Inlaid Traffic Lane Lines

I-90, Edgewick Road to Hyak

WA-RD 184.1

Post Construction/Annual Report
May 1989

Washington State Department of Transportation
Planning, Research and Public Transportation Division

in cooperation with the
United States Department of Transportation
Federal Highway Administration

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

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16. ABSTRACT

Three types of stripping materials installed in recessed grooves are evaluated for reflectivity and durability. Initial performance evaluations have two of the materials showing very little wear and providing good daytime delineation but marginal nighttime delineation. The other material is showing considerable damage in the form of cracking and spalling and is providing good nighttime delineation but only marginal daytime delineation due to the loss of material.

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INLAID TRAFFIC LANE LINES

I-90, Edgewick Road to Hyak

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POST CONSTRUCTION/ANNUAL REPORT
EXPERIMENTAL FEATURE WA 86-13

Prepared for
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Federal Highway Administration

May 1989

DISCLAIMER

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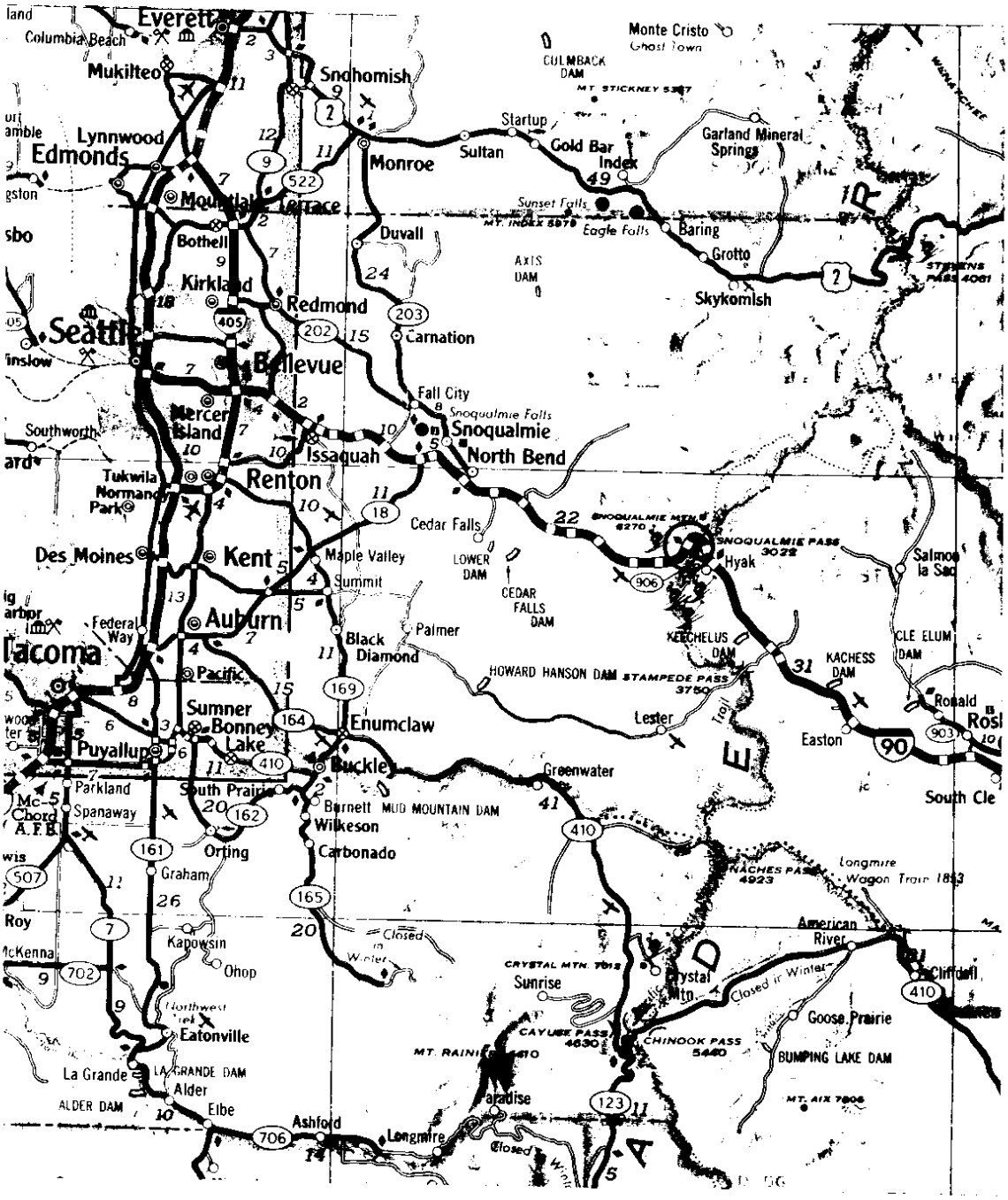


INTRODUCTION

Three types of striping materials were installed in recessed grooves in the PCC pavement in the Snoqualmie Pass vicinity of I-90 in the summer of 1986. The inlaid stripes were one of the items in a contract which also called for the installation of snowplowable lane markers in recessed grooves. The purpose of both the inlaid stripes and the lane markers was to provide a more permanent lane delineation system then painted stripes. This report addresses only the evaluation of the inlaid lane lines.

BACKGROUND

On the Snoqualmie Pass section of I-90 it is not uncommon for the painted stripes to be completely missing during the winter months as a result of wear from snowplows, vehicles equipped with chains and studded tires, and vehicles running on sanded roadways. A more permanent lane delineation system was needed, especially during the winter months with its dark, rainy nights. Past studies have shown that various forms of striping materials can survive when placed in recessed grooves, but that bead retention and reflectivity were major unsolved problems ("Permanent Lane Markings - Recessed Lane Edge Stripe", K.W. Anderson, WA-RD 46.1, July 1981).

PRODUCT SELECTION

The three products selected to be evaluated were; (1) Concresive 1170, a white pigmented epoxy supplied by Adhesive Engineering Company, (2) Lafrentz System 400, a methyl methacrylate supplied by Lafrentz Road Services Ltd., and (3) Norline Hot Thermoplastic supplied by Norris Paint Company, Inc. The first two products were specified in the contract, the last was selected by the contractor from a list of approved products provided in the contract plans.

TEST SECTIONS

Two separate test sections were setup for each type of striping material. The sections, one 2376 feet long and the other 422 feet long, consisted of the three lane divider stripes in the eastbound direction. Each material was installed in areas of equal length in each of the sections, as shown in Figure 1. A fourth section, 1478 feet long and consisting of one lane divider stripe located where I-90 becomes 5 lanes, was left empty for future product studies.

INSTALLATION

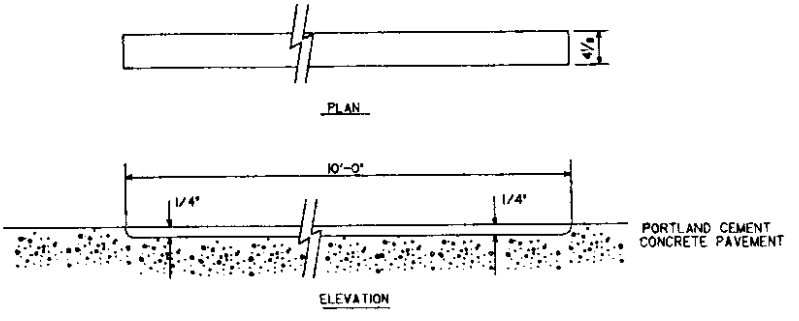
Grinding

A concrete saw with a 65 horsepower engine was used to cut the 10 foot long by 4 inch wide by 1/4 inch deep grooves (see Figure 1). The hardness of the aggregate in the pavement forced the contractor to experiment with several brands of blades before satisfactory production was achieved. The grooves were flushed with clear water and blown clean with compressed air prior to any installation of materials.

Milepost

50.63	51.08	51.53	51.98	52.06	52.14	52.22
TYPE A	TYPE B	TYPE C	TYPE A	TYPE B	TYPE C	

TYPE A Concresive 1170 (Epoxy)
TYPE B Lafrentz System 400 (Methyl Methacrylate)
TYPE C Norline (Hot Thermoplastic)



INLAID LANE STRIPE DETAIL

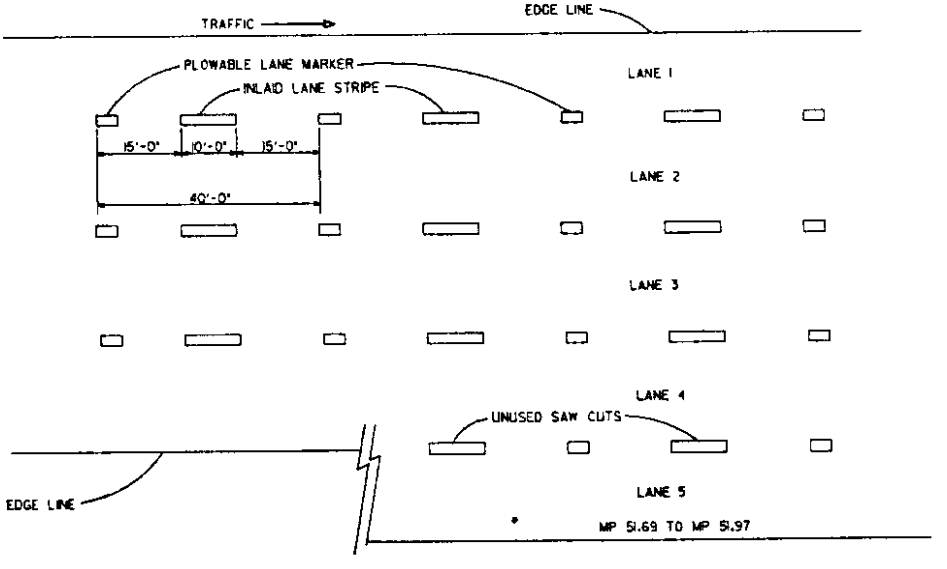


Figure 1. Test section layout and saw cut detail.

Product Application

Concresive 1170 (Type A)

The Concresive epoxy was kept as warm as possible in the cab of a truck prior to mixing. An electric drill was used to mix the two component epoxy with glass beads. The beads were added to provide for reflectivity as the materials wears under traffic. The mixture was then spooned into the grooves by hand and troweled smooth. A final top dressing of glass beads completed the installation.

Lafrentz System 400 (Type B)

The two components which make up the material, the methyl methacrylate resin and hardener, and the benzoyl peroxide catalyst were mixed together in five gallon buckets with an electric drill (the resin contains glass beads). The mixture was poured into a hand propelled applicator which distributed the proper thickness of the material into each groove. The pavement in the groove had been primed with a 3M brand primer just prior to the application. A top dressing of glass beads completed the installation.

Norline Hot Thermoplastic (Type C)

The product was melted in a preheater at 425 degrees before it was poured into a heated, hand propelled applicator. It was also not necessary to add glass beads to this product because they are already in the material as it comes from the supplier. The top dressing of glass beads was applied while the material was still hot. The stripe could be reheated with a propane torch if reworking was necessary.

Problems

Concresive 1170

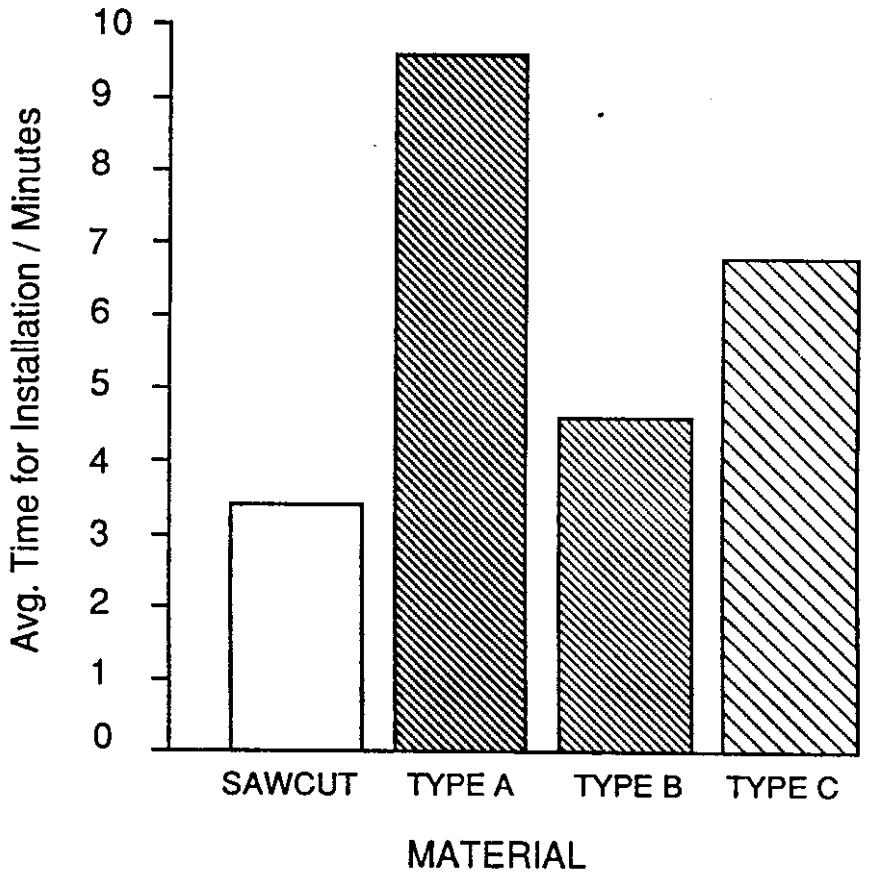
The Concresive stripes took over twice as long to install as the Lafrentz stripes and 1/3 longer then the Norline stripes (see Figure 2) due to the unavailability of mechanized application equipment and a long cure time for the epoxy. The long cure time (3-5 hours at 80 degrees) restricted the Concresive 1170's usage to only the morning hours of the day due to a daylight only lane closure restrictions in the contract. The long cure time also allowed the beads in the mixture to sink to the bottom of the stripe which reduced the reflectivity of the cured inlay. The contractor also had problems with its low viscosity. The material would flow to the down hill end or lower side of the grooves and would have to be repeatedly troweled back into place until it cured enough to set. This troweling disturbed the top surface of the stripe which necessitated a re-application of the top dressing of beads. If the material had already taken a set a "weed burner" would have to be used to heat the inlay before troweling.

Norline Hot Thermoplastic

The Norline material also exhibited the high fluidity problems experienced with the Concresive product, but because of its much faster set time was less of a problem for the contractor.

Lafrentz System 400

Virtually no problems were experienced in the installation of the Lafrentz material. Installation time was the quickest of all three products (see Figure 2).



TYPE A - Concresive (Epoxy)
TYPE B - LaFrentz (Methyl Methacrylate)
TYPE C - Norline (Hot Thermoplastic)

Figure 2. Installation time for each type of stripe.

PERFORMANCE

Initial

All of the products are providing excellent daylight delineation, but during nighttime hours the performance varies. The Lafrentz and the Norline materials have better reflectivity then the Concresive material and are thus providing better nighttime delineation. Some of the inlays were top dressed with a mixture of 50 percent small beads and 50 percent large beads (see Appendix C). The larger beads did not imbed properly in the material and the resultant decrease in reflectivity caused the stripes treated in this manner to take on a "gray" cast rather than the "white" appearance of the stripes top dressed with all small beads.

First Year

Concresive 1170

The Concresive 1170 is showing very good adhesion to the pavement and very little wear. The wear from snowplows, chains and studded tires appears to be shearing off the top layer of glass beads. This shearing action has eliminated the "gray" appearance noted in initial report, but the resultant loss in the reflectivity of these beads has also reduced the nighttime visibility of the stripes. The material is, however, providing very good daytime delineation.

Lafrentz System 400

The Lafrentz material is also showing very good adhesion and very little wear. The shearing action on the top layer of glass beads is also occurring on this product, and due to a lower initial reflectivity, the nighttime visibility of this product is the lowest of all three materials. The product is, however, providing very good daytime delineation.

Norline Hot Thermoplastic

The Norline material has suffered considerable damage during its first six months of service. The stripes began to crack and spall out of the sawcuts almost immediately. The spalled pieces were found to have small voids which extend almost to the upper surface of the material. These voids appear to be caused by moisture in the pavement being pulled to the surface by the heat of the application process. The material which remains in the sawcuts (about an average of 60 percent of each stripe) is wearing just slightly. The softness of this material allows the beads to wear off rather that shear off as in the other two materials which are much harder. The wear exposes more of the glass beads which allows the nighttime reflectivity to remain very good.

CONCLUSIONS

Preliminary conclusions based on the first year of service are as follows:

1. The Concresive and Lafrentz materials are providing very good daytime delineation, but only marginal nighttime delineation.
2. The Norline material is providing good nighttime delineation, but because of a loss of material is not providing as good daytime delineation as the other two products.

RECOMMENDATIONS

It is recommended that a second application of each of the products be done taking advantage of the knowledge gained from the problems encountered on the initial installation. The unused sawcuts adjacent to the present test sections could be used for this installation.

FUTURE EVALUATIONS

The test sections will be monitored for a period of three years with annual reports issued at the end of each year and a final report at the conclusion of the period.

APPENDIX A

PRODUCT INFORMATION

ADHESIVE ENGINEERING COMPANY PRODUCT DATA

CONCRESIVE[R] 1170

DESCRIPTION

Solventless, rigid, moisture insensitive epoxy coating and bonding agent. Designed for protection of concrete and other material from water, corrosion, and chemical attack. Standard color is concrete gray.

FEATURES	BENEFITS
- High build coating	Ability to be applied on both dry and water-saturated surfaces
- Cured surface is tough and tile-like	Which makes it easy to clean
- Outstanding resistance to moisture and many chemicals	Allows use in damp and moderate chemical environments
- Non-shrink, high-strength adhesive	Allows rapid bonding of fresh concrete to existing concrete
- Will bond and cure under wet conditions	Ability to use in "can't dry" environments

TYPICAL APPLICATIONS

- Coating PCC, cinder block, masonry and wood to provide a waterproof, chemical resistant barrier.
- Coating steel for corrosion protection.
- Bonding fresh concrete to existing concrete.
- Bonding concrete, wood, metals, stone, brick and many rigid plastics to themselves or each other.

Technical Bulletin AEMS 255/5
September 1984

[R] Registered Trade Name

PRODUCT INFORMATION[1]

Form: Two component, low viscosity liquid with controlled flow.

Color: Part A - grey, Part B - clear amber, Mixed - concrete grey.

Mix Ratio: 2 parts A to 1 part B by volume.

Density[2], lb/gal (kg/m^3): Part A - 12.6 (1509)
Part B - 8.1 (970)
Mixed - 11.5 (1378)

Viscosity[1], poise (Pa·s): Part A - 40 (4.0)
Part B - 55 (5.5)
Mixed - 45 (4.5)

Standard Packaging: 1 gallon (3.8 dm^3), 3 gallon (11.4 dm^3), 7 1/2 gallon (28.4 dm^3) and 150 gallon (570 dm^3) units.

Shelf Life: 18 months minimum in sealed containers at 90°F (32°C) or below.

TYPICAL PROPERTIES OF CURED MATERIAL[3]

Property	Test Method	Value
Tensile Strength, psi (MPa)	ASTM D638	6,000 (41.3)
Tensile Elongation, %	ASTM D638	2.5
Compressive Yield Strength, psi (MPa)	ASTM D695	7,000 (48.2)
Compressive Modulus, psi (MPa)	ASTM D695	1.10×10^5 (758.3)
Heat Deflection Temperature, °F (°C)	ASTM D648	100 (38)
Impact Resistance, in. lb (J)	Gardner-Direct	20 (2.3)
Flexural Adhesive Strength, psi (MPa)	ASTM C293[4]	
Dry Concrete		>210 (>1.4)
Wet Concrete		>160 (>1.1)
Slant Shear Strength,[5] psi (MPa)	AASHTO T-237	
Dry Concrete		6,000 (41.3)
Water-saturated concrete		5,000 (34.4)
Fresh concrete to cured concrete		4,000 (27.5)

Bolt Pull-Out Strength: 1/2 in. (13 mm) diameter threaded steel bolt embedded in 3/4 in. (19 mm) dia. hole in PCC with Concresive 1170 - Bolt failure at 12,750 lb (56.7 kN) load.

1 Properties listed in this bulletin are typical and descriptive of the product and should not be used for specification purposes
2 At 77°F (25°C)
3 Cured 7 days at 77°F (25°C) and tested at 77°F (25°C).
4 Bonded Broken Beam.
5 Fresh concrete and adhesive cured for 14 days at 77°F (25°C) and tested at 77°F (25°C).

EFFECT OF TEMPERATURE ON CURE

	Material Temperature 50°F (10°C)	77°F (25°C)
Potlife, 1 quart (0.95 dm^3) mass	85 minutes	30 minutes
1 gallon (3.8 dm^3) mass	60 minutes	25 minutes
Thin Film Hard Dry Time	24 hours	6.5 hours
Full Cure Time	14 days	7 days

CHEMICAL RESISTANCE PROPERTIES OF CURED MATERIAL

CONCRESIVE 1170 provides excellent resistance to continuous immersion in sea water, fresh water, detergent, salt solutions, alcohol beverages, gasoline, kerosene, sour crude oil, fuel oil, mineral oil, weak alkali solutions and weak inorganic acids.

It is not recommended for continuous immersion in organic acids, such as vinegar, strong solutions of minerals acids, bleaches or other highly corrosive chemicals, or for hot water above 140°F (60°C). For exposure to these conditions, refer to technical bulletin on CONCRESIVE 1305.

Where exposure to stronger chemicals is only occasional, such as fume, splash or spill conditions; or when material is in contact for intermittent periods, CONCRESIVE 1170 will tolerate significantly more corrosive chemicals than those listed above.

INSTRUCTIONS FOR USE

(For detailed instructions for bonding new concrete to existing concrete, refer to Application Bulletin AE-1000.)

Surface Preparation: Surfaces must be free of dirt or dust, paint, grease, oil, rust or other contaminants. Surface may be dry, damp or water-saturated. Sandblasting, water blasting, flame blasting, chipping, scarification or etching and rinsing the surface of the old concrete is recommended to expose clean sound surfaces.

Mixing: To assure color uniformity, stir Parts A and B separately before mixing. Where precise color uniformity is essential, specify that all units have the same batch number Mix only the amount of material that can be used before the expiration of the potlife. Measure the components carefully and add Part B to A. Mix thoroughly, using a mechanical mixer, such as an electric drill-powered paint mixer (e.g., a Jiffy mixer, Jiffy Mixer Co., Irvine, CA). Carefully scrape the sides and bottom of the container while mixing. Proper mixing will take from 3-5 minutes, and the material must contain no streaks or lumps.

Application: Apply by stiff brush, short-nap roller, squeegee or airless spray gun. Spray equipment is commercially available that automatically meters, mixes and applies two-component systems at various material temperatures.

To avoid pinholing, apply two or more thin, 6-8 mil (152-203 umm) coats, rather than one thick coat. The second coat may be applied as soon as the first is touch dry. To insure good adhesion between coats, the maximum time between coats should be:

72 hrs. @ 60°F (10°C)
36 hrs. @ 77°F (25°C)
27 hrs. @ 90°F (32°C)

When using airless hot-spray equipment, single coat multi-pass (cross-spray) techniques may be employed.

When the material and the surface temperatures are between 40-60°F (4-16°C) during application, and maximum gloss of the cured coating is desired, the freshly mixed material should be allowed to stand for 5-15 minutes in container before commencing application.

Limitations: CONCRESIVE 1170 is not recommended for use when the ambient and/or surface temperature is below 40°F (4°C) during application and cure, or when free-standing water is present on the surface.

Clean up: Mixed epoxy coating is much easier to cleanup before it hardens. Solvents used for this purpose are methyl ethyl ketone (MEK - flammable) or perchloroethylene or methylene chloride (non-flammable). Two component airless spray equipment normally has a built-in solvent purging system. Cured epoxy coatings may be removed from tools and equipment by using heavy duty epoxy strippers, such as CONCRESIVE 6003.

Handling and Toxicity: This bulletin does not accompany the product when sold. For specific hazard warnings and first-aid instructions, READ THE CONTAINER WARNING LABELS CAREFULLY.

Mixed components contain liquid epoxy resin and amines. May cause allergic skin and respiratory reaction. Harmful if swallowed. Do not get in eyes, on skin or on clothing. Use only with adequate ventilation. Wash thoroughly after handling.

The use of barrier creams, such as Kerodex No. 71 or Indco Labs No. 211, 213, or 214 is recommended. Clean rubber gloves or disposable polyethylene gloves provide the best protection. Should skin contact occur, wash immediately with soap and water or Adhesive Engineering Company's Epocleanse 6001 hand cleaner.

Units of measure: This product data sheet contains reference to the modernized metric system known as the International System of Units (SI). The SI units are contained in the parentheses following the U.S. customary units of measure.

Neither seller nor manufacturer has any knowledge or control concerning the purchaser's us of the product. No express warranty is make by seller or manufacturer with respect to the results of any use of the product. NO IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO AN IMPLIED WARRANTY OF MERCHANTABILITY, OR AN IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, ARE MAKE WITH RESPECT TO THIS PRODUCT. Neither seller or manufacturer assumes any liability for personal injury, loss or damage resulting from the use of this product. In the event that the product shall prove defective, buyer's exclusive remedy shall be as follows: Seller or manufacturer shall, upon written request of buyer, replace any quantity of the product which is proven to be defective, or shall, at its option, refund the purchase price for the product upon return of the product.

LAFRENTZ SYSTEM 400 SPECIFICATIONS

"Flexible, Two Component, Solvent-Free, Cold-Curing Roadmarking Materials"

COLDPLASTIC PAVEMENT MARKING

1. The materials shall be so manufactured to be applied by extrusion onto the pavement in liquid form with glass spheres mixed in and also dropped onto the material after it is applied.

2. The compound shall not deteriorate by contact with sodium chloride, calcium chloride, or other chemicals used against formation of ice on roadways or streets, or because of oil content of pavement materials or from oil dropping from traffic. In the plastic state, the materials shall not give off fumes which are toxic or otherwise injurious to persons or property. To insure the best possible adhesion, the compound as specified, shall be installed in a liquid state in a temperature range of -10°C to +35°C. The material shall not be subject to discoloration or bond failure due to Ultra Violet rays from the sun.

3. During manufacture, reflectorizing glass spheres shall be mixed into the material to the extent of not less than 20 percent nor more than 50 percent by weight of the material. Glass spheres shall also be automatically applied to the surface of the material at a uniform rate of approximately three pounds of glass spheres to every one hundred square feet of line. These glass spheres shall be dropped onto the plastic material while it is in a liquid state after it has been extruded onto the pavement.

4. The curing time shall be controlled by the workers. Normal curing time shall be from 10 - 35 minutes with 100 percent curing complete in under one hour at all times. Curing is complete and the material does not rely on glass beads to keep it from tracking during a prolonged curing time.

5. Physical Requirement - Pavement Markings:
   a) Color: Markings shall be brilliant white or yellow.

   b) Brightness: Value obtained with the Gardner Multi-purpose Reflectometer when measuring 0° to 45° day-light luminous directional reflectance with the green filter: Shall not be less than 70 percent for white or 55 percent for yellow.
   c) Water absorption: Materials shall have no more than 0.5 percent by weight of retained water when tested by ASTM designation D-570, "Water Absorption of Plastics" procedure (A) (24 hr. Immersion).

d) Softening Point: Materials shall not have a softening point.

e) Specific Gravity: Specific gravity of the plastic compound at 25°C, shall be from 1.90 - 2.20.

f) Abrasion Resistance: Materials shall have a maximum weight loss of 0.5 grams when subjected to 200 revolutions on a Taber Abraider at 25°C using H-22 Calibrade wheels weighted to 500 grams. The test samples shall be prepared by forming representative lots of materials at a thickness of 3 mm ± 0.1 mm on a 100 mm square plate. The test surface shall be kept wet during the test.

g) Indentation Resistance: The reading of the Shore Durometer, Type A2 as described in ASTM designation, D-1706, after fifteen seconds and using a 0.907 kilogram weight shall not be less than the amounts specified below when the material is tested after heating for four hours:

Temperature	Reading
46°C	65 ± 2
25°C	95 ± 2

h) Chemical Resistance: 5 cm x 5 cm test sections should show no signs of degradation after exposure to:

1) 5% NaCl (24 hr. Immersion)
2) 5% CaCl (24 hr. Immersion)

6. General Requirements

6.1 Glass Beads

a) Imperfections: The surface of the spheres shall be smooth and free from film, scratches and pits. At least 80 percent shall be of true spherical shape, and free from milkiness, dark or air inclusions and other defects.

b) Index of Refraction: The liquid immersion method at 25°C may be used to determine the refractive index of the glass spheres. A refractive index of 1.50 to 1.60 is required.

c) Gradation: The spheres shall meet the following gradation requirements when tested in accordance with ASTM designation D-1214.

1) Spheres included in the manufacture of the material:

U.S. Standard Sieve	% Passing
Passing #270 um	80 - 100
Passing #100 um	0 - 10

2) Spheres for application on liquid material:

U.S. Standard Sieve	% Passing
Passing #900 um	90 - 100
Passing #300 um	20 - 50
Passing #200 um	0 - 10

6.2 The material shall be suitable for application in film thicknesses from 0.5 mm up to 15.0 mm. Normal surface applications will be from 1.5 to 2.0 mm thick.

6.3 The material when cured shall be flexible when cast into film thicknesses of 2.0 mm to 5.0 mm.

6.4 The material shall contain no solvents.

6.5 The material shall be suitable for application on Concrete, New Asphalt, and old Asphalt. Bond strength on any of these surfaces shall be sufficient for the material to remain in place for a number of years, under most normal conditions.

NORRIS PRODUCT BULLETIN

Norline Thermoplastic Traffic Line Striping

Norline Thermoplastic is a long lasting reflective striping material for traffic marking. It is hot extruded or sprayed directly and securely on any pavement. Norline Thermoplastic must be preheated to a temperature of at least 425° F (218°C) and applied to a pavement surface at a temperature of at least 400°F (204°C). A clean dry surface and a temperature of 50°F (10°C) is recommended.

APPLICATION:

Standard extrusion shoe widths are 4", 5", 6", 8", and 12" (10, 12.7, 15, 20, and 30 cm). A thickness of about 1/8" (0.3 cm) or 125 mils is the normal film thickness.

COVERAGE:

One ton (907 Kg.) will lay 4000-5000 lineal feet (1.6 Km) of 4" line depending on texture and condition of road surface; or approximately 3,300 linear feet (1 Km) of 6" line.

DRY TIME:

At an air temperature of 50 ± 3°F (10 ± 2°C) the dry time for no track should be a minimum of 2 minutes. At an air temperature of 90 ± 3°F (32 ± 2°C) the dry time should be no more than 10 minutes. These times are based on the film thickness of approximately 125 mils and at a relative humidity of from 50% to 70%.

TYPICAL USES:

Norline Thermoplastic Striping is used for crosswalks, center lines, lane lines, edge lines, barrier lines, limit lines, parking areas, airfield markings, safety zones, gore markings, stop bars, and industrial safety markings.

PACKAGING:

Norline Thermoplastic is available in granular form packaged in 50 lb. bags that have a composition allowing them to melt and become part of the not melt mixture at application temperature.

SURFACE PREPARATION:

Norline Thermoplastic Epoxy Sealer is recommended prior to application of the thermoplastic striping. This will assure adhesion to a variety of surfaces and provide long life to the striping material.

GLASS BEAD PRODUCT INFORMATION

General Requirements

1. The glass spheres shall consist of transparent, water-tight glass particles in spherical shape.

2. The refractive index shall not be less than 1.50 when tested by the liquid immersion method at room temperature.

3. The glass spheres shall meet the following requirements for freedom from imperfections when inspected visually:

   At least 90% by visual count of each separate size fraction of glass spheres when separated on the sieves shall be free of the following imperfections:

   a. Dark specks of a diameter greater than one-fourth that of the glass sphere.

   b. Air inclusions of a diameter greater than one-half that of the glass sphere.

   c. Incipient fractures.

   d. Milkiness or surface scoring or scratching.

Waterproof Overlay Glass Spheres

Waterproof overlay glass spheres shall consist of glass spheres on which a film of water-repellent material is applied during the process of glass sphere manufacture.

1. The glass spheres shall meet the following requirements for size when tested in accordance with the Standard Method of Test for Sieve Analysis of Glass Spheres, ASTM Designation D-12141:

   Percent by weight passing U.S. No. 20..... 100
   Percent by weight passing U.S. No. 30..... 90-100
   Percent by weight passing U.S. No. 50..... 10-35
   Percent by weight passing U.S. No. 70..... 0-15
   Percent by weight passing U.S. No. 100..... 0-5

2. Waterproof overlay glass spheres shall meet the following requirement for crushing strength when tested in accordance with the Standard Method of Test for Crushing Resistance of Glass Spheres, ASTM Designation D-1213:

   20-30 Mesh Size.....30 Pounds

3. Moisture Resistance: The glass spheres shall not absorb moisture in storage. They shall remain free of clusters and lumps and shall flow freely from dispensing equipment.
   The glass spheres shall pass the following test for water repellency and free flow:

   Place two pounds of the glass spheres in a cotton cloth bag and immerse in distilled water until saturated. Remove the bag and squeeze excess water from the sample. Suspend the bag at room temperature for two hours. At the end of this time, shake the bag to mix the sample and pour the glass spheres slowly through a clean, dry 60 degree glass funnel having a stem 4" in length and an inside stem diameter of 3/8". The entire sample must flow through the funnel without stoppage. At the start of the test the funnel may be tapped slightly to initiate flow.

4. The glass beads when tested for roundness according to ASTM D-1155-52, Procedure A, shall not contain more than 20% irregular particles.

Adherence Coated Glass Spheres

Adherence coated glass spheres shall consist of glass spheres which have been provided with a silane treatment during the manufacturing process to enhance the adherence of glass spheres to traffic paint.

1. The glass spheres shall meet the following requirements for size when tested in accordance with the Standard Method of Test for Sieve Analysis of Glass Spheres, ASTM Designation D-12141:

Percent by weight passing U.S. No. 20.....	100
Percent by weight passing U.S. No. 30.....	90-100
Percent by weight passing U.S. No. 50.....	10-35
Percent by weight passing U.S. No. 70.....	0-15
Percent by weight passing U.S. No. 100.....	0-5

2. Waterproof overlay glass spheres shall meet the following requirement for crushing strength when tested in accordance with the Standard Method of Test for Crushing Resistance of Glass Spheres, ASTM Designation D-1213:

   20-30 Mesh Size.....30 Pounds

3. The glass spheres shall contain a minimum of 90% true spheres by visual count when viewed under a microscope at 20X to 30X magnification.

VISIBEAD PRODUCT BULLETIN

HOW VISIBEAD OUTSHINES STANDARD GLASS BEADS

VISIBEAD lines remain brighter for a longer time even after normal, wear-related bead "kick-out" for fracturing.

VISIBEAD achieves the optimum 55% bead embedment throughout the line for full-line-width reflectivity.

VISIBEAD won't sink in the middle of the line.

VISIBEAD IN EPOXY: EASY TO APPLY

VISIBEAD uses standard epoxy application methods and equipment. Two application techniques can be used to give epoxy markings wet night reflectivity. The "Single Drop" system uses only VISIBEAD for maximum wet night reflectivity. This may require larger-diameter bead dispensing equipment. The "Double Drop" system combines VISIBEAD and PH-4 Spheres to maximize durability. PH-4 Spheres are slightly coarser than standard beads and application will require an extra bead tank.

VISIBEAD: SPECIFIED FOR HIGH PERFORMANCE

Potter's recommended specifications for VISIBEAD and PH-4 Spheres are shown below. Consistent, high quality manufacturing standards are backed by Potter's stringent Quality Assurance Program. All Potter's highway spheres are sequentially segregated into 2,000 pound lots for quality testing. Quality control records are retained for a minimum of two years and all shipments are certified to meet customer specifications.

SIZE	PH-4 SPHERES	VISIBEAD SPHERES (Single Drop)	VISIBEAD SPHERES (Double Drop)
US Sieve #	% Retained	% Retained	% Retained
12			0
14		0	5-20
16		5-20	40-80
18		40-80	10-40
20		10-40	0-5
25		0-5	
30	5-20		
50	30-32		
80	9-32		
100	0-5		
Pan	0-2		

ROUNDS: 80% Overall; 75% per Screen

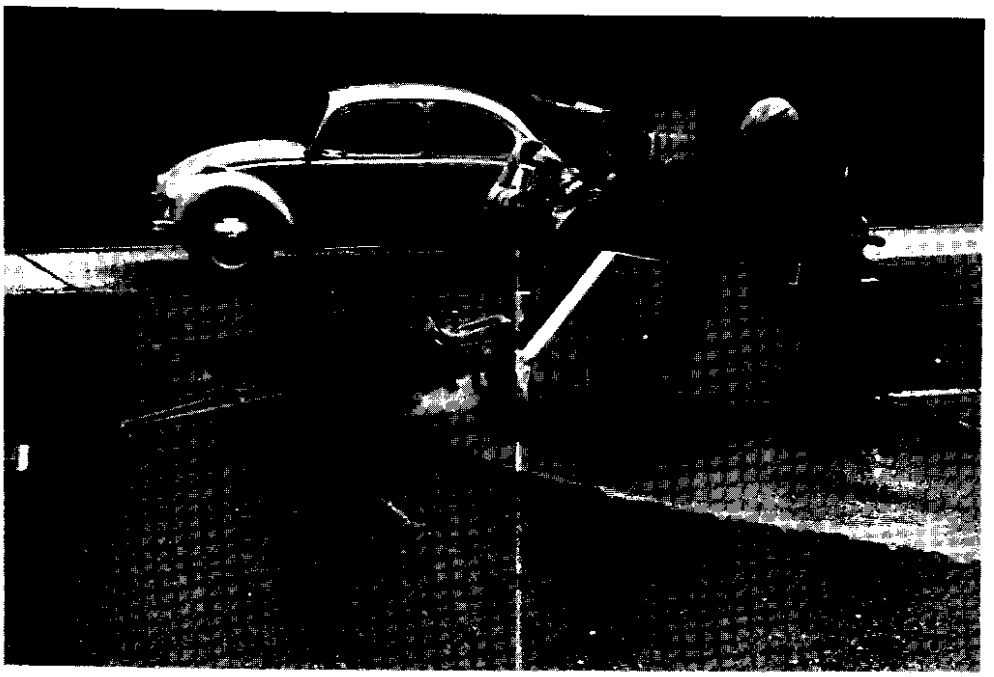
COATING: Embedment Coating for Epoxy

APPENDIX D

PHOTOGRAPHS

PHOTO INDEX

1.



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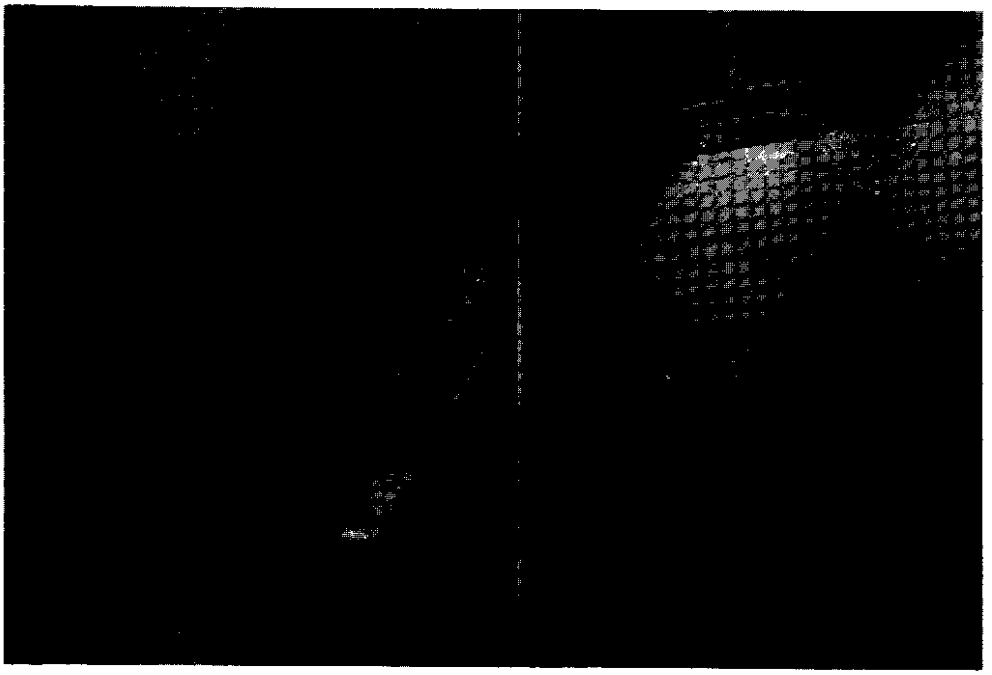

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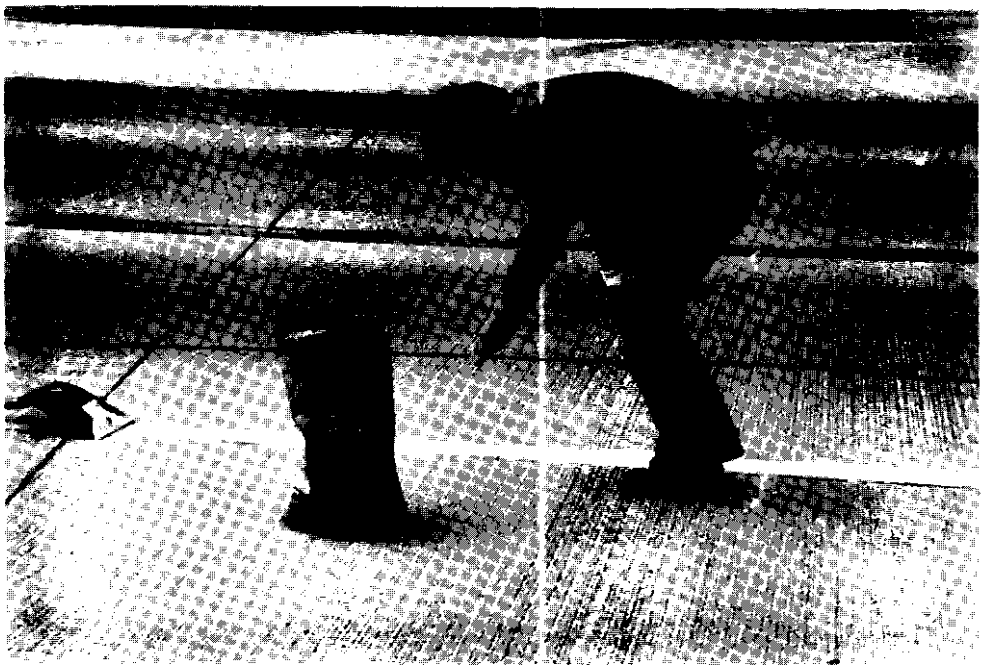

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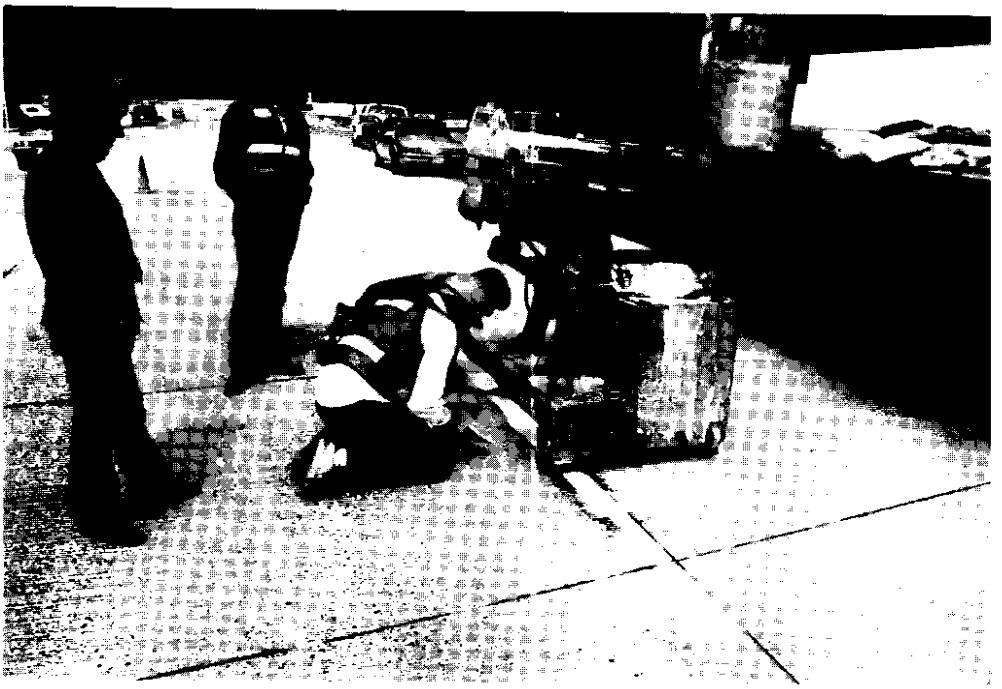

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