Waterborne Paint with Rohm and Haas Rhoplex® HD-21 Binder

Interstates I-89 and I-91, Vermont

June 2002
Reporting on Work Plan 2000-R-7
Final Report

State of Vermont
Agency of Transportation
Materials and Research

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16. Abstract

This report describes the performance of an all-acrylic emulsion binder in waterborne traffic paint that is designed to last for up to three years (two years in the Snow Belt region of the United States). Applied over nine-month old thermoplastic, this material served as a rehabilitation of legend marks on interstate on and off ramps.

This report documents the performance of the pavement marking material in areas classified as Vermont's low, moderate, and high traffic volume areas. Laboratory evaluations include no pick-up time, density, viscosity, and dry film thickness. Field performance data includes retroreflectivity and photographic documentation.

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Introduction

In 2000, various legend marks originally placed as part of the 1999 Interstate IMG MARK(199) project required rehabilitation on some Interstate highway on and off ramps. Recognized as a likely workmanship problem, it was decided that the markings would be rectified by either removing and replacing the existing thermoplastic with a suitable material, or rehabilitating the remaining marks with a waterborne paint containing a third-generation binder called Fastrack® HD-21 manufactured by the Rohm and Haas Company.

The rehabilitation method selected was an overcoat of waterborne paint with Fastrack® HD-21 binder. Marketed as a pavement marking material capable of being placed over well-intact thermoplastic. The product was selected for its lower cost, ease of application, and minimal preparation work. Also advertised as a "durable" waterborne marking, it claims to have a three-year life when applied at a 30 mil wet film thickness.

The purpose of this study is to evaluate the product's effectiveness as a maintenance marking material over existing extruded thermoplastic. Performance analysis includes the evaluation of the drying time, durability, and glass bead retention via retroreflective values.

Product Description

Rhoplex Fastrack® HD-21, manufactured by the Rohm and Haas Company, is an all acrylic emulsion designed for waterborne traffic paints. The binder, created with a patented cross-linking technology, enables traffic paint to adhere to asphalt and concrete pavements longer than traditionally used traffic paints. The product is designed to provide a special interaction with the glass beads by allowing the paint to maintain flexibility and therefore increase the bead retention regardless of the size. The binder is designed to provide a chemical bond between the glass beads and coating resulting in beads that will not shear off but rather wear off through surface abrasion. The end result is a product created to be more durable and provide better retroreflectivity than commonly used traffic paints.

Drying time for traffic paint utilizing the HD-21 binder has been tested to outperform paint with a styrene/acrylic polymer binder in a humidity chamber. As humidity increases, so do the no-pickup times. Data published by the manufacturer indicates that with the relative humidity ranging from 50-90% at 70^{o}F, paint with HD-21 binder dries 20-50% faster than paints with styrene/acrylic polymer binder.

The equipment required for the installation of the product is the same as that for traditionally used waterborne traffic paints. The manufacturer's recommendation for application requires the air and pavement surface temperatures to be a minimum of 50^{o}F and 5^{o}F above the dew point during the time of application.

Project Description

As a rehabilitation of pavement markings originally placed between October 10-13, 1999, 292 thermoplastic letters on a total of 22 interstate ramps received an overcoat of waterborne paint manufactured with the Rhoplex Fastrack® HD-21 binder. These markings were applied using stencils on Interstate I-91 at Exits 1, 2, 3, 11, and 20, as well as at Exits 4, 5, 6, 9, 10, 12, and 16, on Interstate I-89. Refer to Appendix A for a detailed description of the letters that were remarked.

Project Costs

The rehabilitation of the legend marks was done under the 1999 IMG Mark (199) striping contract. All the costs associated with the repairs were paid for by the contractor, with no additional expense to the state. As a result no cost data is available with this report.

Product Evaluation

Installation

Between July 18-20, 2000, waterborne paint with the HD-21 binder was applied on the interstate on and off ramps. All the legend marks were placed by hand-application using a Poweliner 5000 handcart with a 6" nozzle. Glass beads were broadcasted by hand over the letters immediately after the paint was applied. To establish the desired wet film thickness of 30 mils, passes made over the first letters were checked using a disposable thickness gauge. The thickness gauge used only measured up to 20 mils therefore it was approximated that three passes produced the thickness desired.

On July 18, 2000, the rehabilitation of 9-month-old thermoplastic marks in the Brattleboro area (Exits 1-3) and in White River Junction (Exit 11) began. Hazy, humid weather conditions prevailed and in neighboring Keene, NH, a daily mean temperature of 69^{o}F with a dew point of 57^{o}F was reported. These conditions attributed to long drying times ranging from 20-35 minutes.

During the course of these applications it was recognized that some of the letters were receiving less material than that determined necessary to provide the desired dry film thickness. The contractor responded during the course of the day along with an increase in the amount of glass beads broadcasted on top of the letters. Later applications revealed waves or ripples in the paint, indicating thicker applications. Sample cards were taken on some of these marks to later determine the dry film thickness. The results are represented in Table 2.

On July 19, 2000, rehabilitation continued at interstate ramps on I-91 in St. Johnsbury (Exit 20), and I-89 in Randolph (Exit 4), Northfield (Exit 5), South Barre (Exit 6), Middlesex (Exit 9), and Waterbury (Exit 10). Due to debonding of the existing material, the applications in St. Johnsbury required the removal of most of the thermoplastic letters as shown in Figure 1. A sample card was taken for dry film thickness evaluation at this site. At the time of installation the temperature was 58^{o}F and the dew point 46^{o}F.

Applications at the other sites were completed in the afternoon. The daily mean temperature was reported as 63°F and the dew point was 56°F at the Montpelier National Weather Station. The averaging drying time for these sites ranged from 20-30 minutes.

Figure 1. St. Johnsbury – Deteriorated Thermoplastic (9 months old). (Photo taken July 13, 2000)

On July 20, 2000, legend marks in Colchester (Exit 16) and Williston (Exit 12) were remarked. The recorded average daily temperature at the Burlington weather station was 61°F with an average dew point of 54°F. The average drying time of the markings ranged from 7-30 minutes. Sample cards were taken at selected sites to determine the material's dry film thickness.

By the end of the day the nozzle (#335 medium-duty tip) became clogged. According to the work crew, clogging had occurred more frequently throughout the application of this product than they typically experienced with more traditionally used waterborne paints and binders. They reported the filter for the unit had to be changed daily as opposed to their usually weekly practice with other waterborne paints and binders.

Laboratory Tests

Waterborne Paint Sample Tests

On July 17, 2000, two pints of the paint manufactured by AEXCEL (Product Code: 72W-A087, Batch #: 57653), and supplied for the project, were collected for laboratory testing from the top of the handcart immediately after it was filled. This paint, manufactured with HD-21 binder, was tested for no pick-up time (ASTM D-711), weight per gallon (ASTM D-1475), and viscosity (ASTM D562). This sample was outside specifications on two of the three criteria. As shown in Table 1, both the weight per gallon and viscosity were too high. Due to the sampling collection procedure and the possible lack of mixing prior to sampling, it was decided to collect a second sample.

On July 20, 2000, two pints of paint were sampled from the nozzle of the handcart in between material applications. The same laboratory tests were performed, with one of the three criteria, weight per gallon, being below the specified range as seen in Table 1. Refer to Appendix B for a copy of the laboratory batch report supplied by the manufacturer.

Laboratory Test	Specification Requirements	Sample 1 (18-Jul-00)	Sample 2 (21-Jul-00)
		Temp = 24.5° C RH = 62%	Temp = 20.8° C RH = 54%
No Pick-Up Time (ASTM D-711)	10 Minutes @ 23 +/- 2° C 50 +/- 5% RH	5 minutes	8 minutes
Weight Per Gallon (lbs/gal) (ASTM D-1475)	White Paint 13.7 lbs/gal (min) 14.3 lbs/gal (max)	14.34 lbs/gal (outside spec.)	13.23 lbs/gal (outside spec.)
Viscosity (ASTM D-562)	78 ku (min) 95 ku (max)	98 ku (outside spec.)	92 ku

Material Source: AEXCEL (with Rohm & Haas HD-21 Fastrack Binder)
Batch Number: 57653 (both Samples 1 and 2)

Table 1. Laboratory Test Results – Waterborne Traffic Paint

Dry Film Thickness Test

Field samples were collected at selected sites during the application of the marking material. Aluminum sheets were placed within the legend area and were sprayed with the traffic paint to evaluate the dry film thickness. Using an electronic digital caliper, paint chips from the sample cards were measured. The results are represented in Table 2.

Location	Exit #	Ramp	Dry Film Thickness (mils)
Brattleboro	1 (I-91)	Northbound Off	**15**
	1 (I-91)	Northbound Off	**11**
	1 (I-91)	Northbound Off	**13**
	1 (I-91)	Northbound Off	**9**
	3 (I-91)	Northbound Off	**14**
St. Johnsbury	20 (I-91)	Northbound On	**16**
Williston	12 (I-89)	Northbound Off	**6**
	12 (I-89)	Southbound Off	**11**
	12 (I-89)	Southbound Off	**10**

Table 2. Dry Film Thickness – Waterborne Traffic Paint

Based on the manufacturer's literature, 30-33 mils wet film thickness equates to 18-19 mils dry film thickness. These samples indicate an approximate 15-25 mil wet film thickness at the time of installation, in contrast to the manufacturer's recommended practices.

Field Tests

Retroreflectivity

Three separate interstate ramps were selected for retroreflectivity tests: Barre (Exit 6), Middlesex (Exit 9), and Waterbury (Exit 10), with each having two separate legends evaluated. Using an LTL 2000 retroreflectometer with 30-meter geometry, 6 to 7 readings were taken in predetermined areas on each selected legend in accordance with ASTM E1710. Retroreflectivity readings taken in 2000 and 2001 were taken at 15 days and one year after installation, respectively. Follow-up readings taken in April 2002, after nearly two years of service, were taken in the same locations as previously identified. The results are represented in Table 3.

Location	Symbol	2000 Average (mcd)(m^{-2})(lx^{-1}) (03-Aug-00)	2001 Average (mcd)(m^{-2})(lx^{-1}) (19-Jul-01)	2002 Average (mcd)(m^{-2})(lx^{-1}) (12-Apr-02)
		Air Temp = 70°F	Air Temp = 68°F	Air Temp = 57°F
Barre (Exit 6)	Yield	109	65	57
	Yield	143	73	57
Middlesex (Exit 9)	Stop	71	27	28
	Ahead [1]	151	65	27
Waterbury (Exit 10)	Only	308	60	58
	Only	293	66	66

1. Portions of markings lost, average for 2001 and 2002 based on 5 readings rather than the initial 6 readings.

Table 3. Retroreflectivity Test Results

Durability

To monitor the durability of the marking material, visual observations and photo documentation was used to record the performance. The following photographs represent some of the markings before construction, at construction, and approximately one-year later.

Figure 2A. Pre-Construction
(Photo taken July 12, 2000)

Figure 2B. Post-Construction
(Photo taken July 18, 2000)

Figure 2C. One-Year of Service
(Photo taken July 18, 2001)

BRATTLEBORO (I-91, EXIT 1)
Southbound Off-Ramp

Figure 3A. Pre-Construction
(Photo taken July 12, 2000)

Figure 3B. Post-Construction
(Photo taken July 18, 2000)

Figure 3C. One-Year of Service
(Photo taken July 18, 2001)

BRATTLEBORO (I-91, EXIT 3)
Northbound Off-Ramp

Figure 4A. Pre-Construction
(Photo taken July 6, 2000)

Figure 4B. Post-Construction
(Photo taken July 19, 2000)

Figure 4C. Ten-Months of Service
(Photo taken May 25, 2001)

MIDDLESEX (I-89, EXIT 9)
Southbound On-Ramp

Figure 5A. Pre-Construction
(Photo taken July 13, 2000)

Figure 5B. Post-Construction
(Photo taken July 19, 2000)

Figure 5C. Nine-Months of Service
(Photo taken April 17, 2001)

ST. JOHNSBURY (I-91, EXIT 20)
Southbound Off-Ramp

Figure 6A. Pre-Construction
(Photo taken July 6, 2000)

Figure 7A. Pre-Construction
(Photo taken July 6, 2000)

Figure 6B. Post-Construction
(Photo taken July 20, 2000)

Figure 7B. Post-Construction
(Photo taken July 20, 2000)

Figure 6C. Ten-Months of Service
(Photo taken May 25, 2001)

WILLISTON (I-89, EXIT 12)
Northbound Off-Ramp

Figure 7C. Ten-Months of Service
(Photo taken May 25, 2001)

WILLISTON (I-89, EXIT 12)
Southbound Off-Ramp

The majority of the rehabilitated markings on these interstate highway ramps receive some of Vermont's highest traffic volumes. In 2000, the annual average daily traffic (AADT) along the interstate in these areas ranged from 32,900 in Williston (I-89), 29,600 in Colchester (I-89), 23,400 in Brattleboro (I-91), to 6,300 in St. Johnsbury (I-91). As a result of the pavement markings transverse placement to traffic flow, loss of the marking material due to vehicular wear is inevitable, particularly in the wheel path areas in the high traffic volume areas. This is exhibited by comparing the markings in St. Johnsbury (Figures 5A-C), a low volume interchange, to those in Williston (Figures 7A-C) and in Brattleboro at Exit 3 (Figures 3A-C), both high volume interchanges.

Another cause for pavement marking deterioration at some of the sites may be attributed to the material on which they were placed. An examination of some of the traffic markings indicates that failure of the underlying thermoplastic may have occurred before the traffic paint with HD-21 binder. As seen in Figures 2A-C (Brattleboro, Exit 1), a comparison of the pre-construction photo to that taken one-year later identifies a loss of the base thermoplastic material – as seen in the "P" in "STOP" – with paint remaining along the periphery. Factors that contribute to this type of failure may be associated to the higher profile of the thermoplastic, the physical condition of the thermoplastic, and the bond between the thermoplastic and the pavement. As a result of the thermoplastic's performance, the life of the paint with HD-21 binder may have been affected.

Wear due to snowplow abrasion is another factor in the performance of any pavement marking material in the northern tier states. Vermont's diverse climate lends itself to varied snowfall amounts throughout the state. Storm deposition and frequency variations result in different plow practices in each district. Different plowing techniques and plow maintenance in these districts may also contribute to performance differences in the varying regions.

Due to the level of deterioration and reconstruction of some ramp intersections, a total of 63 of the rehabilitated letters were remarked in 2001. These areas include both Williston off-ramps at Exit 12 (43 letters), northbound off-ramp in Colchester at Exit 16 (11 letters), and the southbound off-ramp in Brattleboro at Exit 1 (9 letters).

In 2002, the remaining legend marks were, in large part, the underlying thermoplastic material with little or no evidence of any paint remaining. Some of the waterborne paint with HD-21 binder is present on the asphalt bituminous pavement but is worn beyond any effective daytime recognition and provides no nighttime benefits. Photographs of some of the sites are presented in Figures 8-10. A few legends remaining are likely the result of several material applications over the years as seen in Figure 10 and not the remnants of the waterborne paint with HD-21 binder.

Figure 8. Waterbury (I-89, Exit 10, NB off ramp) after two years of service.
(Photos taken June 4, 2002)

Figure 9. White River Junction (I-91, Exit 11, NB off ramp) after two years of service.
(Photo taken May 16, 2002)

Figure 10. Middlesex (I-89, Exit 9, SB off ramp) after two years of service.
(Photo taken June 4, 2002)

Summary

Rhoplex Fastrack® HD-21 all-acrylic binder, manufactured for use with waterborne paint, is marketed as being able to provide a service life of up to three years in most conditions when applied at a 30-33 wet film thickness. In Vermont, where a need exists to plow roads during snowfall events, the manufacturer anticipates only a two-year service life will be obtained with the marking material.

The locations of the test sites provided perhaps one of the most extreme tests for the material. Located on interstate ramps in some of the state's highest traveled areas, and placed transverse to traffic, these markings were subjected to significant plow abrasion and unlike long-lines, extensive traffic wear. Although these conditions are normal for legend marks, another factor contributing to the performance of the material was its ability to adhere to nine-month old thermoplastic pavement marking material.

The existing thermoplastic was examined prior to painting. In areas where the thermoplastic was found to be in poor condition or adhered poorly was removed prior to the application of the waterborne paint. The weather conditions during the three days of application were within the manufacturer's recommendation for application with temperatures above 50^{o}F and 5^{o}F above the dew point.

The material drying time ranged from 7-35 minutes. The humidity was high on all three days of application, which probably contributed to the long drying times and the need for coning. In addition, the material's application on two different surfaces – thermoplastic and its adjacent bituminous concrete surface – may have affected the drying time due to its ability to be absorbed or cure to the respective material.

The material was applied at a wet film thickness varying from 15-25 mils, somewhat less than the desired 30-33 mils. The variation in thickness is attributed to two primary reasons: quality control of the hand application and the density of the paint at the time of application.

The applicators experienced the filter clogging at the end of each day's application. As a result, the filter had to be changed daily rather than their normal routine of weekly with traditionally used binders in waterborne traffic paint. The traffic paint used was believed to be a denser material attributing to the clogging. Laboratory tests supported this as a likely cause.

Two separate sets of laboratory tests were performed on the traffic paint. The first set failed two of three criteria; the weight per gallon and viscosity were too high. It was believed that the material was not properly mixed before sampling so a second set of tests was performed. The second set of tests failed only one criterion; the weight per gallon was too low. This sample was collected from the end of the nozzle at the end of a day's application. Since the paint filter had a tendency to clog at the end of the day, it may be possible that the low density was the result of the retention of solids in the filter.

As expected, the markings with the shortest drying time of 7 minutes were the ones that had a dry film thickness of only 6 mils. Limited quality control measures and the end of the day placement of these markings may have affected the application thickness. If the traffic paint were less dense due to some retention of solids in the filter, then a thin, more water/solvent based material would result. This could result in a material with a shortened life expectancy because of the lack of binding solids. Unfortunately, as the result of an intersection reconstruction, these marks were lost early in the study and no conclusive evidence is available.

The ability for the material to retain glass beads was monitored by way of retroreflectivity data collection at three separate sites. Readings were taken at Waterbury (Exit 10), Middlesex (Exit 9), and Barre (Exit 6) which all receive moderate traffic volumes for Vermont interstate interchanges, ranging from a 15100 to 24700 AADT in 2000. Data was collected 15 days, one year, and two years after service. Overall, the average retroreflectivity decreased by approximately 60% at these sites after one year and 68% after two years. The readings in 2002 are likely that of the remaining underlying

thermoplastic since little to no evidence of the waterborne paint bonding to the thermoplastic exists.

Significant variations between the initial readings at each site may be in part to the bead application method. Glass beads were applied by hand with no uniform measure of distribution hence, causing a fluctuation in the initial readings. This method also tends to be slow and the paint surface can dry rapidly, not allowing the beads to become properly embedded. Yet, after one year of service, most of sites have similar retroreflectivity values. The uniform measure may be associated with the paint's ability to retain glass beads or it may be associated with the remaining underlying thermoplastic. Since the glass beads are distributed via a hopper in a thermoplastic application, the tendency for uniform values is more likely.

Visual and photographic documentation of the sites reveals varying results. Those sites subjected to high volumes of traffic exhibited significant wear. Some other marks exhibited loss due to abrasive damage. Overall, the performance of the marking material had a service life of less than the anticipated two years and some cases, less than one as seen in Brattleboro (Figure 2C) and Williston (Figure 6C). After one year, 22% of the markings were remarked due to lane reconfigurations and their minimal existence. In addition, several more marks in the Brattleboro area should have been remarked in 2001 but due to timing and limited funding this did not take place.

In conclusion, waterborne traffic paint containing Rhoplex Fastrack® HD-21 binder placed over thermoplastic pavement markings on Vermont interstate on and off ramps failed to remain for the anticipated two-year life. Factors such as high traffic volumes, the ability to bond to thermoplastic, the condition of the underlying pavement marking material, plowing procedures, snow plow maintenance, and poor quality control in the field had an affect on the material's durability. Since there was no test as to the material's performance on longitudinal lines or bond to clean pavement, the performance of the material in any other application is inconclusive at this time.

APPENDIX A

Appendix A

Statewide IMG MARK (100)-300
Summary, from Engineers Field Book, of Durable Letters installed

Rout	Exit	Ramp	Item	No	No Letters	Date Inst.	NOTES
I-89	4	SB Off	STOP	2	8	10/12/99	T
			AHEAD	1	5	10/12/99	T
		NB Off	STOP	1	4	10/12/99	T
			AHEAD	1	5	10/12/99	T
I-89	5	NB Off	STOP	1	4	10/12/99	T
			AHEAD	1	5	10/12/99	T
			YIELD	1	5	10/12/99	T
I-89	6	NB Off	YIELD	2	10	10/12/99	E
			AHEAD	1	5	10/12/99	E
I-89	9	SB Off	STOP	1	4	10/11/99	E
			AHEAD	1	5	10/11/99	E
			STOP	2	8	9/18/99	E
	9	SB On	YIELD	1	5	10/11/99	E
I-89	10	NB Off	STOP	1	4	10/10/99	E
			AHEAD	1	5	10/10/99	E
			ONLY	4	16	10/10/99	E
I-89	12	NB Off	STOP	1	4	10/10/99	E
			AHEAD	1	5	10/10/99	E
			ONLY	1	16	10/10/99	E
		SB Off	SIGNAL	1	6	10/10/99	E
			AHEAD	1	5	10/10/99	E
			ONLY	6	24	10/10/99	E
I-89	16	NB Off	SIGNAL	1	6	10/11/99	E
			AHEAD	1	5	10/11/99	E
		SB Off	SIGNAL	1	6	10/11/99	E
			AHEAD	1	5	10/11/99	E
		I-89	**TOTAL**		**180**		

G/PCW/MARKINGS/INTERSTA/MARK199/TREPSUM.xls prep:pcw 04/19/2000

Statewide IMG MARK (100)-300
Summary, from Engineers Field Book, of Durable Letters installed

Route	Exit	Ramp	Item	No	No Letters	Date Inst.	NOTES
I-91	1	NB Off	STOP	3	12	10/12/99	T
			AHEAD	1	5	10/12/99	T
		NB On	YIELD	1	5	10/13/99	T
		SB Off	STOP	2	8	10/13/99	T
			AHEAD	1	5	10/13/99	T
			YIELD	1	5	10/13/99	T
I-91	2	NB Off	STOP	2	8	10/13/99	T
			AHEAD	1	5	10/13/99	T
			YIELD	1	5	10/13/99	T
		SB Off	STOP	3	12	10/13/99	T
			AHEAD	1	5	10/13/99	T
I-91	3		YIELD	2	10	10/13/99	T
		NB OFF	AHEAD	1	5	10/13/99	T
I-91	11	NB Off	STOP	1	4	10/12/99	T
I-91	20	SB Off	STOP	1	4	10/11/99	T
		SB On	YIELD	1	5	10/11/99	T
		NB On	YIELD	1	5	10/11/99	T
		NB Off	YIELD	1	5	10/11/99	T
		I-91	**TOTAL**		**113**		
	PROJECT		**TOTAL**		**293**		

APPENDIX B

LABORATORY BATCH REPORT

NAME OF PAINT: White Fast-Dry Waterborne Traffic Paint

PRODUCT CODE: 72W-A087
BATCH NO. 57653

	SPECIFICATION	RESULTS
PIGMENT % BY WEIGHT	61.10 +/- 2.5%	61.96%
NVM ON WT. OF PAINT:	78.0 +/- 2.5%	78.6%
% NVM ON VEHICLE	43.8 +/- 2.0 %	43.7%
CONSISTENCY @ 77 DEGREES FAHRENHEIT	80 - 90 K.U.	88 K.U.
WEIGHT PER GALLON @ 77 ° F. :	14.04 +/- .20	14.03 lbs.
RESIN SYSTEM	ROHM & HAAS HD-21	
DRY TIME (NO TRACK)	2 minutes max.	2 minutes
BLEED RATIO	.97 min.	.98
FINENESS OF GRIND	3 Hegman min.	3 Heg.
COLOR	N/A	N/A
REFLECTANCE:	87% min.	92%
OPACITY (5 Mil.)	.97 min.	.98
FLEXIBILITY	½" Mandrel Bend	Passes
FREEZE/THAW TEST	Max. ± 5 K.U.	Passes

Total gallons manufactured	325
55 gallon drums filled	0
5 gallon pails	65
Manufactured date	6/07/2000

We certify that this product was manufactured, tested, and found to conform to Rohm & Haas HD-21 and the State of Vermont specifications for high performance traffic paint. The undersigned hereby affirms that the statements made in the foregoing affidavit are true.

Ryan M. Vodicka

Ryan M. Vodicka
Chemist

Subscribed and affirmed before me this 7 day of AUGUST, 2000

Gail G. Cavanaugh

Notary Public

NOTARY PUBLIC STATE OF OHIO

GAIL A. CAVANAUGH
Notary Public, State of Ohio
My Commission Expires Aug. 2, 2003
(Recorded in Lake County)

AEXCEL Laboratory Test Report