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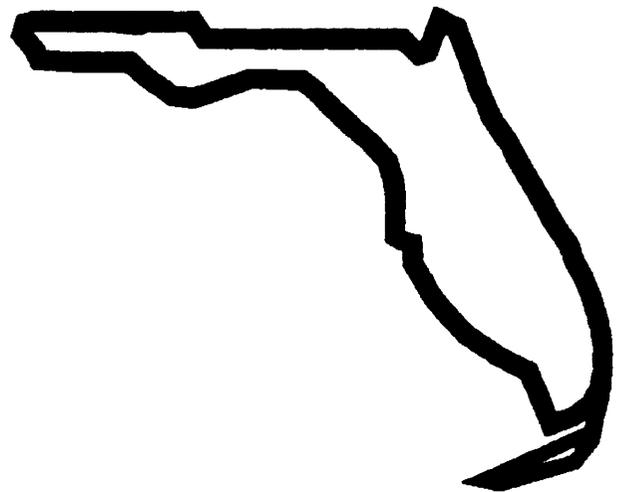
# **Development of Improved Procedures for the Removal of Pavement Markings During FDOT Construction Projects**

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16. Abstract <b>Highway construction projects often require the removal of existing or temporary pavement markings. Effective removal presents a challenge. Incomplete removal may leave suggestions of marking which can be confusing to the motorist passing through the work zone. Aggressive removal may result in pavement scars which under wet nighttime conditions may also be mistaken by the motorist as pavement markings. This study reviews the current removal technology and suggest best management practices for pavement marking removal in highway construction work zones. Field testing of different removal options was performed and the results are documented. Additionally the use of light reflectance as a measure of marking removal was investigated. Ultra-High Pressure Low Volume Water Blasting was demonstrated as a superior removal methodology. A management implementation plan for a State Highway Agency is suggested.</b>					
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## **DISCLAIMER**

“The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the Florida Department of Transportation or the U.S. Department of Transportation.

Prepared in cooperation with the State of Florida Department of Transportation and the U.S. Department of Transportation.”

# SI\* (MODERN METRIC) CONVERSION FACTORS

## APPROXIMATE CONVERSIONS FROM SI UNITS

## APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol	When You Know	Multiply By	To Find	Symbol
<b>LENGTH</b>								
in	inches	25.4	millimeters	mm	millimeters	0.039	inches	in
ft	feet	0.305	meters	m	meters	3.28	feet	ft
yd	yards	0.914	meters	m	meters	1.09	yards	yd
mi	miles	1.61	kilometers	km	kilometers	0.621	miles	mi
<b>AREA</b>								
in <sup>2</sup>	square inches	645.2	square millimeters	mm <sup>2</sup>	square millimeters	0.0016	square inches	in <sup>2</sup>
ft <sup>2</sup>	square feet	0.093	square meters	m <sup>2</sup>	square meters	10.764	square feet	ft <sup>2</sup>
yd <sup>2</sup>	square yards	0.836	square meters	m <sup>2</sup>	square meters	1.195	square yards	yd <sup>2</sup>
ac	acres	0.405	hectares	ha	hectares	2.47	acres	ac
mi <sup>2</sup>	square miles	2.59	square kilometers	km <sup>2</sup>	square kilometers	0.386	square miles	mi <sup>2</sup>
<b>VOLUME</b>								
fl oz	fluid ounces	29.57	milliliters	ml	milliliters	0.034	fluid ounces	fl oz
gal	gallons	3.785	liters	l	liters	0.264	gallons	gal
ft <sup>3</sup>	cubic feet	0.028	cubic meters	m <sup>3</sup>	cubic meters	35.71	cubic feet	ft <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.765	cubic meters	m <sup>3</sup>	cubic meters	1.307	cubic yards	yd <sup>3</sup>
NOTE: Volumes greater than 1000 l shall be shown in m <sup>3</sup> .								
<b>MASS</b>								
oz	ounces	28.35	grams	g	grams	0.035	ounces	oz
lb	pounds	0.454	kilograms	kg	kilograms	2.202	pounds	lb
T	short tons (2000 lb)	0.907	megagrams	Mg	megagrams	1.103	short tons (2000 lb)	T
<b>TEMPERATURE (exact)</b>								
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F
<b>ILLUMINATION</b>								
fc	foot-candles	10.76	lux	lx	lux	0.0929	foot-candles	fc
fl	foot-Lamberts	3.426	candela/m <sup>2</sup>	cd/m <sup>2</sup>	candela/m <sup>2</sup>	0.2919	foot-Lamberts	fl
<b>FORCE and PRESSURE or STRESS</b>								
lbf	poundforce	4.45	newtons	N	newtons	0.225	poundforce	lbf
psi	poundforce per square inch	6.89	kilopascals	kPa	kilopascals	0.145	poundforce per square inch	psi

\* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

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# CHAPTER ONE

## INTRODUCTION

### **1.1 Background**

Pavement marking and removal is an integral part of highway construction. Their role in providing a safe driving environment cannot be underrated. Proper markings help the motorist navigate the roads properly. Since markings only last a finite length of time, due to wear and tear of the road, they must eventually be removed and subsequently replaced. To avoid confusion to the motorist, the markings must be removed such that the least amount of material is visible to the driver, and such that damage to the road is minimal.

With the increasing population has come a commensurate increase in vehicles traveling our roads. Because of the wear and tear the roads are experiencing, pavement marking and removal is occurring on a continual basis. To handle the volume of marking and removal occurring today, the FDOT is looking for an improved way to manage the process.

In the past, pavement marking and removal on FDOT highway construction projects has been a challenging subject. Construction managers have had to solve many problems associated with removal of pavement markings. There are many variables that need to be taken into account to ensure successful removal of pavement markings. Not only must the most effective removal method be used for the marking and surface, management of the entire job process must be diligent. Proper scheduling, planning, and organization are essential.

## **1.2 Purpose**

The purpose of this research is to investigate the problems associated with pavement marking removal, and to offer some solutions to these problems. Testing will be performed using a variety of marking materials and removal techniques, and a subjective analysis will be included. From the results of the testing, conclusions and recommendations will be addressed.

## **1.3 Problem Statement**

Highway construction operations often require traffic to be shifted to alternate vehicle paths. When this occurs, the original permanent markings must be removed and temporary markings must be applied. When the traffic pattern is shifted back after completion of the application of new markings, the temporary markings must be removed.

To avoid confusing or misguiding the motorist, removed markings should not be visible under any driving conditions (i.e. day, night, wet, dry).

Preformed tapes are commonly used for temporary striping purposes. Tapes do not present a removal problem; however, tapes are not durable enough for lengthy installations. For this reason, traditional painting methods are often used in place of the tapes because they are more durable.

Although several methods have been used over the years to remove pavement markings, none have been completely successful. Each method has its inherent advantages and disadvantages in certain situations. Most removal methods still leave some degree of damage to the road, or delineation problems that confuse and upset the motorist. Of

special importance are the problems associated with the road surface during inclement weather, as well as nighttime conditions. This can present a serious safety issue.

Pavement marking removal is technically difficult. The paint material is designed to be extremely durable so that it will hold up to the constant abrasion from passing traffic. The surface of the pavement is extremely porous in order to provide required friction values. Taken together these properties make paint removal difficult. Removing the paint marking may also entail removing a portion of the pavement surface. The problem is that scars left on the pavement surface can be misinterpreted by the motorist as pavement markings. This misinterpretation is especially likely under wet conditions when vehicle lights are in use.

### 1.3.1 Current Specifications

Past FDOT specifications on pavement marking removal provided that, “Where a detour changes the lane use or where normal vehicle paths are altered during construction, all existing pavement markings that will be in conflict with the adjusted vehicle paths shall be removed. Over-painting will not be allowed. The removal may be accomplished by any method that will not materially damage the surface texture of the pavement and which will eliminate the previous marking regardless of weather and light conditions.”

It should be noted that research of other state DOT agencies revealed similar specifications for removal of pavement markings. None of the states had specific requirements for the method of removal. All states left the choice for the method of removal up to the contractor. The specifications simply state the requirements for the condition of the surface after removal.

## **CHAPTER TWO**

### **STATE OF THE ART REVIEW**

#### **2.1 Removal Methods Used in the Past**

A literature search revealed several studies on pavement marking removal. The studies were conducted by the Federal Highway Administration and others. The following seven methods were the most common in the literature: Chemical Methods; Grinding; High-Pressure Water Jet; Hot-Compressed Air-Burning; Excess-Oxygen Burning; Hydro-blasting; Sandblasting. Each method will be discussed with respect to their respective advantages and disadvantages.

##### **2.1.1 Chemical Methods**

Chemical paint remover is applied to the paint stripe by hand or machine. It is allowed to react for 10 to 20 minutes, depending on road surface temperature. A water jet operating at pressures between 500 to 2500 psi is then used to flush the chemical and paint from the pavement. This method was claimed effective on both asphalt concrete and portland cement concrete pavements, but damage may result if the chemical is left on the pavement too long or water jet pressure is too high. This procedure is limited to temperatures above freezing and is most effective for stripes 10 to 20 mils thick. Thick paint buildups require a second or third application, thus slowing the operation and increasing cost.

##### **2.1.2 Grinding**

This has been the most commonly used method in the past, particularly because of its effectiveness at removal of durable materials such as thermoplastics, epoxies. A grinding machine is used to grind off the marking to the surface. The problem with grinding is

that, in most instances, grinding is too effective. If the operator grinds too far, the surface texture and appearance will be affected. The resulting scars resemble a marking and can lead to confusion for the motorist while driving. Grinding is also a relatively slow and expensive method. Its use is not recommended for open-graded asphalt or rough-textured concrete.

### 2.1.3 Water Blasting

A high-pressure water jet—2,000 to 3,000 psi—is sprayed onto the marking. It has reportedly been effective in removing paint stripes from concrete pavement. Also reported to remove about 90% of the line from asphalt pavement, but an outline of the obliterated line may remain. One disadvantage of water blasting is that its operation is restricted to temperatures above freezing. It also may remove some fine aggregates from asphalt pavement. At the above pressures, water blasting may not be effective at removal of materials such as thermoplastics, epoxies.

### 2.1.4 Hot Compressed-Air Burning

This system uses a high-temperature blast (over 2400 F) of exhaust gases from propane combustion in a high-velocity compressed air stream to oxidize the marking. Good results have been reported in removing the paint stripe, but the air blast may remove some pavement material. The obliterated paint and beads remain bonded to the pavement surface, creating a scar. A wire brush is used to remove some of this smudge, but the scar is still visible during daytime as well as at night. Weathering and traffic wear tends to make the pavement discoloration less obvious, but it still may be visible after 3 months. As in any burning method, asphalt pavement and pre-formed expansion joint material in concrete pavement may be damaged if the burner head moves too slowly.

### 2.1.5 Excess-Oxygen Burning

This method uses a high-temperature flame (4,500 to 5,000 F) of propane and oxygen directed at the pavement surface. A second burner tip directs pure oxygen at the burning surface to accelerate oxidation of the paint stripe. Best results are achieved on thin paint layers. Markings over 20 mils usually require more than one pass. Obliterated paint and beads remain bonded to the pavement surface, but can be removed using a stiff wire brush. After a few weeks of weathering and traffic wear, this scar normally blends into the surrounding pavement and no longer appears as a visible line.

### 2.1.6 Hydro-blasting

This method uses a high-pressure water blast in combination with sand to sandblast pavement markings hydraulically. Blasting is performed at pressures between 5,000 to 10,000 psi, and sand is used at an hourly rate of 300 lb. Hydro-blasting reportedly removes all paint and beads from concrete pavement with little apparent damage. A thin white-gray slurry remains on the pavement, but after a few weeks of weathering and traffic wear, the scar is no longer evident. This method is less effective on asphalt pavement, and in some cases surface aggregate may be scoured or polished, resulting in a scar that can be visible at night and during conditions of low visibility. Once again, weathering and traffic wear eventually minimize the scar. Hydro-blasting, which requires a relatively long equipment train and is confined to temperatures above freezing, is also relatively slow and generally not effective on thermoplastic removal. However, some promise has been reported for removing paint lines from asphalt pavement.

### 2.1.7 Sandblasting

Widely used in the past for removal of paint stripes, sandblasting reportedly achieves fair to excellent results on both asphalt and concrete pavements. However, as with grinding, operator skill plays a crucial role in effective removal of markings without damage to the pavement. Sandblasting is not effective on open-graded asphalt since it is difficult to remove stripes completely without damaging the pavement surface. It is generally slow, requires a relatively large equipment train, and leaves residue that must be cleaned up.

### 2.1.8 Motor Grader

This method has the power to remove markings of any type. Unfortunately, effective removal results in tremendous damage to the pavement, as with grinding. The blade used for this method is very wide, and therefore more of the pavement is affected.

### 2.1.9 Black Paint

In the past, black paint has been used to cover up the markings for temporary purposes. Over painting is not a satisfactory solution for several reasons. First, it wears off fairly quickly leaving the original marking visible. It also can increase the reflectivity of the marking so that under wet conditions with vehicle lights the black painted marking may appear as a white traffic marking. Most State Highway Agencies now do not allow painting over with black paint.

## **2.2 FDOT/Consultant's/Contractor's Opinion of Methods**

Many face to face as well as telephone interviews were held with personnel, both with the FDOT district offices, and Construction Engineering Consultants. Their opinions on the

removal methods currently being used in the State of Florida were solicited. They were also asked to provide their opinion on the direction pavement marking removal should follow in the future to avoid the current problems. Most of these construction professionals offered the following general observations:

1. They believed that of the removal methods that they had seen, water-blasting produced the best results.
2. They were supportive of the effort to improve the management process for pavement marking removals.

The following removal criteria which was in use by FDOT District Six is representative of the specifications found to be in use:

“The contractor shall remove any existing or proposed pavement markings that conflict with the traffic control plans. When the conflict no longer exists, the Contractor shall restore pavement markings to their original position. Removal of existing and/or temporary pavement markings shall be accomplished by the following methods: a) on asphalt pavement by milling and asphalt overlay, by grinding and asphalt overlay, sand or water blasting, or by other means approved by the engineer; b) on concrete pavement by sand or water blasting, or by other means approved by the engineer. Payment shall be done by item 2710-11 for paint removal (by square meter) and by pay item 2711-7 for thermoplastic removal (by square meter). Cost of asphalt overlay required when milling or grinding is used in traffic areas shall be included in the above mentioned pay item. Use of black paint to cover existing and/or temporary markings is prohibited.”

In cases of friction course marking mistakes, the surface will be ground or milled flush with the friction course top and a prime-sand mixture will be applied to scarred areas.

A 36,000 psi, 10 gal/min machine should be out in the beginning of 1998, which will be capable of removing the thicker markings.

### **2.3 Current Water Blasting Removal Technology**

Pavement marking removal technology has dramatically improved in the last couple of years. One of the most efficient technique currently in use is water blasting the surface at very high-pressures to remove both short term (i.e. paints) and long-term (i.e. thermoplastics) markings. The water blasting equipment on the market today provides significantly higher pressures and better technology than those used in the past. This has allowed water blasting to overcome some of its previous shortcomings with pavement marking removal.

Current ultra-high pressure water blasting equipment consist of a pump and engine combination which is typically truck mounted. A towed trailer provides the water supply. Pressures in the range of 36,000 psi are commonly used. Flow rates are in the range of 6 to 10 gpm. Blasting is effected through a rotating nozzle suspended directly above the pavement surface. Hand manipulated blasting nozzles can also be operated from the same equipment. Most traffic paint and thermoplastics up to 50 mils in thickness can be satisfactorily removed with a single pass. Removal rates range from approximately 10 feet per minute for thermoplastic to 60 feet per minute for traffic paints. It should be noted that removal efficiency and quality are highly dependent upon operator skill and experience.

### **2.4 Marking Materials**

Several marking materials have been used over the years for striping of state highways. It is important to understand the different marking types, their advantages and limitations, so that the contractor or engineer can make a sound decision as to which material to use

for a given situation. Pavement markings are divided into two distinct classes: short-term and long-term. Short-term consist primarily of various types of paints. Long-term includes thermoplastics, epoxies, and pre-formed tapes. Since this report is specific to the applications of the FDOT, the focus will be placed on the use of paints, pre-formed tapes, and thermoplastics for marking of state highways.

#### 2.4.1 Traffic Paints

Traffic paints are most commonly used for short-term applications, or where the life-cycle costs to repaint the road are cheaper than using a more durable marking material such as thermoplastic. Often this ends up being the case. The initial cost of thermoplastics can be as much as nine times as much as standard traffic paints. The thermoplastic would have to last about ten years to compete with paint based solely on cost. On higher-volume roads, however, where repainting is necessary, durable materials become cost competitive in much less than five years.

The types of paint available include alkyd, latex, and chlorinated-rubber. These are broken down into water and solvent borne, with water-borne being the most commonly used today, both for environmental and performance reasons. Typical life of painted markings is roughly one year depending on traffic volumes.

Traffic paints have the following advantages:

- 1) Inexpensive relative to durable markings
- 2) Easy to apply
- 3) Consistent markings for the period until repainting is necessary.

The following are some disadvantages associated with paints:

1. Wet-night visibility is poor because retro-reflective beads are covered with water
2. Not durable on highways with heavy traffic.

Several factors are important to consider in the application of traffic paints. These include time of application, weather limitations, surface preparation, mixing of the paint, rate of application, required film thickness, alignment of the stripes, application of glass spheres, and reflectivity measurements.

#### 2.4.2 Thermoplastics

Thermoplastics fall into the class of durable pavement markings. Typical life of thermoplastics is between 4-8 years depending on traffic volume. Thermoplastics are generally known to be good performers, especially on new asphalt concrete pavements. This is due to the excellent bond that forms between the thermoplastic and the new AC surface. Performance on existing AC surfaces has not been as successful. Performance on portland-cement-concrete pavements has been highly inconsistent.

Thermoplastics offer the following advantages:

- 1) Long-lasting/durable
- 2) Good wet-night visibility
- 3) Can be used in a wide variety of situations (i.e. edge lines, lane lines, center lines, gore areas, bike lane symbols).

The following are some disadvantages of thermoplastics

- 1) Difficult to remove because of thickness and the excellent bond that forms with the pavement surface
- 2) Relatively expensive, especially when compared to traffic paints.

Thermoplastic is usually extruded or painted onto the pavement surface in a molten state by mechanical means, with surface application of glass spheres. After the surface cools to normal pavement temperatures, a durable, reflectorized marking will remain.

### 2.4.3 Pre-formed Tapes

Although often used for intersection markings, the most common use for pre-formed tapes is for temporary markings in construction zones. There are a several reasons for this. The most important reason is ease of removal. They can also be extremely durable.

Tapes do have disadvantages though. First, they are quite expensive. This limits their use for high volume roads. They also possess low long-term reflectivity, which makes the material less suited for longitudinal markings.

## CHAPTER 3

### RESEARCH METHODOLOGY

#### **3.1 Testing Site**

The site for the pavement marking removal research was located at Camp Blanding in Starke, Florida. A 300 foot by 75 foot asphalt concrete and portland cement concrete runway test strip was used to place and subsequently remove paint, thermoplastic, and temporary tape. Only the asphalt concrete section was used for testing, as this it is the more common pavement used in Florida, and the one where most removal problems occur. A photo of the site is shown in Figure3-1 and a detailed site plan is included as Appendix C.



Figure 3-1 Pavement Marking Removal Test Site

### **3.2 Application of Pavement Markings**

Pavement markings were applied on the asphalt concrete portion of the test site. Eight lines were placed, each measuring 100 feet in length by 6 in. in width. The markings were placed on 8.5 foot centers. All markings were yellow in color, with reflective beads applied for reflectivity (see Appendix D for marking specifications). The eight lines were configured as follows:

- a. 20-mil Paint line
- b. 100-mil thermoplastic line
- c. 100-mil thermoplastic line
- d. 90-mil thermoplastic line
- e. 90-mil thermoplastic line
- f. 90-mil thermoplastic line
- g. 90-mil thermoplastic line
- h. 35-mil temporary tape line

Figures 3-3 through 3-5 are photos of the pavement stripe application at the test site.



Figure 3-2. Preparation of AC Pavement for Markings



Figure 3-3 Application of 100 mil Thermoplastic



Figure 3-4 Reflective Glass Bead Dispenser on Thermoplastic Unit

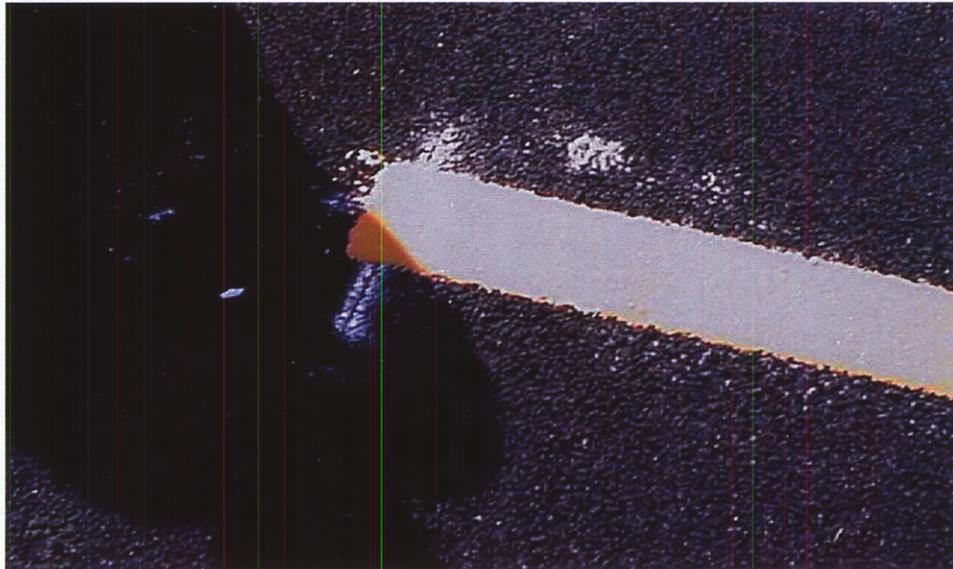


Figure 3-5 Reflective Glass Beads on Thermoplastic Line



Figure 3-6 Test Site with all Markings Applied

### **3.3 Testing of Pavement Markings**

To ensure compliance with FDOT standards, the FDOT performed tests for the reflectivity and chromaticity (i.e. color) of the markings. The results are shown in Appendix E, along with the testing procedure used by the FDOT for evaluating the above parameters. Reflectivity measurements were taken with a MiroLux 12 (15 meter geometry) portable unit reflectometer. The chromaticity measurements were taken with a FDOT BYK portable chromaticity instrument.

It should be noted that the technology in this area is improving rapidly. The FDOT was considering purchasing the latest equipment, which is called the Laserlux. It consists of a unit attached to the side of a van, which relays real-time data to a computer on the inside of the van as the machine passes over the marking. However, the Laserlux

machine was not available for use during testing. A photo of the equipment used to test the markings is shown in Figure 3-7.



Figure 3-7 FDOT BYK Portable Chromaticity Instrument

### **3.4 Removal of Pavement Markings**

The methods used to remove the markings included water blasting at very high pressures, grinding, and a combination of the two. The removal scenarios were as follows:

- a. 20-mil paint line removed by Ultra High Pressure (UHP) waterblasting
- b. 100-mil thermoplastic line removed by UHP waterblasting
- c. 100-mil thermoplastic line removed by grinding flush followed by UHP blasting
- d. 90-mil thermoplastic removed by UHP waterblasting
- e. 90-mil thermoplastic removed by grinding to be followed with emulsion overlay
- f. 90-mil thermoplastic removed by grinding only
- g. 90-mil thermoplastic line removed by UHP waterblasting with portable unit
- h. 35-mil temporary tape line removed by UHP waterblasting

Figures 3-8 through 3-13 document the marking removal methods.

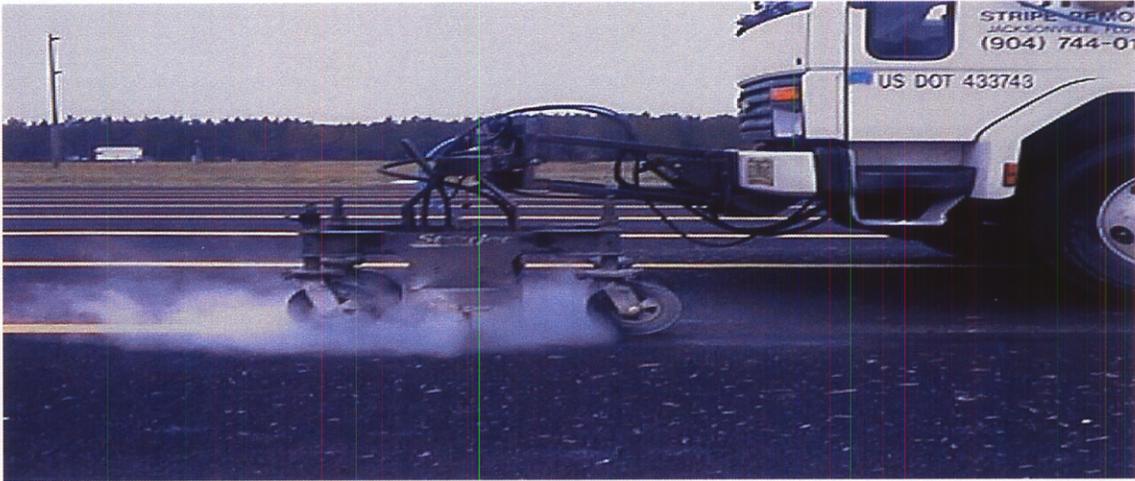


Figure 3-8. Water Blasting Paint Stripe (line A) with Truck Unit



Figure 3-9 Water Blasting Thermoplastic (line B) with Truck Unit.



Figure 3-10 Grinding Thermoplastic (Line C) Flush with Surface before Water Blast Clean

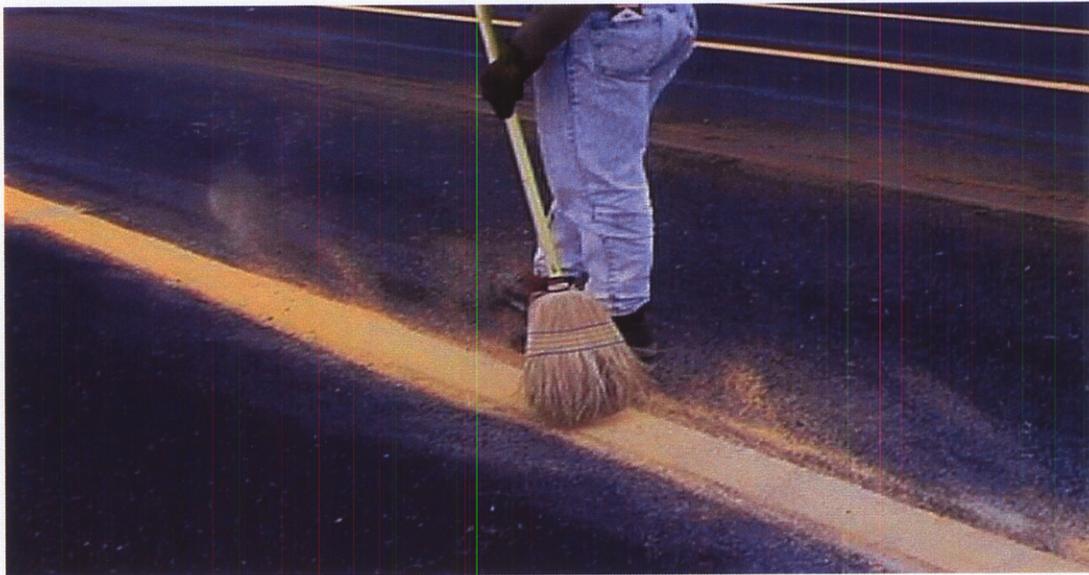


Figure 3-11 Sweeping Off Ground Thermoplastic Residue before Water Blast Clean (line C)

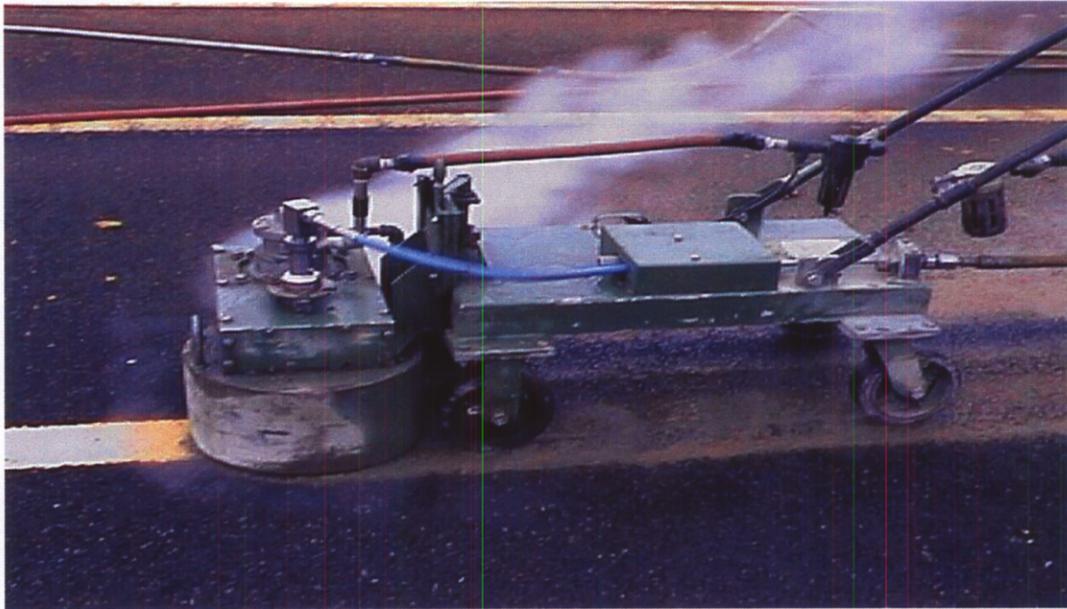


Figure 3-12 Water Blasting Thermoplastic (line G) with Walk-Behind Unit

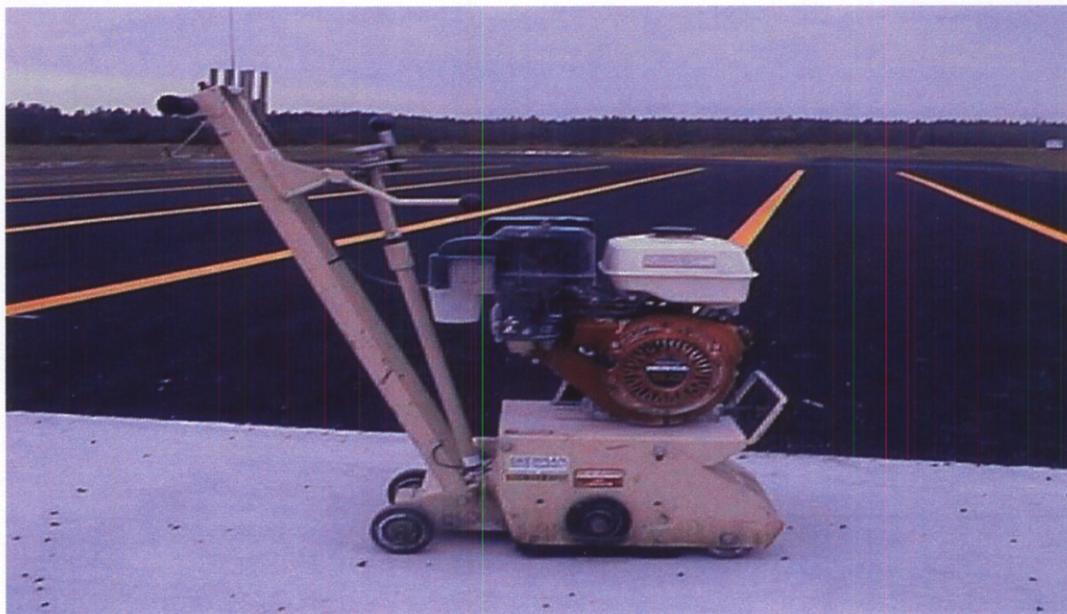


Figure 3-13 Grinder Used for Grinding (Line's C,E,F)

## EVALUATION CRITERIA

### **4.1 Evaluation Procedures**

Evaluation of the marking removal was based on completeness of removal, the condition of the pavement surface after removal (i.e. degree of scarring), potential for the scarring to confuse the motorist, the rate of removal in feet per minute.

Completeness of removal was evaluated on a scale of 1 to 5, with 1 representing only a small fraction of removal and 5 representing essentially total removal.

The condition of the surface after removal was based on the disparity in color and texture from the surrounding pavement. Once again, a rating system between 1 and 5 was used for judging. A 1 in this case represented a barely noticeable difference in color and texture, and a 5 represented a very pronounced difference in color and texture. Color contrast was called “positive” if the scar appeared lighter than the adjacent pavement, and “negative” if darker.

The potential for the scar to be mistaken for a pavement marking was also evaluated on a scale of 1 to 5. A 1 represented almost no chance for confusion (i.e. minimal scarring), and a 5 represented a very probable chance for confusion (i.e. heavy scarring). Based on the ranking given, the marking was designated as “effectively removed” or “not effectively removed.”

In addition to the evaluation completed at the time of removal (i.e. daytime), the lines were also evaluated at night during wet conditions. Wet-night conditions typically present the most problems for the motorist in distinguishing between an existing marking and one that has already been removed.

## **CHAPTER 5**

### **DATA ANALYSIS**

#### **5.1 General**

The results of the removal testing is presented in three forms: 1) tables; 2) narrative descriptions; 3) photographic documentation. The photographic documentation will follow the descriptions, and will be used to recommend removal and scarring standards to the FDOT. Tables 5-1 and 5-2 present a summary of the removal results.

#### **5.2 Removal of Line A Results**

The first line on the pavement test section consisted of an 20-mil water borne, lead-free paint that was removed by water blasting. The water blasting was accomplished using the STARJET truck unit operating at a pressure of 36,000 psi, a flowrate of 4.5 gal/min, head rotation of 2,800 rpm, and nozzle distance from the surface of  $\frac{3}{4}$  inch. The majority of the line was removed in a single pass. Removal was complete, and there was only a slight color disparity, with the removed line appearing slightly lighter than the surrounding pavement. This was due to the operator being a little too aggressive on the AC pavement. If the operator is too aggressive, the end result is a scraping off of the black coating on the surface. This is where the fine-tuning of the flowrate, distance the nozzles are from the surface and the head rotation come into play. Texture change was negligible. Based on the color and texture change, the potential for the scar to be mistaken for a marking was small (rated at 2 out of 5). In general, removal of a painted AC surface was quite effective using water blasting. See Figure 5-1 for a photo of the final surface condition.

Table 5-1 Production Rate and Effectiveness of Removal

Line	Pvt. Type	Marking Type & Size	Removal Method	Removal Time (min)	Removal Rate (fpm)	Degree of Removal
A	AC	Water-based Paint, 20 mil	Waterblast	3.1	32.3	5
B	AC	Thermo, 100 mil	Waterblast	5.2	19.2	4
C	AC	Thermo, 100 mil	Grind Flush+Waterblast	7.5	13.3	4
D	AC	Thermo, 90 mil	Waterblast	5.5	18.2	4
E	AC	Thermo, 90 mil	Grind+Overlay	3.5	28.6	3
F	AC	Thermo, 90 mil	Grind	4.2	23.8	3
G	AC	Thermo, 90 mil	Wblast w/ Hand Unit	8.3	12.0	5
H	AC	Temporary Tape, 35 mil	Waterblast	4.2	23.8	4

Table 5-2 Evaluation of Removal Results ( Daytime )

Line	Pvt. Type	Equipment & Procedure	Thickness Removed (mils)	Color Change	Texture Change	Potential for scar to be mistaken
A	AC	36,000 psi, 4.5 gal/min 2800 rpm, Single Pass	20	2 (+)	1	2
B	AC	Same as above. 80% on 1st pass, 20% on 2nd	100	3 (+)	1	2
C	AC	Same as above. Also, 9 HP Edco grinder	100	3 (+)	2	3
D	AC	Same as above, but low- ered nozzles to 1/2 in.	90	3 (+)	1	2
E	AC	Edco 9 HP grinder	90	4 (+)	5	5
F	AC	Edco 9 HP grinder	90	4 (+)	5	5
G	AC	36,000 psi walk-behind unit, single pass	90	3 (+)	1	2
H	AC	Same as above	35	3 (+)	1	2



Figure 5-1. Line A After Water Blasting.

### **5.3 Removal of Line B Results**

The second line consisted of a 100-mil thermoplastic, which was also removed by water blasting at the same pressure, flowrate, and head rotation as with Line A. As could be expected, the rate of removal (see table 5-1) was less than with the paint due to the thickness of the thermoplastic marking. The first pass removed about 80%, with the second pass removing about another 10-15%. A small percentage of thermoplastic remained in the pores of the AC friction course layer. There was a slightly more prominent color disparity between the removed marking and the surrounding pavement than with the painted marking. Once again, color contrast was “positive” because the scar was lighter than the surrounding pavement. Texture change was again negligible. Based on the color and texture changes, the potential for the scar to be mistaken for a marking was still low (also rated 2 out of 5). Therefore, although removal of

thermoplastic is slower than with paints, it is still quite effective. See Figure 5-2 below for the final surface conditions of Line B after removal was complete.



Figure 5-2. Final Surface Conditions of Line B after Water Blasting.

#### **5.4 Removal of Line C Results**

The third line also consisted of a 100-mil thermoplastic, which was removed by a combination of grinding the marking flush with the surface followed by water blasting the remaining layer using the same pressure, flowrate, head rotation, and nozzle distance. Production was a little slower (see Table 5-1) due to the extra step of grinding, but the results were almost identical to Line B's, where water blasting was used as the sole removal method for the 100 mil thermoplastic. As with Line B, removal was almost complete (4 out of 5), color disparity was moderate (3 out of 5), and color contrast was "positive" since the scar was lighter than the surrounding pavement. There was a slight texture change (2 out of 5), which was probably due to the grinder grazing the surface. For this reason, the potential for the scar to be mistaken for a marking was given a 3 out of 5. From these results, it appears that the combination of grinding the surface flush followed by water blasting the remaining layer is an effective removal option. See

Figures 5-3 and 5-4 for photos of the final surface conditions of line C after grinding the top layer, and after finishing the final layer with water blasting.

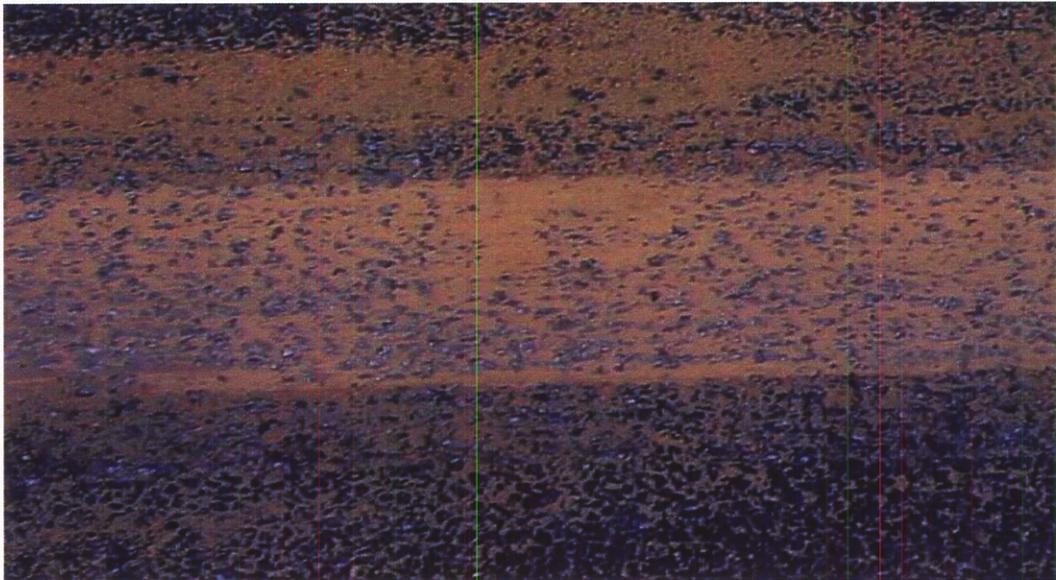


Figure 5-3 Line C after Grinding Flush



Figure 5-4 Line C After Water Blasting

### **5.5 Removal of Line D Results**

Line D consisted of a slightly thinner thermoplastic line (90 mil), which was removed solely by water blasting the surface with the same values for pressure, flowrate, head rotation. Nozzle distance was changed from  $\frac{3}{4}$  inch to  $\frac{1}{2}$  inch to try a more aggressive approach with the thermoplastic. Rate of removal was almost identical to the removal of the 100-mil thermoplastic (see Table 5-1). The completeness of removal was almost complete (4 out of 5). A small amount of thermoplastic remained in the voids between the aggregates in the friction course layer of the AC pavement. Color change was about the same as with Line B and Line C (3 out of 5), color contrast was “positive,” and texture change was negligible (1 out of 5). Thus, the potential for the scar to be mistaken for a marking was small (2 out of 5). The removal results for a 90-mil thermoplastic line using water blasting were similar to the results for a 100-mil thermoplastic line using water blasting.

## **5.6 Removal of Line E Results**

Line E consisted of a 90-mil thermoplastic removed by grinding with an Edco 9 HP grinder. Rate of removal was similar to removal of the paint line using water blasting (see Table 5-1). Completeness of removal was poor with a single pass (3 out of 5). Color disparity was high (4 out of 5), and color contrast was “positive”. This was due to the grinder scraping off the black coating of the AC friction course surface, which left what resembled a white marking. Texture change was quite noticeable (5 out of 5), manifested as deep grooves in the surface layer. Based on the color and texture of the surface after removal, the potential for the scar to be mistaken for a marking was high (5 out of 5). The grinding results were in accord with prior input obtained from FDOT construction and maintenance personnel. Grinding of the pavement markings resulted in pavement scarring. See Figure 5-5 for a photo of the surface after grinding.

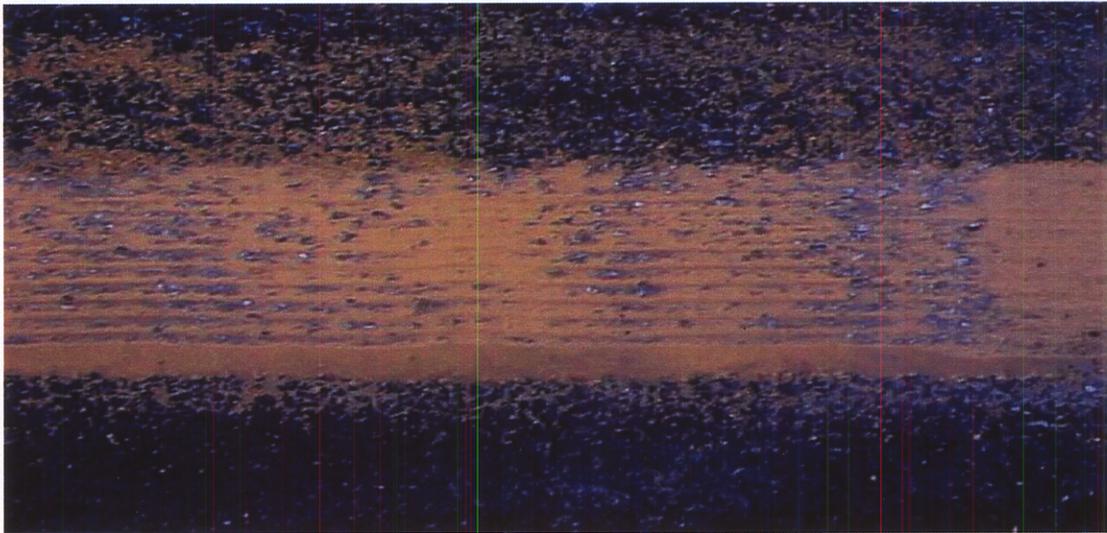


Figure 5-5 Line E after Grinding Pavement Marking

### **5.7 Removal of Line F Results**

Line F also consisted of a 90-mil thermoplastic line removed by grinding. The results were essentially identical to those for Line E. Once again, significant scarring was observed.

### **5.8 Removal of Line G Results**

Line G consisted of a 90-mil thermoplastic, which was removed with a portable walk-behind waterblaster. The waterblast unit provided similar conditions to the truck unit. Rate of removal was almost double that of the truck unit, but the removal was just as efficient as with the truck unit. Completeness of removal was high (5 out of 5), color disparity between scar and surrounding pavement was moderate (3 out of 5). Texture change was negligible (1 out of 5). Therefore, the potential for the scar to be mistaken for a marking was small (2 out of 5). It should be noted that the walk-behind unit is most useful for tight areas where the truck unit cannot easily access. Thus, the walk-behind unit is a viable option for removing markings effectively in difficult to access areas. See Figure 5-8, 5-9 below for final surface conditions after removal of 90-mil thermoplastic line using walk-behind waterblaster.



Figure 5-6. Line G after Removal with Walk-Behind Water Blast Unit.

## **5.9 Removal of Line H Results**

Line H consisted of a 35-mil temporary tape, which was removed by water blasting with the truck unit at the same conditions as the other lines. Removal was almost complete with one pass (4 out of 5), removal rate was slower than with paint, but quicker than with thermoplastic (see Table 5-1), color change was moderate (3 out of 5), and texture change was negligible (1 out of 5). Therefore, the potential to mistake the scar for a marking was small (2 out of 5). In short, removal of temporary tape using water blasting was quite effective. See Figure 5-7 for a photo of the final surface conditions. A second pass would have removed the tape that still remains in the picture.



Figure 5-7. Removal of Temporary Tape (Line H) Using Water Blasting.

## **5.10 Nighttime Evaluation Results**

Evaluation of the scars under wet and dry nighttime conditions revealed similar results to those observed during the day. All scars were visible to some extent. Although removal was essentially complete on all markings that were removed by water blasting, a scar was present which resembled a light colored pavement marking. This was due to the water blasting scraping off the black coating from the AC friction course. As expected, the markings removed by grinding left scars that were highly visible. Due to the distinct difference in color and texture from the surrounding pavement, the scars might be mistaken for pavement markings.

## **CHAPTER SIX**

### **REFLECTIVITY AS A MEASURE OF MARKING REMOVAL QUALITY**

#### **6.1 Objectives**

Pavement markings are seen by the motorist because of their contrasting reflectivity against the reflectivity of the pavement background. It is the luminance of the marking that produces its visibility. When the marking has been removed from the pavement surface the reflectivity of the previously marked areas should be reduced to values similar to the adjacent pavement surface.

One of the problems with inspection and enforcement of pavement marking removal operations is that acceptance of the work remains largely a subjective matter. There is no quantifiable measurement of the degree of marking removal or the extent of pavement scarring. As an extension of the basic objectives of this research study, the research team also performed a preliminary investigation of the possibility of using reflectance as a measure of marking removal. The results of this investigation are reported in this chapter.

#### **6.2 Research Procedure**

A prototype testing device was assembled to provide a relative measure of the reflectance from the pavement surface. This testing device consisted of a light box with a light meter mounted on one side and a light source mounted at the other end. Both the light source and the meter were oriented at approximately 30 degrees to the horizontal axis. A Sekonic Model L508 meter with a narrow focus of one degree was used.

The testing procedure involved taking light meter reflectivity readings directly on the path of the removed pavement stripe and on the undisturbed pavement surface on both

adjacent to the spot where the stripe reading was taken. The objective was to determine the relative change in reflectivity resulting from the removal process.

Figure 6-1 presents a photograph of the reflectivity testing device. Figure 6-2 presents a photograph of the Sekonic meter.

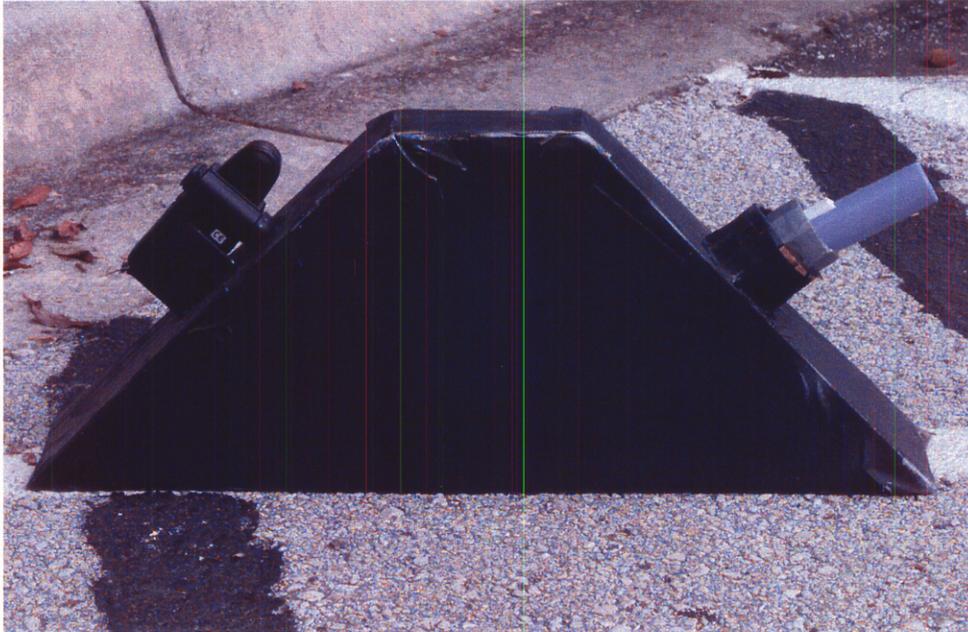


Figure 6-1 Reflectance Testing Device

### **6.3 Test Results**

The results of the reflectance testing are presented in Table 6-1. The relative reflectance of the pavement surface of the stripe path after removal varied from 0.94 to 6.49 times the reflectance from the adjacent undisturbed pavement surface. The average ratio was 3.16. This agrees with the visual observation of pavement lightening caused by the removal of asphalt from the surface aggregate. The lowest ratio was measured on Line C which was removed by surface grinding and then ultra-high pressure blasting. The highest value was measured on Line F which was removed with grinding only.



6-2 Sekonic Light Meter

#### **6.4 Conclusions**

Light meter reflectance measures do indicate that the surface reflectance of pavement is increased in the areas where blasting or grinding occur. Improvements in the testing equipment and methods could reduce the variability of the test measurements.

Additionally since night time wet conditions are the most critical, testing during these conditions should be performed. In general the concept appears to be viable, however additional research is needed to refine the methodology.

Table 6-1 Light Reflectance Results

Test Line	Left Side Stripe Path Luminance cd/sf	On Stripe Path Luminance cd/sf	Right Side Stripe Path Luminance cd/sf	Average Luminance Undisturbed Pavement	Ratio of Luminance Stripe Path to Undisturbed Pavement
A	42.00	240.00	59.00	50.50	4.75
B	59.00	170.00	30.00	44.50	3.82
C	120.00	84.00	59.00	89.50	0.94
D	30.00	59.00	21.00	25.50	2.31
E	84.00	240.00	42.00	63.00	3.81
F	59.00	240.00	15.00	37.00	6.49
G	84.00	84.00	15.00	49.50	1.70
H	84.00	84.00	30.00	57.00	1.47
Average Values	70.25	150.13	33.88	52.06	3.16

## CHAPTER 7

### CONCLUSIONS/RECOMMENDATIONS/IMPLEMENTATION

#### 6.1 Conclusions

Managing the removal of pavement marking in construction work zones is important. Poor removal techniques can result in motorist confusion and present a real safety hazard. FDOT construction engineers and maintenance of traffic engineers must be aware of the importance of proper removal and the hazards of pavement scarring.

Field testing and job site observations indicate that pavement markings can be effectively removed. Ultra-high pressure water blasting was demonstrated as an efficient means of removing even the most durable thermoplastic marking without significant scarring of the pavement surface. Observations in this study indicated that pavement scarring is possible with water blasting and with grinding. Operator skill and experience significantly effect the results. Perhaps due to the nature of the removal process, mechanical grinding appears to present the largest possibility for pavement scarring.

#### 6.2 Recommendations

The results of this study suggest the following recommendations:

1. The FDOT CPAM should be revised to include a section on pavement marking removal. This should address the importance of complete removal and the dangers of pavement scarring. Painting over of existing markings should be prohibited.
2. Pavement marking removal issues should be added to the current Construction Engineer Training Program.
3. Although this study indicates that water blasting is a superior method for removal, providing a “method specification” is generally not desirable. Therefore it is not recommended that one method be specified to the exclusion of another. A

performance type specification approach is suggested. Pavement marking removal must be accomplished to the point where there is essentially no chance of the motorist mistaking the removed line path for a valid pavement marking. Scarring must be minimal. Inspection and acceptance of the removal should be made by the FDOT project engineer. The suggested procedure would be to require that the contractor remove a test section of marking. This initial section would be used for the following purpose:

- a) Demonstrate the suitability of the contractor's removal method, operator skill, and equipment.
  - b) Establish an acceptable level of removal quality for the project
4. When excessive scarring occurs the pavement surface should be repaired with a method appropriate for the situation.

### **6.3 Implementation Plan**

#### 6.3.1 Technical Summary

Highway construction projects often require the removal of existing or temporary pavement markings. Effective removal presents a challenge. Incomplete removal may leave suggestions of marking which can be confusing to the motorist passing through the work zone. Aggressive removal may result in pavement scars which under wet nighttime conditions may also be mistaken by the motorist as pavement markings. This study reviews the current removal technology and suggest best management practices for pavement marking removal in highway construction work zones. Field testing of different removal options was performed and the results are documented. Additionally the use of light reflectance as a measure of marking removal was investigated. Ultra-High Pressure Low Volume Water Blasting was demonstrated as a superior removal methodology. A management implementation plan for a State Highway Agency is

suggested. Implementation is expected to result in improved work zone safety and more efficient management of the pavement removal activity.

### 6.3.2 Technology Transfer Plan

This report and its technical summary should be provided to the following FDOT personnel:

District Construction Engineers  
FDOT Maintenance of Traffic Engineers  
FDOT Specifications Engineer  
FDOT State Training Engineer

Each of the above will include the results of this study in their respective areas. Additionally, copies of the report should be made available on request to other State Highway Agencies and Transportation Agencies. Presentation of the research findings should be made at appropriate meetings of the above listed managers.

### 6.3.3 Implementation Test

Maintenance of Traffic reviews and State QAR reviews should also include evaluations of pavement marking removals. Instances of improper removal should be noted and reported. The Director of Construction should monitor and report on the quality of the pavement marking removal in FDOT work zones.

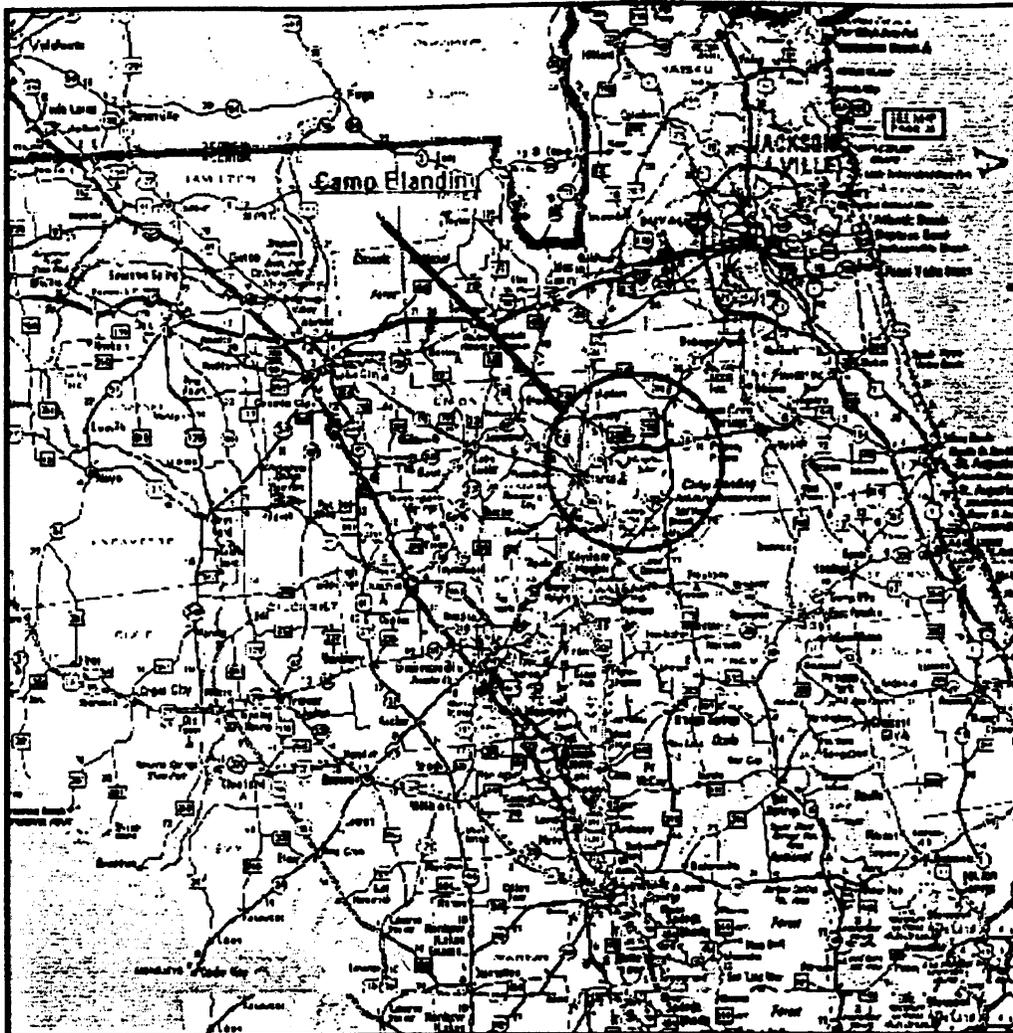
#### REFERENCES CITED

- <sup>1</sup> Florida Department of Transportation, Standard Specifications for Road and Bridge Construction (Florida: FDOT Map and Publication Sales, 1996) 85-86, 622-623.
- <sup>2,3</sup> Charles W. Niessner, Traffic Stripe Removal (Washington DC: U.S. Department of Transportation, Federal Highway Administration, July 1997).
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- <sup>5</sup> D. Kilgore, Improved Stripe Removal by High-Temperature Burning with Excess Oxygen (U.S. Department of Transportation, Federal Highway Administration, January 1980).
- <sup>6</sup> D. Kilgore, Equipment Improvements for Removal of Traffic Markings by High-Temperature Burning with Excess Oxygen (U.S. Department of Transportation, Federal Highway Administration, January 1980).
- <sup>7</sup> James E. Bryden, Wayne D. Kenyon, Methods for Removal of Pavement Markings (New York: New York Department of Transportation, May 1986) 2.
- <sup>8</sup> John F. Scally, Jr. (Maryland DOT), letter to Pete Carola, 8 May 1997,
- <sup>9</sup> Cliff Holler (Reynolds, Smith, Hill), Personal interview, 6 August 1997.
- <sup>10</sup> Benny Crouse (FDOT District 1), Telephone Interview, 13 August 1997.
- <sup>11</sup> Bill Walsh (FDOT District 4), Telephone Interview, 13 August 1997.
- <sup>12</sup> Charles Newman (FDOT District 6), Telephone Interview, 14 August 1997.
- <sup>13</sup> Florida Department of Transportation, FDOT District VI Standard Traffic Control Plan Notes and Designer Instructions (Florida: FDOT D6 Traffic Ops, February 1997).
- <sup>14</sup> David Martineau and Tom Fitzpatrick (JISI), Personal Interview, 7 August 1997.
- <sup>15</sup> NLB Corporation, company information packet sent to Pete Carola, 6 August 1997.
- <sup>16</sup> James E. Bryden, Development of a Statewide Pavement Marking Policy (New York: New York State Department of Transportation, July 1988) 13,15.
- <sup>17</sup> Sidney Q. Kidd, Final Report State Study No. 67-17 Cold Plastic and Hot Thermoplastic, Foil-Back Tape, Removable Tape, and Paint Pavement Marking (Mississippi: Mississippi State Highway Department, February 1991) Appendix A 3-5.

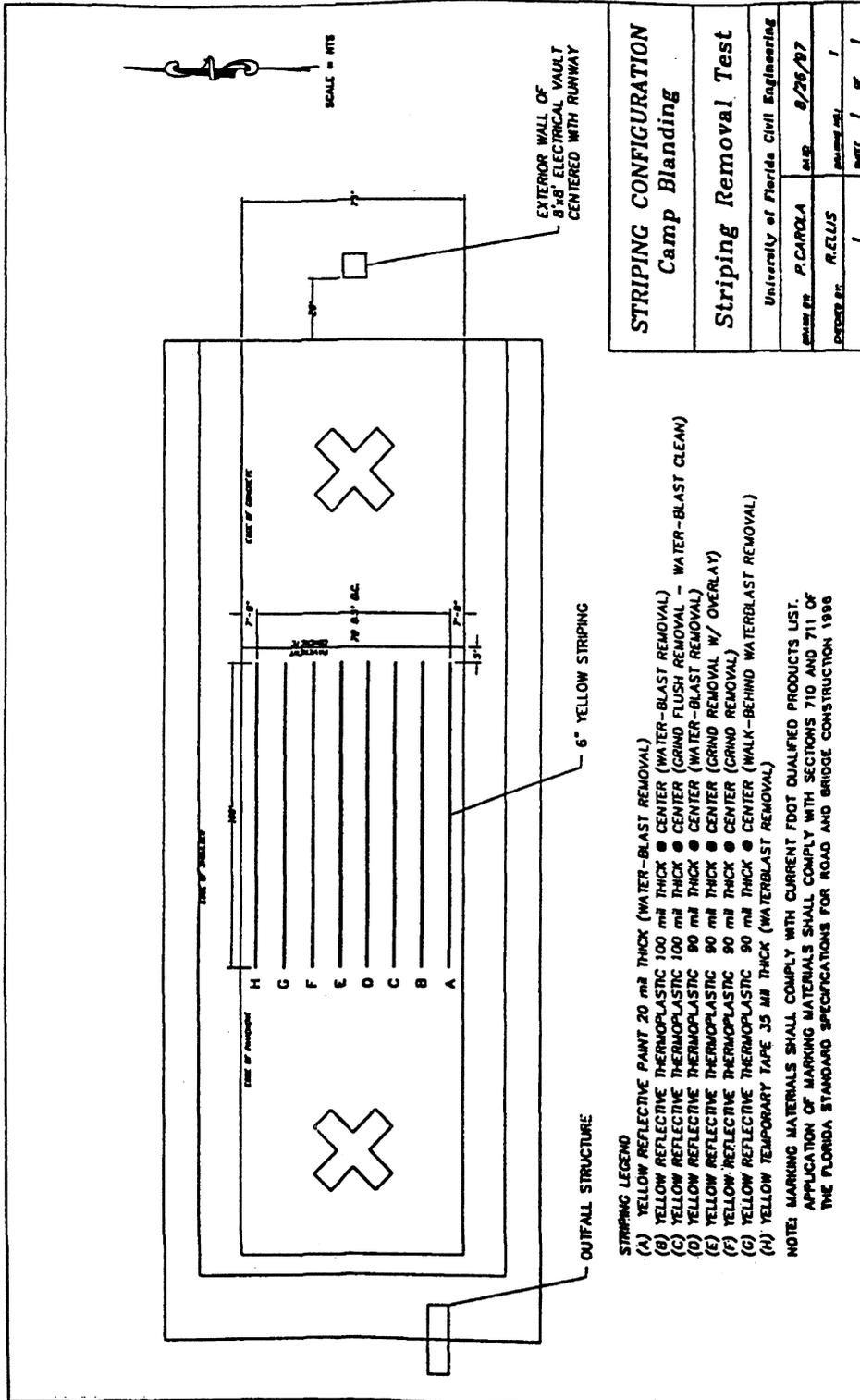
# Appendix

# Site Location

## LOCATION OF CAMP BLANDING ON SEGMENT OF FLORIDA MAP



[Return to the ISU Home Page](#)



**STRIPING CONFIGURATION**  
Camp Blanding

**Striping Removal Test**

University of Florida Civil Engineering	
DESIGNED BY: P. CAROLA	DATE: 8/26/97
CHECKED BY: R. ELLIS	SCALE: 1" = 1'
DATE: 1	SHEET: 1 OF 1

- STRIPING LEGEND**
- (A) YELLOW REFLECTIVE PAINT 20 MI THICK (WATER-BLAST REMOVAL)
  - (B) YELLOW REFLECTIVE THERMOPLASTIC 100 MI THICK ● CENTER (WATER-BLAST REMOVAL)
  - (C) YELLOW REFLECTIVE THERMOPLASTIC 100 MI THICK ● CENTER (GRIND FLUSH REMOVAL - WATER-BLAST CLEAN)
  - (D) YELLOW REFLECTIVE THERMOPLASTIC 90 MI THICK ● CENTER (WATER-BLAST REMOVAL)
  - (E) YELLOW REFLECTIVE THERMOPLASTIC 90 MI THICK ● CENTER (GRIND REMOVAL W/ OVERLAY)
  - (F) YELLOW REFLECTIVE THERMOPLASTIC 90 MI THICK ● CENTER (GRIND REMOVAL)
  - (G) YELLOW REFLECTIVE THERMOPLASTIC 90 MI THICK ● CENTER (WALK-BEHIND WATERBLAST REMOVAL)
  - (H) YELLOW TEMPORARY TAPE 35 MI THICK (WATERBLAST REMOVAL)

NOTE: MARKING MATERIALS SHALL COMPLY WITH CURRENT FDOT QUALIFIED PRODUCTS LIST.  
APPLICATION OF MARKING MATERIALS SHALL COMPLY WITH SECTIONS 710 AND 711 OF THE FLORIDA STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION 1996

# Marking Material Test Data

303-02

FLORIDA DEPARTMENT OF TRANSPORTATION  
TEST REPORT FOR GLASS SPHERES-NOT PRETESTED

PAGE 1  
DATE: 7/07/97

CQR0137

PROJECT NO: 99902-5000 W.P.NO: 2369990 46  
MATERIAL NO: 795A SAMPLE NO: A0168 DATE SAMPLED: 07/01/97  
STATION FROM: N/A STATION TO: SAMPLE FROM: JENKINS  
ROADWAY SIDE: C OFFSET DIST.: 000.0 LF OFFSET DIR  
MAINLINE FLAG: Y REFERENCE LINE: BEADS 70306-D  
LAB NO: 23604 TESTED BY: 8C CN: 07/07/97 PASS/FAIL STATUS: P

DISTRICT: 2 CONTRACT: N/A ROAD NO: N/A  
SOURCE: N/A PLANT NO: QUANTITY: 44,000.00 LB  
PRODUCER: INTENDED USE: PAVEMENT MARKINGS.

QUAL	TYPE OF TEST/MEASUREMENT	RESULT	MINIMUM	MAXIMUM
	PASSING 20 MESH	100.0000 PCT		100.0000
	PASSING 30 MESH	83.0000 PCT	75.0000	95.0000
	PASSING 50 MESH	31.0000 PCT	15.0000	35.0000
	PASSING 100 MESH	0.3000 PCT		5.0000
	RETAINED 30 ROUND	80.0000 PCT	70.0000	
	RETAINED 50 ROUND	76.0000 PCT	70.0000	
	RETAINED 100 ROUND	87.0000 PCT	70.0000	
	OVERALL ROUNDNESS	81.0000 PCT	70.0000	
	LOT NO.	70306D		
	SUBMITTED BY	J E JOHNSON		

FLORIDA DEPARTMENT OF TRANSPORTATION  
TEST REPORT FOR THERMOPLAST COMP-NO PRETEST

PAGE 1  
DATE: 9/10/97

PROJECT NO: 99902-5000 W.P.NO: 2369990 46  
MATERIAL NO: 350A SAMPLE NO: A0403 DATE SAMPLED: 08/29/97  
STATION FROM: N/A STATION TO: SAMPLE FROM: JENKINS  
ROADWAY SIDE: C OFFSET DIST.: 000.0 LF OFFSET DIR.:  
MAINLINE FLAG: Y REFERENCE LINE: BATCH NO. 70710-7  
LAB NO: 24037C TESTED BY: 8C CN 09/08/97 PASS/FAIL STATUS: P

DISTRICT: 2 CONTRACT: N/A ROAD NO: N/A  
SOURCE: N/A PLANT NO: QUANTITY: 44,000.00 LB  
PRODUCER: INTENDED USE: PAVT MARKINGS

QUAL	TYPE OF TEST/MEASUREMENT	RESULT	MINIMUM	MAXIMUM
	GLASS SPHERES	40.0000 PCT	35.0000	
	TRUE SPHERES	79.0000 PCT	70.0000	
	SOFTENING POINT	109	90.0000	
	MILL ANALYSIS	ACCEPTED	1.0000	
	BATCH NO.	70710-7		
	WHITE	YELLOW		
	RM	CHROMATICITY		
	RM	29010-3553	55020-3530	
	RM	28530-3602		
	RM	JE JOHNSON	SC 881 3758	
	CC	SMO CHEM LAB		

Florida Method of Test  
for  
Traffic Striping Field Test

Designation: 5-541

1. SCOPE

- 1.1 This method delineates a field service test for evaluating the performance of the following materials: thermoplastic, hot spray thermoplastic, preformed materials for pavement stripes, fast dry traffic paint - water borne, and two component reactive materials for traffic stripes.

NOTE: The values stated in SI units are to be regarded as the standard. The values in parentheses are for information only.

2. THERMOPLASTIC AND HOT SPRAY THERMOPLASTIC

2.1 Equipment:

- 2.1.1 Application equipment per Section 711-3.
- 2.1.2 Miro-Lux Reflectometer or equivalent.
- 2.1.3 BYK Gardner Handy Color Colorimeter or equivalent.
- 2.1.4 Micrometer or vernier calipers.
- 2.1.5 Stopwatch (0 to 60 sec outer dial, 0 to 30 min inner dial).
- 2.1.6 Tinned Panels (30-31 gage, 150 x 250 mm (6.0 x 10.0 in)) or duct tape.
- 2.1.7 10x magnifier (6.45 mm<sup>2</sup> (1.0 in<sup>2</sup>) field of view).
- 2.1.8 Calibrated glass sphere application bucket.

2.2 Material Quantities

2.2.1 Qualified Products List (QPL) Evaluation.

2.2.1.1 White: 210 kg (475 lb).

2.2.1.2 Yellow: 210 kg (475 lb).

2.2.2 Project Evaluation: As specified.

2.3 Roadway Type

2.3.1 QPL Evaluation - asphaltic concrete.

2.3.2 Project Evaluation - As specified.

2.4 Average Daily Traffic Count (ADT)

2.4.1 QPL Evaluation - 8,000 to 12,000 vehicles per lane.

2.4.2 Project Evaluation - As specified.

2.5 Test Section Length Per Sample.

2.5.1 QPL Evaluation - 1.0 km (0.6 mi).

2.5.2 Project Evaluation - As specified.

2.6 Application: For QPL evaluation, the thermoplastic and/or hot spray thermoplastic test samples (white and yellow) shall be applied as centerline skip lines per the requirements of Section 711. For project evaluation, the thermoplastic and/or hot spray thermoplastic shall be applied as per the project specifications. Written recommendations per the Manufacturer, not in conflict with the aforementioned provisions, shall also apply. Measure the ambient air and pavement surface temperature prior to application. An infrared temperature gun shall be used to determine the temperature of the thermoplastic as it exits the application apparatus. Determine the set to bear traffic time during application of the beaded lines. The set to bear traffic time shall be defined as the minimum elapsed time required to meet the following condition: after driving over the line in a simulated passing maneuver, with a passenger car at a speed of 40 to 55 km/h (25 to 35 mph), there shall be no visual deposition of the striping material to the pavement surface when viewed from a distance of 15 m (15 ft).

2.7 Evaluation: Failure during the test period in any category of evaluation shall constitute reason for rejection of the material. In the case of QPL evaluation, rejection of a material shall result in termination of the test.

2.7.1 Test Duration: The stripes shall be evaluated during a traffic exposure period according to the following time table:

Thermoplastic:

- a. Initial: Within fourteen days of application.
- b. Intermittent: At the discretion of the Department.
- c. Final: 3 years  $\pm$  2 weeks after application.

Hot Spray Thermoplastic:

- a. Initial: Within fourteen days of application.
- b. Intermittent: At the discretion of the Department.
- c. Final: 1 year  $\pm$  2 weeks after application.

2.7.2 Thickness: Stripe thickness shall be measured using a micrometer or vernier calipers. The measurement of stripe thickness shall be accomplished by placing duct tape or tinned panels of known uniform thickness in the area to be striped. After striping, the sample is removed from the pavement and measured for thickness with a proper correction for the tinned panel or duct tape. Thickness checks shall be made at the beginning, middle and end of the first one kilometer lot. Additional random thickness checks shall be taken at the discretion of the Department. The thickness for a kilometer lot shall be the average of all measurements taken within the one kilometer lot. Thickness shall meet the requirements of Section 711-4.2 or as specified.

- 2.7.3 Glass Spheres: Glass sphere application shall meet the requirements of Section 711-4.3. Measure the glass sphere application rate utilizing the calibrated bucket and stopwatch. For initial evaluation only, measure glass sphere embedment employing 10X magnification. Glass sphere application checks shall be made at the beginning, middle and end of the first one kilometer lot. Additional random glass sphere application checks shall be taken at the discretion of the Department. The glass sphere application for a kilometer lot shall be the average of all measurements taken within the one kilometer lot.
- 2.7.3 Retroreflectivity: The retroreflectivity shall be measured with a Miro-Lux 12 retroreflectometer or equivalent. For QPL evaluation, the retroreflectivity shall be the average of 10 random skip line measurements (one measurement per skip line) per test section. For project evaluation, retroreflectivity measurements shall be made at the beginning, middle and end of the first one kilometer lot. Additional random retroreflectivity measurements shall be taken at the discretion of the Department. The retroreflectivity measurements for a kilometer lot shall be the average of all measurements taken within the one kilometer lot.
- 2.7.4 Color: The daytime reflectance and chromaticity shall be measured with a BYK Gardner Handy Color Colorimeter or equivalent in accordance with ASTM E 1347. The instrument shall be set to read X, Y, and Z coordinates with 45/0 bidirectional geometry, observer angle of 2°, and illuminant C. Perform calibration in accordance with the instrument manufacturer's recommendations. After calibrating, measure a Federal Test Standard Number 595-color 33538. Ensure location on stripe to be measured is free from dirt, grease, oil, tire marks, or other foreign matter. Use a broom to gently brush away any loose debris. Avoid the removal of glass spheres. A clean cloth dampened with water may be used to gently clean the material. Do not use solvents. Ensure the stripe is completely dry before taking a measurement. For QPL evaluation, the day time reflectance and chromaticity shall be the average of 10 random skip line measurements (one measurement per skip line) per test section. For project evaluation, color measurements shall be made at the beginning, middle and end of the first one kilometer lot. Additional random color measurements shall be taken at the discretion of the Department. The color measurements for a kilometer lot shall be the average of all measurements taken within the one kilometer lot.
- 2.7.5 Durability: For QPL evaluation, 10 random skip lines shall be measured for the percent of striping material completely removed from the pavement or pre-existing stripe. For project evaluation, durability measurements shall be made at the beginning, middle and end of the first one kilometer lot. Additional random durability measurements shall be taken at the discretion of the Department. The durability measurements for a kilometer lot shall be the average of all measurements taken within the one kilometer lot.

### 3. PREFORMED MATERIALS FOR TRAFFIC STRIPES

#### 3.1 Equipment

- 3.1.1 Application equipment per Section 711-3.
- 3.1.2 Miro-Lux Reflectometer or equivalent.
- 3.1.3 BYK Gardner Handy Color Colorimeter or equivalent.
- 3.1.4 Micrometer or vernier calipers.
- 3.1.5 10x magnifier (6.45 mm<sup>2</sup> (1.0 in<sup>2</sup>) field of view).

#### 3.2 Material Quantities:

##### 3.2.1 Qualified Products List (QPL) Evaluation.

- 3.2.1.1 White: 250 linear meters.
- 3.2.1.2 Yellow: 250 linear meters.

##### 3.2.2 Project Evaluation: As specified.

#### 3.3 Roadway Type: per 2.3.

#### 3.4 Average Daily Traffic Count (ADT): Per 2.4.

#### 3.5 Test Section Length Per Sample: Per 2.5.

#### 3.6 Application: For QPL evaluation, the preformed material samples (white and yellow) shall be applied as centerline skip lines per the requirements of the most current FDOT Standard Specifications for Road and Bridge Construction. For project evaluation, the preformed material shall be applied as per the project specifications. Written recommendations per the Manufacturer, not in conflict with the aforementioned provisions, shall also apply. Measure the ambient air and pavement surface temperature before application.

#### 3.7 Evaluation: Per 2.7.1.

##### 3.7.1 Test Duration: The stripes shall be evaluated during a traffic exposure period according to the following time table:

- a. Initial: Within fourteen days of application.
- b. Intermittent: At the discretion of the Department.
- c. Final: 3 years ± 2 weeks after application.

##### 3.7.2 Thickness: Stripe thickness shall be measured using a micrometer or vernier calipers. Thickness checks shall be made at the beginning, middle and end of the first one kilometer lot. Additional random thickness checks shall be taken at the discretion of the Department. The thickness for a kilometer lot shall be the average of all measurements taken within the one kilometer lot. Thickness shall meet the requirements of Section 711-4.2 or as specified.

##### 3.7.3 Glass Spheres: Per 2.7.3.

3.7.4 Retroreflectivity: Per 2.7.4.

3.7.5 Chromaticity: Per 2.7.5.

3.7.6 Durability: Per 2.7.6.

4. FAST DRY TRAFFIC PAINT - WATER BORNE.

4.1 Equipment

4.1.1 Standard application apparatus.

4.1.2 Miro-Lux Reflectometer or equivalent.

4.1.3 BYX Gardner Handy Color Colorimeter or equivalent.

4.1.4 Paint Wet Film Thickness Gage, 1  $\mu\text{m}$  increments up to 350  $\mu\text{m}$  (1.0 mil up to 12 mil), 1  $\mu\text{m}$  increments from 350  $\mu\text{m}$  to 800  $\mu\text{m}$  (2.0 mil increments from 12.0 mil to 30.0 mil).

4.1.6 Stopwatch (0 to 60 sec outer dial, 0 to 30 min inner dial).

4.1.7 Tinned Panels (30-31 gage, 150 x 250 mm (6.0 x 10.0 in)).

4.1.9 10x magnifier (6.45 mm<sup>2</sup> (1.0 in<sup>2</sup>) field of view).

4.1.18 Calibrated glass sphere application bucket.

4.2 Material Quantities

4.2.1 Qualified Products List (QPL) Evaluation.

4.2.1.1 White: 190 L (50 gal).

4.2.1.2 Yellow: 190 L (50 gal).

4.2.2 Project Evaluation: As specified.

4.3 Roadway Type: per 2.3.

4.4 Average Daily Traffic Count (ADT): per 2.4.

4.5 Test Section Length Per Sample: per 2.5.

4.6 Application: For QPL evaluation, the traffic paint test samples (white and yellow) shall be applied as centerline skip lines per the requirements of the most current FDOT Standard Specifications for Road and Bridge Construction. Three skip lines shall be applied without drop-on glass beads. Each non-beaded skip line shall be separated by fifteen consecutive beaded skip lines. For project evaluation, the traffic paint shall be applied as per the project specifications. Written recommendations per the Manufacturer, not in conflict with the aforementioned provisions, shall also apply. Measure the ambient air and pavement surface temperature before application. The measurement of stripe thickness shall be accomplished by placing tinned panels of known uniform thickness in the area to be striped (non-beaded only). After striping, the sample is immediately removed from the pavement and measured for thickness with a paint wet film thickness gage. Thickness checks shall be made at the beginning, middle and end of the first one kilometer lot. Additional random thickness checks shall be taken at the discretion of the Department. The thickness for a kilometer lot

shall be the average of all measurements taken within the one kilometer lot. Determine the set to bear traffic time during application of the beaded lines. The set to bear traffic time shall be defined as the minimum elapsed time required to meet the following condition: after driving over the line in a simulated passing maneuver, with a passenger car at a speed of 40 to 55 km/h (25 to 35 mph), there shall be no visual deposition of the striping material to the pavement surface when viewed from a distance of 15 m. (15 ft).

4.7 Evaluation: Per 2.7.

4.7.1 Test Duration: The stripes shall be evaluated during a traffic exposure period according to the following time table:

- a. Initial: Within fourteen days of application.
- b. Intermittent: At the discretion of the Department.
- c. Final: 6 months after application.

4.7.2 Glass Spheres: Per 2.7.3.

4.7.3 Retroreflectivity: Per 2.7.4.

4.7.4 Chromaticity: Per 2.7.5.

4.7.5 Durability: Per 2.7.6.

5. TWO COMPONENT REACTIVE MATERIALS FOR TRAFFIC STRIPES.

5.1 Equipment

- 5.1.1 Standard Application Apparati.
- 5.1.2 Miro-Lux Reflectometer or equivalent.
- 5.1.3 BYK Gardner Handy Color Colorimeter or equivalent.
- 5.1.4 Paint Wet Film Thickness Gage, 1  $\mu\text{m}$  increments up to 350  $\mu\text{m}$  (1.0 mil up to 12 mil), 1  $\mu\text{m}$  increments from 350  $\mu\text{m}$  to 800  $\mu\text{m}$  (2.0 mil increments from 12.0 mil to 30.0 mil).
- 5.1.5 Glass bead catch bag.
- 5.1.6 Stopwatch (0 to 60 sec outer dial, 0 to 30 min inner dial).
- 5.1.7 Tinned Panels (30-31 gage, 150 x 250 mm (6.0 x 10.0 in)).
- 5.1.9 10x magnifier (6.45 mm<sup>2</sup> (1.0 in<sup>2</sup>) field of view).
- 5.1.18 Calibrated glass sphere application bucket.

5.2 Material Quantities

5.2.1 Qualified Products List-(QPL) Evaluation.

- 5.2.1.1 White: 190 L (50 gal) with required catalyst.
- 5.2.1.2 Yellow: 190 L (50 gal) with required catalyst.

5.2.2 Project Evaluation: As specified.

Table One. Chromaticity and 15 Meter Retroreflectivity Measurements.

Line Material	Measurement	Units	Data Point 1 Near Line Beginning	Data Point 2 Near Line Middle	Data Point 3 Near Line End	Measurement Mean
Thermo Tape	Chromaticity	(unitless)	x= .4908 y= .4489	x= .4839 y= .4504	x= .4817 y= .4451	x= .4855 y= .4481
Thermo Tape	Retroreflectivity	(mcd/m <sup>2</sup> /lux)	284	319	309	304
Thermoplastic	Chromaticity	(unitless)	x= .4536 y= .4306	x= .4518 y= .4300	x= .4540 y= .4272	x= .4531 y= .4293
Thermoplastic	Retroreflectivity	(mcd/m <sup>2</sup> /lux)	190	183	205	193
Paint	Chromaticity	(unitless)	x= .4644 y= .4359	x= .4550 y= .4112	x= .4614 y= .4415	x= .4603 y= .4415
Paint	Retroreflectivity	(mcd/m <sup>2</sup> /lux)	186	192	190	189

Note 1: All materials are yellow, and have been installed on FC2 asphaltic cement.

Note 2: Drop on beads were present on yellow Thermoplastic and Paint lines.

Note 3: Retroreflectivity is taken at a 15 meter geometry using a Mirolux 12 portable unit.

Note 4: Chromaticity is taken with a "C" illuminant using a BYK portable color meter.

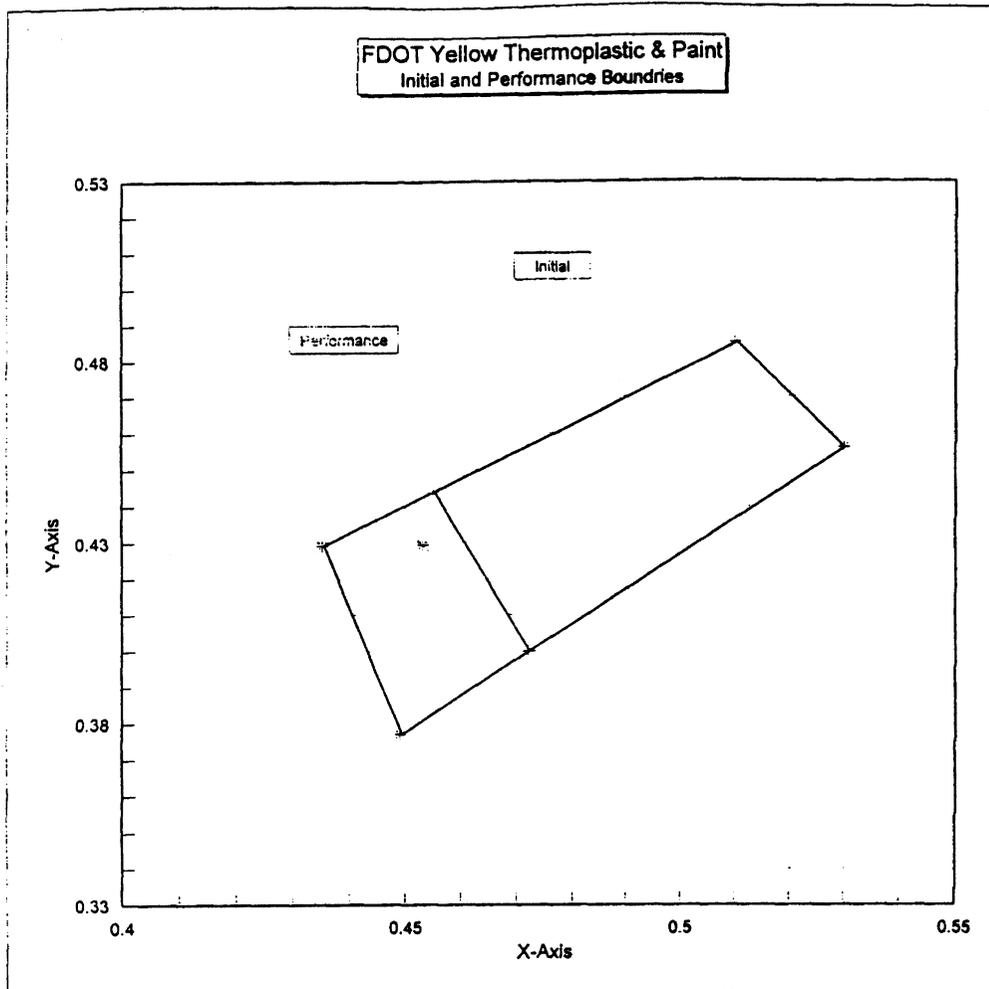


Figure - Yellow Thermo & Paint 97 (After August 1, Initial Color Box Day 1 thru Wk 2, Performance > Wk 2)

Table 97 - Yellow Thermoplastic and Paint, Chromaticity Test Results. August 1997

YELLOW	COORDINATE VALUES	
	x	y
Regulatory Value No. 1	0.4550	0.4440
Regulatory Value No. 2	0.5100	0.4850
Regulatory Value No. 3	0.4720	0.4000
Regulatory Value No. 4	0.5300	0.4560
Regulatory Value No. 5	0.4350	0.4290
Regulatory Value No. 6	0.4490	0.3770
Mean Of Three Tests	0.4531	0.4293
Test # 1	0.4536	0.4306
Test # 2	0.4518	0.4360
Test # 3	0.4540	0.4272

Notes: Tests results requested by UF School of Civil Engineering involve field testing of physical parameters for a test section. Material is a yellow thermoplastic with drop on beads installed on FC2 Asphaltic Cement. Testing was performed using a FDOT BYK portable chromaticity instrument on 11-5-97.

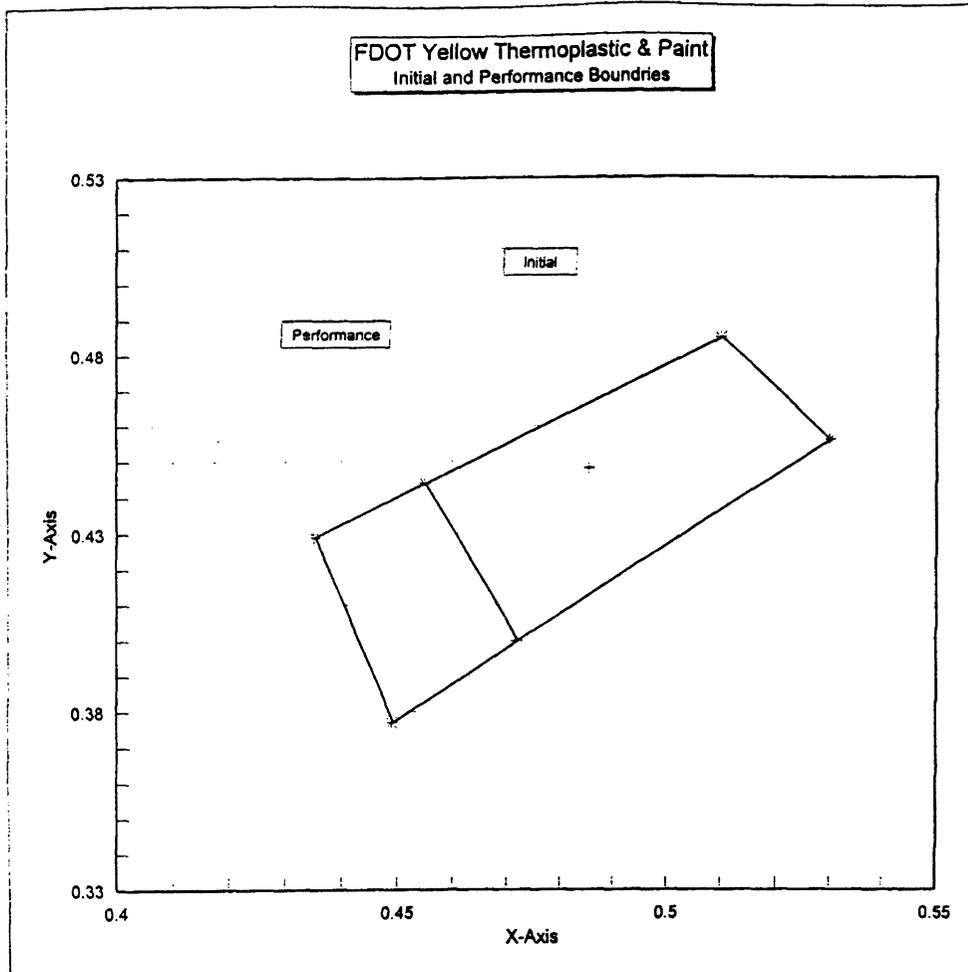


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Regulatory Value No. 4	0.5300	0.4560
Regulatory Value No. 5	0.4350	0.4290
Regulatory Value No. 6	0.4490	0.3770
Mean Of Three Tests	0.4855	0.4481
Test # 1	0.4908	0.4480
Test # 2	0.4839	0.4504
Test # 3	0.4877	0.4455

Notes: Tests results requested by UF School of Civil Engineering involve field testing of physical parameters for a test section. Material is 3M yellow thermoplastic tape installed on FC2 Asphaltic Cement. Testing was performed using a FDOT BYK portable chromaticity instrument on 11-5-97.

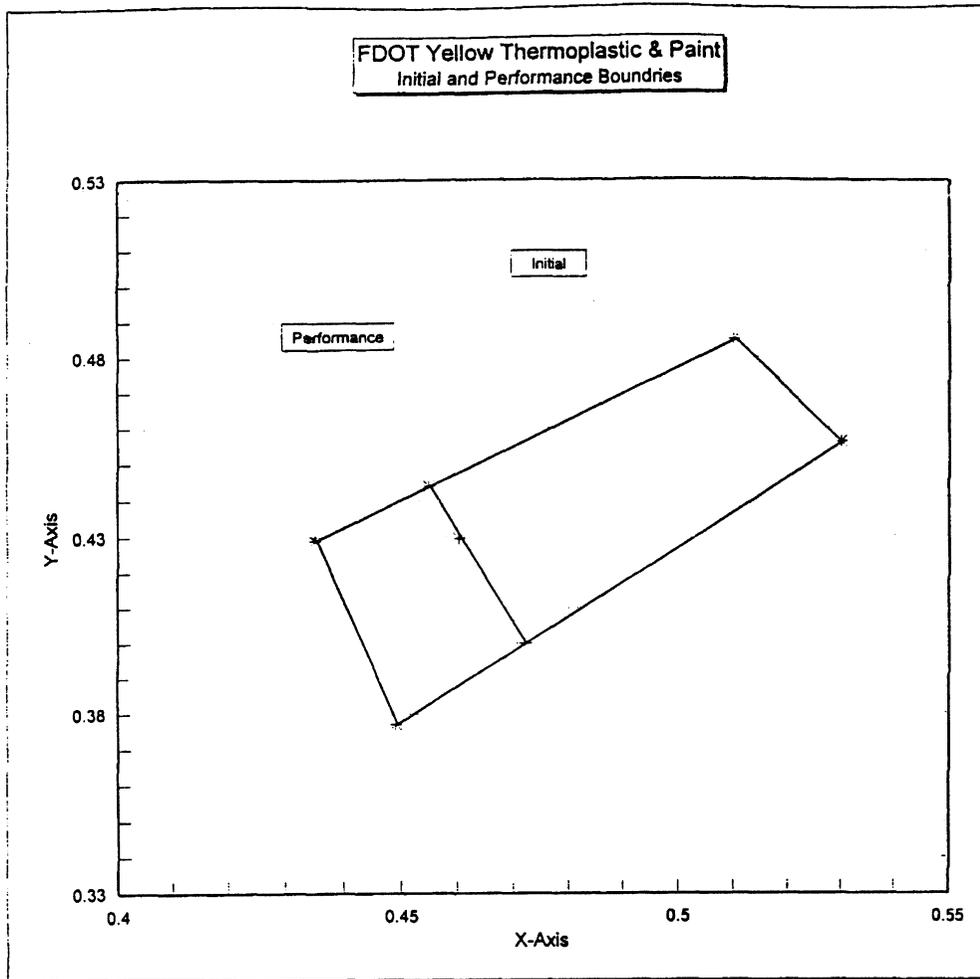


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Regulatory Value No. 3	0.4720	0.4000
Regulatory Value No. 4	0.5300	0.4560
Regulatory Value No. 5	0.4350	0.4290
Regulatory Value No. 6	0.4490	0.3770
Mean Of Three Tests	0.4603	0.4295
Test # 1	0.4644	0.4359
Test # 2	0.4550	0.4112
Test # 3	0.4672	0.4245

Notes: Tests results requested by UF School of Civil Engineering involve field testing of physical parameters for a test section. Material is a yellow paint stripe with drop on beads installed on FC2 Asphaltic Cement. Testing was performed using a FDOT BYK portable chromaticity instrument on 11-5-97.



## SAFETY COATINGS, INC.

P. O. Box 399 • FOLEY, AL 36536 • PHONE (334) 943-1638 • FAX 943-3689

### C E R T I F I C A T I O N

WE, SAFETY COATINGS, INC., DO CERTIFY THAT THE 1,925 GALLONS OF BATCH NO. 09724, WHITE, AND THE 1,375 GALLONS OF BATCH NO. 09719, YELLOW, LEAD-FREE WATERBORNE, FLORIDA FAST DRY, THAT WE MANUFACTURE MEETS FLORIDA D.O.T. SPECIFICATION 971-019 AND HAS BEEN FOUND TO CONFORM IN ALL RESPECTS. THESE PAINTS CONTAIN LESS THAN 0.15 PPM LEAD AND HAVE LESS THAN 120 GMS/LITER V.O.C.

THE ABOVE MATERIALS WERE SOLD TO JENKINS PAINTING, INC. OF CHIEFLAND, FLORIDA, TO BE USED ON VARIOUS JOBS.

SAFETY COATINGS, INC.

JANAY I. STUCKEY  
DIR SALES / CUST RELATIONS

SWORN TO AND SUBSCRIBED BEFORE ME THIS

1st DAY OF OCTOBER, 1997.

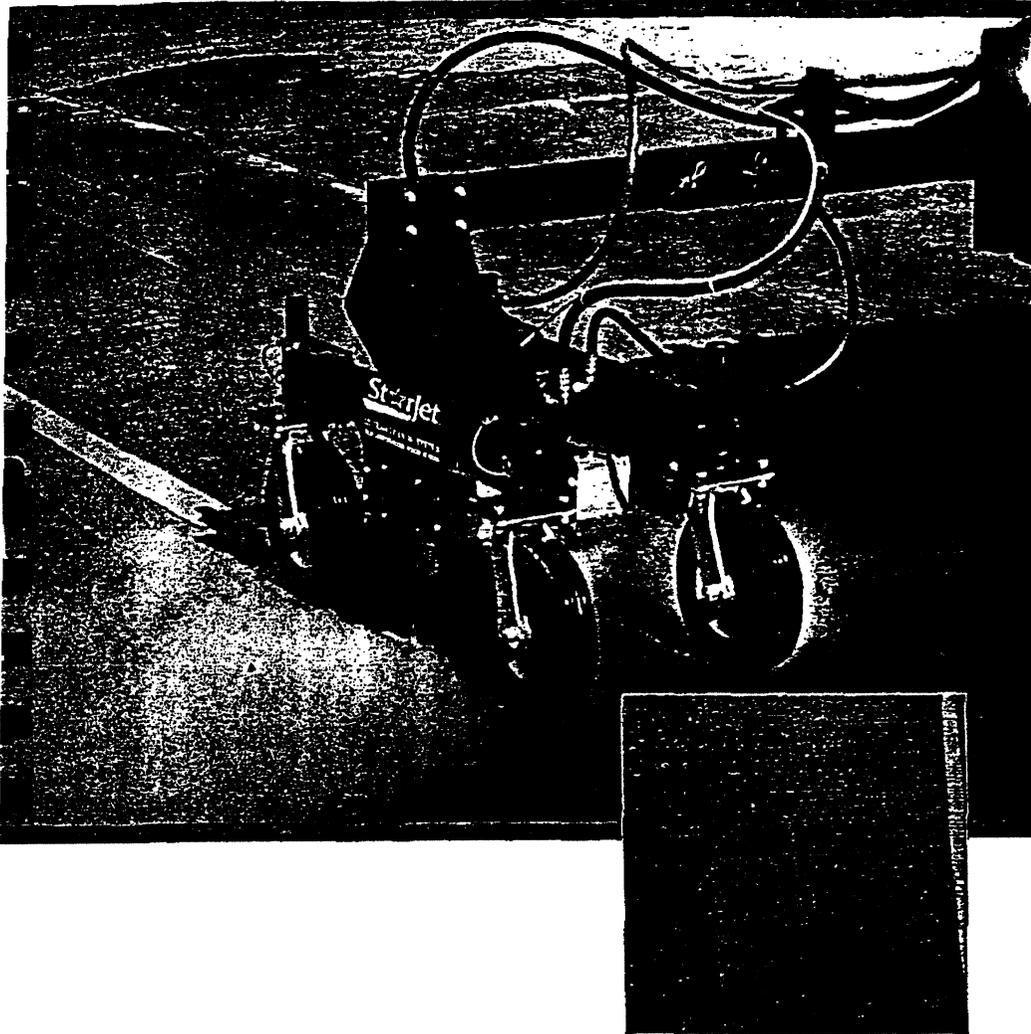
NOTARY PUBLIC  
STATE OF ALABAMA AT LARGE

MY COMMISSION EXPIRES JANUARY 30, 1999.

# Water Blasting Equipment Specifications

*Starjet*

**Stripe Removal System Takes Off  
Pavement Marking Without Damage**



**NLB Corp.**

*The Leader in High-Pressure Water Jet Technology*

# WITH STARJET™ STRIPES JUST DISAPPEAR



All STARJET™ system operating controls (above) are conveniently located in the truck cab.

Now there's a mobile ultra-high pressure water jet system that removes painted stripes and coatings from highways and parking decks in just minutes.

The STARJET™ system from NLB Corp. makes short work of permanent or temporary stripes... even thermal material. It won't damage concrete or asphalt, because it uses nothing but 36,000 psi (84 bar) water.

The patented STARJET™ assembly features a series of rotating water jet nozzles in an eight-inch-meter star pattern. Nozzle size and placement can be adjusted to achieve a blended pattern, no matter what the compressive strength of the surface. The assembly mounts to the front of a truck and can be positioned to the right or left of the vehicle to remove stripes as the truck is driven. Removal rates vary with the type of marking to be removed and the surface involved, but rates of up to 7,000 linear feet (34 m) per hour have been achieved.

The ultra-high pressure water for the STARJET™ unit is provided by an NLB ULTRA-CLEAN 36<sup>®</sup> pump, mounted on the truck bed. The pump is rated up to 36,000 psi and 6 gpm (2,500 bar and 22.7 lpm). The truck pulls a 1,625-gallon (6,150 l) tank trailer, which supplies water to the pump via a transfer pump. A second water tank is recommended to ensure a continuous water supply.

In addition to the standard drive train, the truck features a hydraulic pump and motor drive — supplied by NLB — to assure smooth, consistent speed control from zero to 2 mph. This also controls the STARJET™ system's rotating speed, lowers the assembly to the road to begin work, and lifts it for normal truck travel. All operating controls are located in the cab for maximum convenience (see photo). Controls and instrumentation include:

- Digital readout and adjustment of truck speed
- Digital readout and adjustment of STARJET™ nozzle rotating speed
- Start/Stop of STARJET™ nozzle rotation
- Digital readout of pump pressure
- Pump engagement and disengagement
- PTO/Hydraulic system engage and disengage
- Hydraulic truck drive clutch engage and disengage



## FEATURES AND SPECIFICATIONS

### NOZZLE

- Stainless steel rotating seal with up to 15 nozzle outlets
- Hydraulically driven; speed variable to 3,000 rpm
- Closed-loop proportional speed control

### NOZZLE ASSEMBLY

- 12"-diameter (0.4 cm) steel housing with discharge outlet
- Height adjustable to 17" (43 cm)
- Four-wheel assembly simplifies stripe removal near curbs and gutters
- Unit easily swings to right or left of truck
- Assembly is hydraulically raised for transport and lowered for operation

### WATER TANK TRAILER

- 1,625-gallon (6,150 l) capacity
- Electric brakes
- Emergency breakaway brakes with integral battery

### TRUCK DRIVE

- Hydraulic, with variable-speed of 0-2 mph (3.2 km/h) via closed-loop proportional control
- Dual output/2-speed
- Air-operated, in-line clutch rear axle

### HYDRAULIC SYSTEM

- Powers truck drive, nozzle assembly lift, nozzle rotation, and transfer pump drive
- Pressure-compensated piston pump rated at 31 gpm, 3,000 psi max. (117 lpm, 200 bar)
- Water-cooled heat exchanger
- 200-gallon (750 l) reservoir
- Block-mounted hydraulic valves

*NOTE: For pump specifications and mounting details, please consult ULTRA-CLEAN 36° system data sheet.*

### OPTIONAL ACCESSORIES

- Dual-lance capability
- SPIN JET® spray bar installed on a four-wheeled, manually pushed stripe remover for small areas or locations not accessible by truck

