THERMOPLASTIC PAVEMENT MARKINGS IN VERMONT

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STATE OF VERMONT
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MATERIAL AND RESEARCH DIVISION

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INTRODUCTION:

Over the next few years, solvent based traffic marking paint will be phased out and substitutes will have to be identified. Some of the proposed replacements include waterborne paint, epoxy, polyester, and thermoplastic pavement markings. In the State of Vermont, thermoplastic pavement markings have been used on all new construction projects since 1992. Due to winter snowplow operations, some problems have occurred with respect to product durability. For this reason, the Agency of Transportation's Materials and Research Division undertook a detailed study of pavement markings during the summer of 1994. The purpose of this study was to record the overall performance of all thermoplastic markings throughout the state. The major portion of this process entailed a detailed inspection of all 1992 and 1993 projects, as well monitoring most new applications. Skid resistance and retroreflectivity were also considered. A computer database was used to chronicle the information pertaining to this inspection.

INSPECTION OF 1992 AND 1993 PROJECTS:

Originally it was hoped that thermoplastic pavement markings would have a life of five years. During early 1994, a decision was made to survey year old and two year old thermoplastic markings throughout the state. The procedure for this inspection resulted in a quantitative analysis of both edge lines and lane lines expressed as a numeric rating and as a percent of loss. A descriptive rating was also assigned.

The inspections took place during May, early June, and September 1994. Seventy-six projects constructed in 1992 and 1993 were surveyed for durability during this time. The procedure entailed a detailed visual survey which was accomplished by driving over the entire project slowly and observing the lines. For the purposes of the inspection, each project was broken down into smaller segments. Each of these segments then received a rating for the left edge, center, and right edge line. The ratings were averaged and weighted by multiplying the average rating by the segment length in feet. All of the segments were totalled and divided by the length of the project in feet. This resulted in the overall rating, which determined the percentage of retained material and the descriptive rating that would be assigned to the project.

On the average these projects have performed satisfactorily over the previous one to two years. There were a few noticeable problems, as certain projects had significant losses associated with them. One such project on VT 11 in Chester and Springfield had a complete loss of edge lines for at least 0.5 miles. Other such situations did exist, but they were not necessarily as severe. The majority of the problems appeared to be due to bonding problems associated with a low application temperature, coupled with snowplow scraping. Of all projects inspected, 64% were rated at or above a good rating, and 19% were rated at or below a poor/fair rating. The following table breaks the percentages down by each category:

RATING	NUMBER OF PROJECTS	%
Poor	11	15%
Poor/Fair	3	4%
Fair	10	13%
Fair/Good	3	4%
Good	19	25%
Good/Excellent	8	11%
Excellent	21	28%
Total	76	100%

Although a majority of the projects had good results with thermoplastic pavement markings, there is concern with the 19% (14 projects) rated at or below poor/fair. As with the problems associated with VT 11 in Chester and Springfield, the majority of these poor ratings can best be attributed to poor bonding due to low temperatures at application.

Presently there are two contractors that apply thermoplastic in the State of Vermont. A third contractor (from out of state) also was awarded a bid on a state project, but only applied epoxy markings and therefore is not considered here. The following table illustrates the breakdown of projects between the two in-state contractors:

	Contractor A 51 of 76 projects (67.1%)				Contractor B 25 of 76 projects (32.9%)			
Rating	1992	1993	Total	%	1992	1993	Total	%
Poor	1	0	1	2%	6	5	11	44%
Poor/Fair	0	0	0	-	2	1	3	12%
Fair	3	1	4	8%	4	2	6	24%
Fair/Good	2	1	3	6%	0	0	0	-
Good	8	8	16	31%	0	3	3	12%
Good/Excellent	3	4	7	14%	0	1	1	4%
Excellent	3	17	20	39%	0	1	1	4%
Total			51	100%			25	100%

Given the wide difference between the contractors, the most likely reason for the wide disparity of the ratings is the application technique chosen by each contractor. Contractor A has a large applicator truck which is geared more to long line application, while Contractor B has a much smaller vehicle. As a result, they can store less heated material and must stop the vehicle and let the material heat to application temperature once their tank is empty. This increases

the chance that some material may be applied too cool. As was said previously, if there is a low temperature when applying this material, a bond failure may occur, which would facilitate the loss of material by snowplow scraping. It does appear that Contractor B improved the application techniques from 1992 to 1993;however, this may be due to the fact that the 1992 applications have been in place for two winters while the 1993 applications have only weathered one winter.

Another important factor is the performance of the two different types of thermoplastic. Currently we have a hydrocarbon and an alkyd thermoplastic material approved for use in the State of Vermont. The following table illustrates the differences in the durability of these two materials:

	Hydrocarbon Thermoplastic 45 of 76 projects (59.2%)				Alkyd Thermoplastic 31 of 76 projects (40.8%)			
Rating	1992	1993	Total	%	1992	1993	Total	%
Poor	1	0	1	2%	6	5	11	35%
Poor/Fair	0	0	0	-	2	1	3	10%
Fair	3	0	3	6%	5	2	7	23%
Fair/Good	0	0	0	-	2	1	3	10%
Good	7	8	15	34%	1	3	4	13%
Good/Excellent	2	4	6	13%	1	1	2	6%
Excellent	3	17	20	45%	0	1	1	3%
Total			45	100%			31	100%

Since the hydrocarbon is used only by Contractor A and the alkyd is used by both, it is interesting to note the differences between the two materials. Only one hydrocarbon was rated in either of the lower two categories, while 14 alkyds were present here. Alkyd does have a limited application temperature range (400 - 430 degrees F), which may account for the failures above.

Generally it can be said that projects where hydrocarbon has been applied using long line vehicles with automatic controls have a greater chance of realizing a five year life than those with alkyd material that has been applied with a much less sophisticated apparatus.

APPLICATION OF NEW THERMOPLASTIC MARKINGS:

Another task was to evaluate and observe new applications of pavement markings. A variety of tests were performed on each project, three of which include:

- Checking mil thickness of the pavement marking. This is done by placing duct tape on the projected line path, letting the thermoplastic truck mark over it, and then pulling up the tape to measure the mil

thickness. Our specification assigns 125 mils as the standard.

- Checking for moisture on the pavement. The inspector places a small piece of tar paper down on the pavement and has the thermoplastic truck place some material on it. After a few seconds the tar paper is turned over and the underside is observed for droplets of moisture. If any moisture is present the material should not be installed.

- Checking the temperature of the thermoplastic. This is done by using a digital thermometer, and measuring the temperature of the flowing material(i.e., material between the truck and the pavement). The thermometer reading should be no lower than 400 degrees F and no higher than 440 degrees F.

Twenty five projects were inspected. These projects were evenly split between the two contractors, with 12 applied by Contractor A, and 13 by Contractor B. Another firm had a contract to apply thermoplastic, but, due to the method of application they chose, they were not allowed to apply it. As a result they had to subcontract to one of the in-state contractors. This firm did apply epoxy paint on one of the 1994 projects, and is being tracked separately.

Due to time and lack of resources, not all of the new projects were inspected. Again, overall, the conduct of the applications was satisfactory; however, there were problems associated with one contractor's equipment. This equipment utilized the ribbon extrusion method, which is not approved for use in this state. As a result, this equipment will not be able to be used in 1995 and beyond.

At this time, little can be determined from these applications. A number of projects did have in excess of 130 mils of thickness on their lines. After the end of the current snowplowing season, these projects will be resurveyed and any significant losses will be documented.

RETROREFLECTIVITY:

During the late summer of 1990, thermoplastic markings were placed on VT 67A in Bennington. These lines were manufactured by Pavemark Inc. of Atlanta GA, and were of the alkyd type, and were originally used as a comparison for 3M Series 380 and 350 Pavement Marking Tape (Report U94-11). Retroreflectivity readings have been taken over the past four years and are summarized in the following table. For our purposes 100 millicandellas (mcdl) or lower is considered poor.

	MILLICANDELLAS	
DATE	WHITE	YELLOW
9/6/90	460	342
5/10/91	100	199
8/9/94	144	121

Although there is a three year gap between the second and third readings, these readings are still significant. This section of VT 67A can best be described as an urban collector, with an intersection between it and US 7 within 500 feet of these markings. This data shows that, even after three years, the lines still have good reflectivity. It is unknown why the reading for white thermoplastic on May 10, 1991 differs so much from the reading on August 9, 1994. One problem could have been that the line was not swept or cleaned off prior to testing. Although the results are promising, more readings will have to be gathered before any conclusions can be drawn.

SKID RESISTANCE:

Resistance to slippage of vehicles on the pavement markings is an important factor to consider. In order to measure this, the Materials and Research Division underwent a test in September, 1993 to quantify the skid resistance. The test was conducted at the Caledonia County State Airport, with thermoplastic pavement markings applied in four 100 foot test stripes. White traffic paint was applied on the tarmac in two 100 foot sections. For the thermoplastic tests, glass was added as follows: one section with 100% beads, one with no beads, one section with equal parts of glass beads and crushed glass, and one with 70% glass beads and 30% crushed glass. The pavement was dried with a Ripack heat shrinker for 50 feet of the 100 foot length for each of the thermoplastic sections except for the one with no beads.

Skid resistance was tested in 1993 and 1994, with both a portable British Pendulum Tester (BPT) and a FHWA portable trailer mounted skid tester. Each line was tested in five different locations with the BPT, and three separate skid runs with the FHWA equipment. Statistical analysis was used to compare the readings from the different test devices, This analysis showed that, the skid resistance of the thermoplastic with beads is the same as that of the paint with beads, as well as improving over one winter. This process was detailed in report U94-15. Unofficial testing was also conducted on various highways throughout Central Vermont in 1993, utilizing the BPT. Edge lines and adjacent pavement areas were tested on VT 14 in Williamstown, VT 66 in Randolph as well as the Berlin State Highway. These tests showed that even over one winter the skid resistance improved greatly compared with the adjacent pavement.

SUMMARY:

Overall thermoplastic pavement markings are performing satisfactorily in Vermont. Although data is limited, retroreflectivity and skid resistance appear to be acceptable. Hydrocarbon thermoplastic applied by fully automated long line vehicles has, on the average, outperformed alkyd material applied with less sophisticated smaller vehicles. Application techniques continue to be a problem, but with added experience the number of projects rated at or below a poor/fair rating should decrease. Again, as with all research projects, performance monitoring will continue with an emphasis on skid resistance, durability and retroreflectivity of the material. Further reports and updates will be published as required.

1994 Applications of Thermoplastic

Run date: 03/10/95

Excellent Applications

Project		Applied	Material
STP 9333(1)S	Lemington	09/01/92	SG70
RS 0311(1)	Troy	09/01/92	SG70
STP 9269(1)S	Morristown	07/01/92	SG70
CMRS0113(55)	Windsor/Hartland	09/01/93	SG70
F 017-(19)	New Haven-Waltham	09/08/93	SG70
F017-1(19)	Ferrisburgh-Vergennes	06/01/93	SG70
F019-4(23)	Waltham-Ferrisburgh	06/01/93	SG70
IR089-2(17)	Waterbury-Richmond	05/01/93	SG70
STP 9303(1)S	Cambridge-Waterville	05/26/93	SG70
STP 9304(1)S	Readsboro-Searsburg	05/01/93	SG70
STP 9305(1)S	Cambridge	07/01/93	SG70
STP 9307	Corinth-Topsham	08/01/93	SG70
STP 9315(1)S	Cambridge	07/01/93	SG70
STP 9319(1)S	Guilford-Brattleboro	06/01/93	SG70
STP 9330(1)S	Westmore-Brownington	07/28/93	SG70
STP 9340	Shoreham	05/01/93	SG70
STP 9348(1)S	Newfane-Townsend	09/21/93	SG70
STP 9353(1)S	Dover-Stratton	06/01/93	SG70
STP 9354(1)S	Peru-Landgrove	06/01/93	SG70
STP-9317	Whitingham	06/01/93	SG70
STP 9344(1)S	Newbury	05/01/93	Pavemark

Good to Excellent Applications

Project		Applied	Material
STP 9222(1)S	Randolph	09/25/92	SG70
STP 9248(1)S	Derby-Charleston	06/01/92	SG70
STP 9260(1)S	Brighton-Morgn-Warrn Gore	10/01/92	Pavemark
CMRS 0113(54)	Sutton	06/01/93	SG70
STP 9274(1)S	St. Albans	09/01/93	SG70
STP 9326(1)S	Bethel-Randolph	07/01/93	SG70
STP 9339(1)S	St. Albans-Sheldon	08/01/93	SG70
STP 9314(1)S	Warren Gore-Norton	06/01/93	Pavemark

Good Applications

Project		Applied	Material
F019-3(43)	Rutland City	07/01/92	Pavemark
F026-1(37)	Ryegate-Newbury	06/01/92	SG70
RS 0113(5)	Dummerston	05/01/92	SG70
STP 9250(1)S	Dummerston	05/05/92	SG70
STP 9270(1)S	Brighton-Ferdinand	09/01/92	SG70

Good Applications (ctd)

Project		Applied	Material
STP 9328(1)S	Hartland	10/01/92	SG70
STP 9349(1)S	Weathersfield	09/29/92	SG70
STP 9355(1)S	Bristol-St.George	08/01/92	SG70
F010-1(32)	Woodford-Searsburg	06/01/93	SG70
RS 0113(53)	Lyndon	09/01/93	SG70
STP 9251(1)S	Newbury-Ryegate	09/01/93	SG70
STP 9259(1)S	Lyndon	05/01/93	SG70
STP 9262(1)S	Castleton	12/07/93	SG70
STP 9266(1)S	East Haven-Newark	06/01/93	SG70
STP 9334(1)S	Orwell-Shoreham	06/01/93	SG70
STP 9350(1)S	Ludlow- Bridgewater	06/21/93	SG70
STP 9318(1)S	Johnson	08/01/93	Pavemark
STP 9267(1)S	Cambridge-Fairfax	06/01/93	Pavemark
STP 9347(1)S	Stowe	08/01/93	Pavemark

Fair to Good Applications

Project		Applied	Material
STP 9225(1)S	Colchester	07/10/92	Pavemark
RS 0177(4)	Strafford	06/01/92	Pavemark
F019-3(46)S	Rutland	07/01/93	Pavemark

Fair Applications

Project		Applied	Material
F034-2(10)c/1	Troy-Newport	09/01/92	SG70
HES 5500(6)S	Williston	09/01/92	SG70
IR091-1(22)	Hartland-Hartford	06/01/92	SG70
STP 9325	Williamstown	07/01/93	Pavemark
STP 9336(1)S	Berkshire	07/01/92	Pavemark
STP 9342(1)S	Ripton	09/01/92	Pavemark
STP 9351(1)S	Richmond	09/01/92	Pavemark
STP 9272(1)S	Richford	07/01/92	Pavemark
STP 9301(1)S	Waterford-St.Johnsbury	05/01/93	Pavemark
STP 9360(1)S	Waterbury	07/01/93	Pavemark

Poor to Fair Applications

Project		Applied	Material
STP 9311(1)S	Chelsea	08/01/92	Pavemark
STP 9332(1)S	Franklin	07/01/92	Pavemark
STP 9343	Bradford	06/01/93	Pavemark

Poor Applications

Project		Applied	Material
F026-2(4)S	Newbury	06/01/92	SG70
F134-3(17) C/2	Derby-Newport	10/01/92	Pavemark
STP 9241(1)S	Sheldon-Franklin	07/01/92	Pavemark
STP 9268(1)S	East Middlebury	09/01/92	Pavemark
STP 9313(1)S	Thetford	08/01/92	Pavemark
STP 9306	Thetford	08/01/92	Pavemark
STP 9335(1)S	Richford	07/01/92	Pavemark
STP 9320(1)S	Royalton-Bethel-Randolph	06/01/93	Pavemark
BRZ 1441(16)	Arlington	05/01/93	Pavemark
RS0134(8)	Chester/Springfield(5 Con)	09/01/93	Pavemark
STP 9254(1)S	Moretown	08/01/93	Pavemark
STP 9310(1)S	Burke	05/01/93	Pavemark