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Cold Weather Waterborne Paint with XSR

REFERENCES:

WP – 2006- R-3

INTRODUCTION

Vermont's construction season typically ranges from five to eight months and specialty work, such as line striping, often occurs at the end of the construction season during the decline of ambient air temperatures. In accordance with the Vermont Agency of Transportation "2006 Standard Specifications for Construction", 646.04(c), during the application of waterborne paint markings, "the temperature of the surface to be painted shall be a minimum of 10°C (50°F) and the ambient air temperature shall be 10°C (50°F) and rising. As most residents are aware, the weather in Vermont is highly variable and often unpredictable. Ambient air temperatures towards the end of the construction season may not meet the requirements referenced within the specifications making the completion of the application of pavement markings difficult. However, an experimental pavement marking known as Cold Weather Waterborne Traffic Paint with XSR, an acrylic resin, is reported to allow application at 35°F and rising with a drying time of 9 minutes.

The following report outlines the initial observations with regards to the application of both an experimental marking of cold weather paint with XSR, and control marking of standard waterborne paint. In addition the report contains information pertaining to laboratory results in order to quantify the unique characteristics of the experimental material as well as field data collection to determine the durability and luminance of the markings over time.

PROJECT DETAILS:

The Vermont Agency of Transportation's Traffic Shop personnel applied the Cold Weather Waterborne Traffic Paint, or experimental traffic markings, to VT Route 100B in Moretown, a two lane roadway with a posted speed limit of 50 mph and an AADT, or

Average Annual Daily Traffic, of 2500. This location was selected by personnel from the Traffic Shop and the Materials and Research Section due to proximity from the Laboratory. Please note that all control and experimental pavement markings were applied over recently installed waterborne pavement markings that appeared to be in relatively good condition. The experimental white pavement markings were applied along the shoulder of the southbound lane between MM 1.50 and MM 7.5. The experimental yellow pavement markings were applied between MM 5.8 and MM 7.5. These lines were comprised of both solid and skip lines. The control section, consisting of standard waterborne paint, was installed along the shoulder of the northbound lane between MM 6.2 and MM 7.5 and was white pavement marking paint only. Please refer to Attachment A for layout of all experimental and control pavement markings. In accordance with the work plan and manufacturers specifications, the Traffic Shop applied a minimum thickness of 15 wet mils. This will prove to be an important variable in relation to dry time, as discussed below.

MATERIAL:

According to the manufacturer, the Franklin Paint Company, Inc. from Franklin, Massachusetts and associated MSDS, or Material Safety Data Sheet, the referenced waterborne traffic paint is a lead free and VOC compliant material. It is marketed as a fast drying paint marking material that can be applied at a minimum temperature of 35°F and rising due to a particular polymer known as Rhoplex Fastrack XSR. Cold Weather Waterborne Traffic Paint is currently being produced in both white and yellow marking materials with a reported high level of durability and good retention of retroreflectivity. At 35°F and a wet thickness of 15 mils, the marking material is expected to dry within 9 minutes.

COSTS:

While this is still considered an experimental marking material by the manufacturer, the current cost for the Cold Weather Traffic Paint is $7.10 per gallon of white marking paint and $7.00 per gallon of yellow marking paint. This price is slightly higher than regular waterborne traffic paint which is approximately $5.00 per gallon. Each gallon covers 300 linear ft with reference to a four inch line at 15 wet mils. Franklin Paint supplied three drums of 50 gallons of each paint type to the traffic shop for application.

INSTALLATION AND OBSERVATIONS:

On November 3, 2006, personnel from the Materials and Research Section accompanied by the Painting Crew from the Traffic Shop observed the installation of the experimental marking material, or Cold Weather Waterborne Traffic Paint with XSR, and the control marking material, or standard waterborne paint. Application of the marking materials began at 9:45 AM to Route 100B in the town of Moretown at MM 7.5 in order to allow the pavement surface to dry properly prior to installation. The Paint Crew explained that there may be some residual standard waterborne paint residing within hoses and that it was suspected that there would be some mixing of the control and standard marking

materials within the first ½ mile of application. This information was considered during the selection of test sites.

The Paint Crew did not perform any surface preparations to the roadway prior to installation, such as the removal of any dirt or debris. As stated previously, the recently applied preexisting waterborne pavement markings appeared to be in good condition with little wear from traffic observed. After Following the installation of the experimental white marking material along the shoulder of the southbound lane, the Traffic Shop proeceeded to apply the yellow experimental marking material. A control section, comprised of standard waterborne paint, was applied along the shoulder of the northbound lane. It is suspected that there may have been some mixing of the experimental and control traffic markings along this location.

Following application and proper dry time, the overall appearance of the experimental paint markings appeared to be much better in comparison to the standard waterborne paint as the cold weather paint retained a consistent texture and greater dry thickness. Figures 1 and 2, as provided below, depict the white and yellow experimental markings following sufficient dry time.

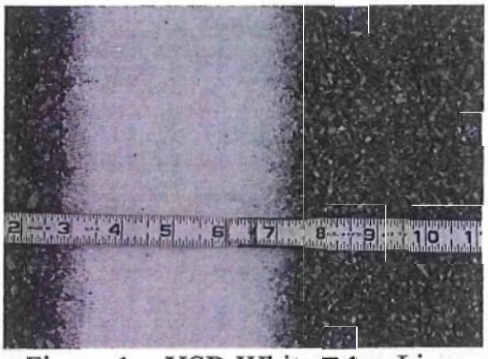


Figure 1 – XSR White Edge Line

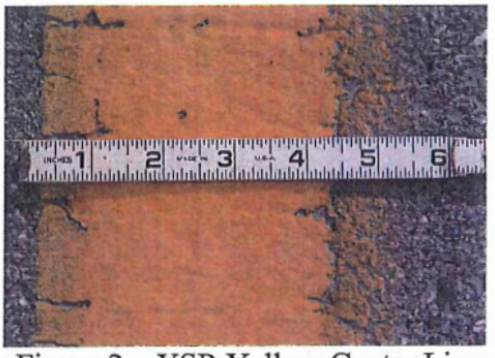


Figure 2 – XSR Yellow Center Line

Observations with regards to relative humidity, temperature, wet mil thickness and approximate dry time was recorded for both the experimental and control markings. It should be noted that while the associated Category II work plan called for a wet thickness of 15 mils, an uneven surface roughness prevented a consistent application thickness. Actual wet thicknesses appeared to range from 10 to 20 mils. This will have an effect on the overall observed drying time as a thinner line is expected to dry more quickly while a thicker line is suspected to dry more slowly. Please note however, that all wet mil thicknesses in relation to dry time were recorded. Table 1, depicting the relationships between marking type, dry time, ambient air temperature and relative humidity is provided below.

Field Drying Time of XSR and Standard Waterborne Paint VT Route 100B, Moretown							
Type of Paint	Color	Direction	Dry to Touch Time Minutes	Air Temperature Deg. F	Relative Humidity %	Pavement Temperature F	Comments
XSR MM 7.00 TS 1	Yellow	Center	13.5	48	31	40	Uneven pavement blotchy line
XSR MM 6.20 TS 2	White	SB	9	44	34	43	Smooth pavement, consistent thickness
XSR MM 5.7	White	SB	>30	38	33	28	Near graveyard Moretown Village
Standard Waterborne TS 4	White	NB	>25	46	33	42	Same location as TS 2 above

Table 1 - Field Drying Time for XSR and Standard Waterborne Paint

It should be noted that the information with regards to MM 5.7, in Table 1, was not a test site but rather an area that was selected in order to assess drying time in a shaded low lying area.

In examining the Table 1, it is difficult to verify or refute the drying time specifications provided by the manufacturer. As stated above, the experimental markings are intended to dry within 9 minutes at an ambient air temperature of 35°F and rising. Only the markings applied at Test Site 2 dried within 9 minutes, however the ambient air and pavement temperature were well above 35°F. There are potential interferences to drying when ground temperatures are below the dew point. As shown in the table above, the surface of the pavement was consistently colder than the ambient air condition potentially causing condensation on the pavement surface resulting in increased drying time. Although ground temperatures were not recorded, antecedent temperatures may have affected this condition. It is promising though to compare the drying times of Test Site 2 and 4 as they were applied under similar ambient conditions with highly varying dry times. Additionally, the influence of direct sunlight is also reflected within the table as the cold weather paint took much longer to dry under shaded conditions.

SURVEILLANCE AND TESTING:

A total of five test sites were established throughout the length of the project in order to collect retroreflectivity readings in accordance with ASTM E 1710-97, "Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Potable Retroreflectometer", and durability, in accordance with ASTM D 913-03, "Evaluating Degree of Resistance to Wear of Traffic Paint". Each test site was established in an area with good sight distance on a straight away and consisted of a total length of 40 feet with data collection conducted at 10 foot intervals starting from the beginning of the test site. Each data collection location was identified

with white marking paint along the shoulder of the driving lane in order to ensure that all future readings will be collected from the same location. Retroreflectivity and wear readings were collected on the day of application (11/3/06) following adequate cure time and once a week following application (11/9/06) per the associated work plan. Please note that Test Site 1 through 3, consist of readings collected on the experimental markings along the shoulder of the southbound lane and centerline markings and Test Site 4 and 5 consist of readings collected on the control markings along the shoulder of the northbound lane. Please refer to Appendix A for a layout of all test site locations.

A summary of retroreflectivity reading are provided below in Table 2 and 3. Please note that readings highlighted in red indicate that they fall below the below the minimum retroreflectivity requirements readings of 250 and 175 mcdl for white and yellow markings, respectively in accordance with ASTM D 6359-99, "Standard Specification for Minimum Retroreflectance of Newly Applied Pavement Marking Using Portable Hand-Operated Instruments" for newly applied pavement markings within 14 days of application. The * in Table 2 denotes that no readings were taken at that site because of an obstruction.

Cold Weather Waterborne Paint with XSR VT Route 100B, Moretown						
Test Site ID:	South Bound White		South Bound Yellow		North Bound Yellow	
	11/03/2006	11/09/2006	11/03/2006	11/09/2006	11/03/2006	11/09/2006
TS 1 123' south of MM 7.00	346	367	149	158	187	188
	349	368	195	161	175	183
	333	351	207	157	187	161
	366	337	200	153	196	153
	367	342	191	96	193	159
Average	352	353	188	145	188	169
Std. Dev.	14	14	23	28	8	16
TS 2 MM6.20	409	350	179	152	79	177
	378	336	171	172	92	174
	379	337	163	143	168	181
	422	*	191	144	167	172
	370	361	172	147	174	100
Average	392	346	175	152	136	161
Std. Dev.	23	12	10	12	46	34
TS 3 Ends at MM 5.80	379	346	199	149	215	203
	384	359	201	134	210	204
	401	364	217	161	213	200
	386	351	181	170	222	189
	404	359	206	107	217	176
Average	391	356	201	144	215	194
Std. Dev.	11	7	13	25	5	12
Overall Average	378	352	188	147	180	175

Table 2– Retroreflectivity (mcdl) for XSR

Standard Waterborne Paint VT Route 100B, Moretown		
	North Bound White	
Test Site ID:	11/03/2006	11/09/2006
TS 4 110' north of MM 6.20	347	318
	403	280
	395	297
	384	353
	402	384
Average	386	326
Std. Dev.	23	42
TS 5 MM 6.80	388	186
	393	193
	393	186
	373	174
	372	187
Average	384	185
Std. Dev.	11	7
Overall Average	385	256

Table 3– Retroreflectivity (mcdl) for Standard Waterborne Paint

As stated within the work plan, several laboratory tests were conducted in order examine the material properties of the experimental pavement marking. For application purposes, it is important that the paint is light enough to flow readily and that the pigment is smooth enough as to not clog the painting apparatus. The assessment began with an examination of the pigment of the paint in accordance with ASTM D 1475, "Density of Liquid Coatings." The white pigmented paint was found to have a density of 13.76 lbs per gallon and the yellow pigmented paint was found to have a density of 13.45 lbs per gallon well within the specifications of 13.7 to 14.3 lbs per gallon for the white pigment and 13.3 to 13.9 lbs per gallon for the yellow pigment. In order to assess the viscosity of the traffic paint marking material with regards to potential clogging of spray nozzles, both the white and yellow paint was tested in accordance ASTM D 562, "Consistency of Paints Using the Stormer Viscometer." The white and yellow marking material was found to have a kinematic viscosity of 95 ku and 88 ku, respectively. This also met the viscosity specification of 78 to 95 ku which is universal for both colors of marking paint. Please see Appendix B and C for a copy of the laboratory testing results for the yellow and white marking paint, respectively.

In addition to an examination of the characteristics of the experimental materials, a third assessment was performed in accordance with ASTM D 711, "No Pick Up Time." This laboratory test seeks to evaluate the amount of time needed to fully cure under varying ambient conditions with consideration to temperature and humidity. Table 4, as provided below, contains a summary of results. Please note that this test was modified as the test specification calls for testing under the following conditions: an ambient air temperature between 70 to 77°F and a humidity level between 45 to 55%.

Laboratory Drying Time of XSR Paint (ASTM D711.Mod.) VT Route 100B, Moretown			
Color	Temperature °F	Rel. Humidity %	No-Pick-Up Time ASTM D711. Mod.
White	73	57	5.0 Minutes
Yellow	73	57	5.0 Minutes
White	46	45	9.5 Minutes
Yellow	46	45	9.0 Minutes
White	38	60	>20 Minutes
Yellow	38	60	18.5 Minutes
Yellow	58	69	15.0 Minutes

Table 4 – ASTM D 711.mod. Laboratory Tests

DISCUSSION:

The application of the experimental cold weather paint was successful in comparison to standard waterborne paint as only standard traffic paint machinery was required. In addition, it appears to be compatible with standard waterborne paint as flushing of the hoses and inside of the truck was not required. Feedback from the paint crew concerning ease of application was positive. As a final aside, the experimental marking did not require the removal of debris or any other roadway surface preparation. It also was found to dry more readily as compared to the standard marking material although dry times were longer than anticipated in accordance with the manufacturer's specifications.

All of the white and the majority of the yellow experimental markings were found to be above the current minimum retroreflectivity requirements immediately following application of 250 and 175 mcdl, respectively, for newly applied pavement markings within 14 days of application as stated within the ASTM standards, ASTM D 6359-99. However, the readings collected along the southbound yellow lines are below expectations one week following application. The initial retroreflectivity readings collected from Test Site 2 are of some concern although readings generally increased one week following application. It is suspected that the lines may not have completely dried prior to data collection. The standard deviations, found immediately and one week following application, are low indicating consistent reliability. The standard waterborne paint was also found to meet ASTM requirements immediately following application with mixed results one week following application.

In consideration to laboratory testing, results indicate that the paint is sufficiently viscous to flow readily and the pigment is smooth enough as to not clog the painting apparatus as it was found to meet the specifications within ASTM D 1475, "Density of Liquid Coatings" and ASTM D 562, "Consistency of Paints Using the Stormer Viscometer." In addition to an examination of the characteristics of the experimental materials, a third assessment was performed to evaluate the amount of time needed to fully cure under varying ambient conditions with consideration to temperature and humidity. As the temperature drops and humidity increases, dry time also increases. In addition, laboratory testing does not verify the reported dry time from the manufacturer of 9

minutes at an ambient air temperature of 35°F and rising. However, please keep in mind that the paint is not heated for testing purposes while it is in the field prior to application. The material is expected to dry more quickly once it has been heated.

Thus far, preliminary results are encouraging with consideration to ease of application and compatibility with standard waterborne paint. In addition, satisfactory minimum retroreflectivity results were obtained, which is generally difficult to achieve during late construction season application when ambient air temperatures are 50°F or below. While it is difficult to ascertain whether the experimental markings increased anticipated retroreflectivity results, overall dry time was decreased as compared to the standard markings which has been shown to have a positive correlation luminance. As a final caveat, it is important to note that all markings were applied over recently installed markings which will reduce the amount paint sinking into the underlying pavement.

FOLLOWUP:

Research personnel will continue to monitor and collect additional information with regards to the overall durability and reflectivity of all test sites per the work plan. Following a determination of service life, a final report will be published comparing the performance of a standard waterborne marking to the experimental low temperature waterborne paint with XSR.

Appendix A

VTrans Working to Get You There

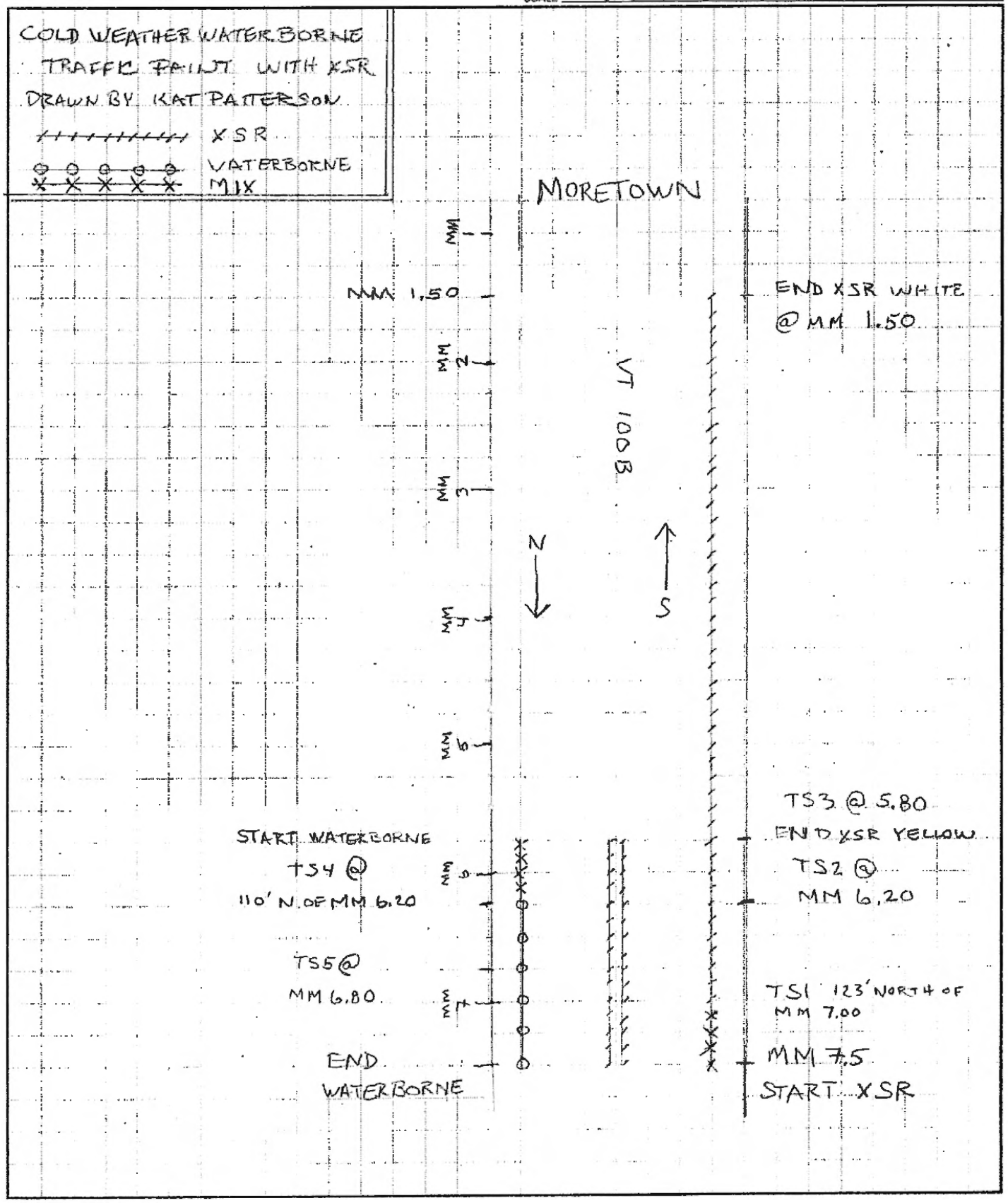
JOB COLD WEATHER WATERBORNE PAINT W/ XSR

SHEET NO. 1 OF 1

CALCULATED BY _____ DATE _____

CHECKED BY _____ DATE _____

SCALE NOT TO SCALE



Appendix B

Vermont Agency of Transportation
Materials & Research Laboratory
Paint Test Report

Lab No. 2006- 105 Project Name & No. EXPERIMENTAL

Pay Name _____ Pay Item _____

Sample Type: Traffic Shop ____ Acceptance ____ Investigative X Other ____

Material Description YELLOW 'XSR' COLD WEATHER WATERBORNE PAINT

Material Source FRANKLIN PAINT CO. Manufacturer FRANKLIN PAINT CO.

Lot No. N/A Date of Manufacture 10-22-06

Date Received 10-24-06 Date Tested 10-27-06 Tested by JERRY MCMAHAN

Temperature (Specification = 23±2°C) 22-8 Humidity (Specification = 50±5%) 55

SPECIFICATION REQUIREMENTS		RESULT
No-Pick-Up Time ASTM D-711	10 Minutes	5.0
Pounds per Gallon ASTM D-1475	Yellow 13.3min. – 13.9max. ~~White 13.7min. – 14.3max.~~	13.45
Viscosity ASTM D-562	78ku min. – 95ku max.	88

Results within specifications? YES

Comments _____

Analyst

Supervisor

Appendix C

Vermont Agency of Transportation
Materials & Research Laboratory
Paint Test Report

Lab No. 2006-104 Project Name & No. EXPERIMENTAL

Pay Name _____ Pay Item _____

Sample Type: Traffic Shop ____ Acceptance ____ Investigative X Other ____

Material Description WHITE 'XSR' COLD WEATHER WATERBORNE PAINT

Material Source FRANKLIN PAINT CO. Manufacturer FRANKLIN PAINT CO.

Lot No. N/A Date of Manufacture 10-22-06

Date Received 10-24-06 Date Tested 10-27-06 Tested by JERRY MCMAHAN

Temperature (Specification = 23±2°C) 22.8 Humidity (Specification = 50±5%) 55

SPECIFICATION REQUIREMENTS		RESULT
No-Pick-Up Time ASTM D-711	10 Minutes	5.0
Pounds per Gallon ASTM D-1475	Yellow 13.3min. – 13.9max. White 13.7min. – 14.3max.	13.76
Viscosity ASTM D-562	78ku min. – 95ku max.	95

Results within specifications? YES

Comments _____

Analyst

Supervisor

Appendix D

Cold Weather Traffic Paint Application
Route 100B, Moretown
November 3, 2006

Kat Patterson, Jesse Carswell and I observed the Traffic Shop's trial use of waterborne traffic paint containing the new Rohm and Haas 'XSR' binder. R&H claims good drying performance at pavement temperatures as low as 35°F. First, 1.7 miles of double yellow centerline was put down, followed by approximately four miles of white line. Finally, several hundred yards of white line was put down with conventional waterborne paint for comparison purposes.

The yellow line was applied to fairly rough pavement, which prevented accurate measurement of the wet film thickness. It appeared to vary from 10 to 20 mils. The target thickness was 15 mils. The uneven film thickness caused variations in drying time. While the line had skinned over within 3 minutes, and was substantially dry to the touch (95% of surface area dry) within 7 minutes, there were isolated small wet spots which did not dry until about 13.5 minutes had elapsed. The air temperature at the site chosen was 48°F and the pavement temperature was 40°F. The relative humidity was 31%. Weather conditions were alternating sun and clouds with brief snow flurries and light winds. After the line appeared to be dry, we drove the truck over and along the line several times. While there was no smearing of the line, there were numerous small splashes of paint on our mud flaps. This splashing was likely due to pooling of paint caused by the rough road surface, as well as possible areas of much colder pavement in areas of deep shade (we saw pavement temperatures as low as 28°F in small isolated areas). It appears that the condition of the pavement is an important variable affecting paint performance, along with temperature and humidity.

After completing the double yellow line, the paint crew put down over 4 miles of white line, essentially all of Route 100B except for the area beyond Moretown Village. At the spot I chose to observe drying performance, the paint was skinned over in 3 minutes and substantially dry in 9 minutes. The pavement was in good condition and wet film thickness was 14 or 15 mils at all spots measured. After 13 minutes, we drove the truck over and on the line as before. There was no smearing and no splashing of paint onto the vehicle. The air temperature was 44°F and the pavement temperature was 43°F. The relative humidity was 34%. Periods of sun alternated with clouds and light snow flurries. We then drove south to the end of the stripe. One small area of the line had a pavement temperature of 28°F and the paint was still very wet after over 30 minutes. There was extensive smearing where vehicles had driven on the line. A nearby area with a pavement temperature of 38°F was dry.

The paint crew then laid down several hundred yards of conventional traffic paint. The wet film thickness was 15 mils. The air temperature was 35°F during application. The sun came back out within one or two minutes, and by about 15 minutes after application the air temperature was 46°F. The pavement temperature was 42°F. The paint began to skin over after 7 minutes and still had numerous wet spots after 15 minutes. There were numerous smeared areas where vehicles had touched the line. In addition, the line of

conventional paint had a less pleasing appearance than the line of cold weather paint directly across the road. The conventional paint line showed far more uncovered spots and looked less substantial than the test paint line, despite the fact that they had identical wet film values of 15 mils.

Overall, the 'XSR' paint formulation performed very well in difficult conditions. It is still necessary to avoid painting pavement below the freezing point, but in moderately cold conditions, this product does quite well. It should be very valuable during the 'shoulder seasons'. We do need to try it in more humid conditions. I suspect from my lab testing that relative humidity will control performance more than temperature, at least in the 35 - 55 degree range.