roadside activities near test sections will be recorded. Surface roughness of the paints will be measured at the initial inspection.
5. Efforts will be made to conduct site visits as night during rain events to visually compare the retroreflective properties of markings with wet night properties as compared to standard marking materials.

STUDY DURATION:

The duration of this study will be no more than three years or until final conclusions can be drawn from the observations and retroreflectivity readings.

REPORTS:

An initial report will be prepared once installation is complete. Interim reports will be prepared and submitted as needed, but not less than biennially. A final report will be published once the evaluation is complete.

Agency of Transportation
Materials and Research Section

Reviewed By:

William Ahearn P.E.
Materials and Research Engineer
Date:

Approved by Material and Research on Date (02/01/10)
Approved by Federal Highway Administration on Date (CPJ)