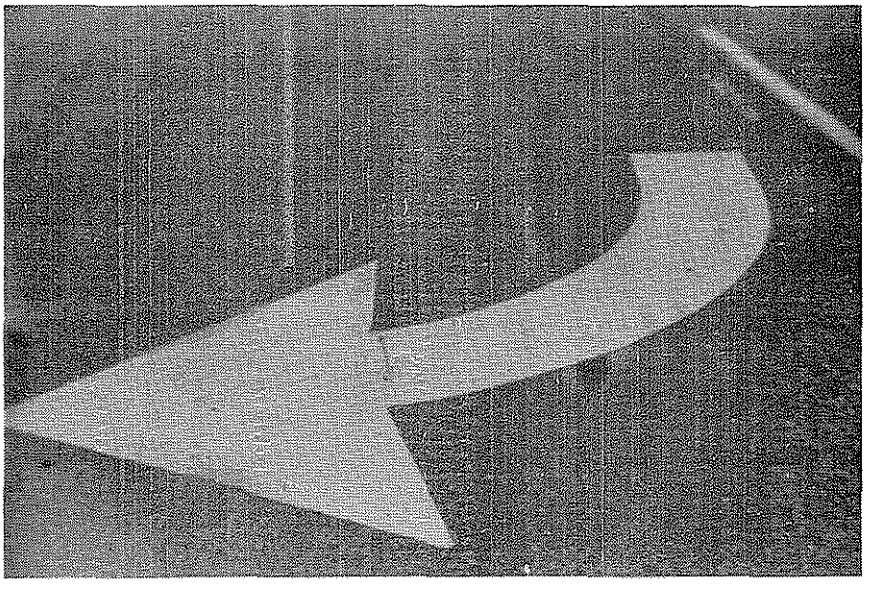
Field Evaluation of Pavement Marking Materials



Highway Division
Office of Materials
June 1979

DISCLAIMER

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FIELD EVALUATION
OF
PAVEMENT MARKING MATERIALS

BY
CHARLES J. POTTER
JUNE, 1979

IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION
OFFICE OF MATERIALS
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ACKNOWLEDGEMENTS

Special thanks to Max Sheeler, Chemical Tests Engineer, and to John Moody, Maintenance Resources & Roadside Engineer, for their assistance in preparing and reviewing this report and to Ralph Kalsem, Materials Lab. Tech. 3, who supervised the field evaluation crew.

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ABSTRACT

Pavement marking materials other than conventional paint must be evaluated as environmental standards become more restrictive. The new EPA classification for solvents state that all oil paints are photochemically reactive and, therefore, contribute to smog. This will eventually result in the elimination of organic solvents from all paints, which may occur in Iowa by 1985.①

The Special Investigations Section of the Office of Materials field reviewed all urban and rural applications of pavement marking materials in the spring of 1979. The field review consisted of a visual estimation of percent marking missing, percent satisfactory, and percent non-satisfactory; reflective readings by ERMA; and notation of special conditions which may have affected performance. ERMA was not effective in evaluating the reflective quality of pavement marking materials.

No pavement marking materials evaluated have been successful enough to date to totally replace conventional painting methods. Preformed cold-lay marking materials such as 3M's Stamark and Prismo's Plastix are generally performing well, especially where rolled into new asphaltic concrete, but hot-lay extruded and non-extruded thermoplastics such as Perma-Line and Pave Mark have not performed well to date. H. B. Fuller's epoxy resin has performed well when applied to properly cleaned and sandblasted pavement. Raised pavement markers have been damaged by snowplows, but they

may still have merit at high accident locations for their safety value.

New pavement marking materials should be evaluated as they become available. One promising new product is Safeline, a thermosetting unsaturated polyester, which has been used successfully in Ohio.

① See Appendix "C", Memo from Sheeler to Given, Code 435.193, Dated July 11, 1978.

FIELD EVALUATION

OF

PAVEMENT MARKING MATERIALS

Introduction:

The Special Investigations Section of the Office of Materials was assigned the task in December 1978 of field reviewing all urban and rural applications of pavement marking materials and preparing a consolidated report which documents location, material used, background information and present level of performance. The work plan for field evaluation of pavement marking materials is included in Appendix "A" of this report. Basically, field evaluation involved:

1. Visual estimation by three (3) independent raters of percent marking gone, percent marking unacceptable, and percent marking performing satisfactorily.
2. Reflective quality evaluation by the Electro-Reflective Measuring Apparatus (ERMA).
3. Observation and noting of special conditions which may have affected the performance of the marking system and any other pertinent remarks.

The field evaluation of pavement marking materials was completed in May, 1979.

Pavement marking installations studied included those listed in Harold Schiel's letter dated June 27, 1978 and John Moody's letter dated July 5, 1978. Both of these letters are included in Appendix "B" of this report. All city PMS Projects listed in Harold Schiel's letter were field surveyed, but few pavement marking installations listed in John Moody's letter could be field evaluated. Many of the installations

have been painted one or several times by maintenance forces since the installations were intitially placed. Also, Item #8 Buena Vista County on U.S. #71 and Iowa #7 from the south junction of Iowa #7 northwesterly to the corporation line of Storm Lake (2.68 miles) was not placed in 1978, but was installed in June 1979. Therefore, wherever field evaluation could not be performed, only material used, location, and background information are provided in Appendix "D" of this report.

Discussion:

Appendix "D" contains individual data sheets for every pavement marking installation studied. The present level of performance for each pavement marking installation was determined according to the work plan included in Appendix "A" of this report. ERMA readings are included on individual data sheets, but their accuracy is questionable. The ERMA device consists of a light and photoelectric cell positioned approximately 15° to the pavement surface and contained in a light-sealed box. Theoretically, the photoelectric cell detects no reflectivity on a perfectly black surface and a reading of 0.00 volts is displayed, while the photoelectric cell detects complete reflectivity on a perfectly white surface and a reading of 6.00 volts is displayed. In actual practice, the ERMA device would not read 0.00 volts and 6.00 volts on black and white standards respectively as the field crew traveled across the state, and reflective quality readings are not relative to each other statewide. Also, background asphaltic concrete and portland cement concrete would read 4.00 or 5.00 volts

without any pavement marking material. The range between good and poor marking material was restricted to two (2) volts or less which is not enough to distinguish between them. Modifications to the ERMA device may increase the range and stabilize readings for future use. Otherwise the ERMA device does not produce meaningful data.

Background information on individual data sheets was compiled from correspondence, previous reports on marking materials, and conversation with city officials and Iowa DOT personnel associated with the various pavement marking installations. Many pertinent comments are made in the "Remarks" column of individual data sheets which are not necessarily repeated as background information. The pavement type for each marking location is noted in the "Reflective Readings" column, the "Remarks" column, or as background information on individual data sheets. Background information and field evaluations reaffirm comments made by Max Sheeler in his letter dated July 11, 1978, included in Appendix "C" of this report.

A brief discussion follows for each pavement marking material studied:

3M Stamark

3M Stamark is a cold-lay preformed marking material that is generally performing very well, especially when rolled into hot asphaltic concrete resurfacing. Stamark was first introduced with spray-applied adhesive which performed poorly. New roller applied adhesive and pre-coated backing have substantially improved this product. Des Moines Stamark installations at West 42nd and Grand and at Euclid and Cornell are performing very well after one winter

(See Page D-34). Stamark was rolled into hot asphaltic concrete resurfacing at these locations, and all markings look good to date except crosswalks which are worn badly due to traffic. Stamark with pre-coated adhesive was applied to portland cement concrete pavement on I-235 in Des Moines in 1977. This installation was placed with a 3M applicator and looks very good at present (See Page D-32). Other Stamark installations in Iowa have had varying degrees of success probably due to different adhesives, application methods, weather conditions, pavement conditions, etc. Stamark seems to last longer on asphaltic concrete than on portland cement concrete, and seems to perform best in low volume traffic installations or where traffic seldom drives on it such as centerline and edgeline markings.

Prismo's Plastix

Prismo's Plastix is a cold-lay preformed marking material that is performing well in Davenport and on the Julien Dubuque River Bridge (See Pages D-10 and D-36). Plastix adheres better to asphaltic concrete pavement than to portland cement concrete pavement. Plastix was rolled into very new asphaltic concrete resurfacing on the Julien Dubuque River Bridge, and the resulting "inlay" effect is performing very well. Plastix has a tendency to move in hot weather at high volume intersections due to stopping traffic movements.

Prismo's Hot-Lay Thermoplastic

(Non-Extruded)

This product was applied to I-235 in Des Moines and U.S. 69 in Ankeny in August 1974. Thermoplastic lane lines were almost completely worn away when surveyed in May 1975. This thermoplastic marking material deteriorates from traffic wear by chipping or flaking off in patches. The result is a broken or dotted line about 1/3 or 1/2 the original 4 1/2 inch width. This product, including application, costs about three (3) times as much as conventional paint applied by maintenance personnel.

Perma-Line's Hot-Lay

Extruded Thermoplastic

This product performed poorly at pavement marking installations in Charles City and Sioux City (See Pages D-12 and D-13). Most markings were gone within one year of application. This product lasts longer on asphaltic concrete pavement than on portland cement concrete pavement, and works best when rolled into new asphaltic concrete resurfacing. The resulting "inlay" effect minimizes snowplow damage. These thermoplastic markings crack badly and will chip off when applied too thickly, especially on portland cement concrete pavement.

Pave Mark's Hot-Lay
Extruded Thermoplastic

This product did not perform well in Webster City or Des Moines with one exception. Thermoplastic lane markings were placed on very new aphaltic concrete resurfacing on Keosauqua Street in Des Moines in 1974. These markings cracked badly but lasted almost five (5) years on this heavily traveled street as compared to three (3) months for conventional paint. This product cracks and chips badly and did not last on portland cement concrete pavement. Pave Mark's thermoplastic marking material does not appear to be any better than conventional paint except when applied to very new asphaltic concrete.

Pave Mark's Hot-Lay Thermoplastic
(Non-Extruded)

Pave Mark's non-extruded thermoplastic marking material was placed on I-35 in Hamilton, Wright, Franklin and Cerro Gordo Counties in 1976. In 1978 the installation was in generally poor condition and was painted by maintenance forces.

H. B. Fuller's Epoxy Resin

Epoxy marking material was applied to I-235 in Des Moines in the spring of 1976. Where the pavement surface was properly cleaned and sandblasted, these markings are still visible today after three (3) winters. Reflectivity is questionable, however, and was not checked at this installation (See Page D-27). Epoxy

marking material did not adhere well to portland cement concrete pavement in Cedar Rapids and did not adhere well to recently sealed bridge decks. Fast setting epoxy used first in Cedar Rapids came loose in one month, but the new two-component epoxy is performing satisfactorily. It is a slow process to apply epoxy marking material, but when done correctly, this product is very durable. All epoxy markings became gray in color after three (3) weeks, but they still retained good reflectivity at night.

3M's Scotchlane

Scotchlane is a cold-lay, preformed, foil marking material backed with precoated adhesive. Scotchlane was applied to very new asphaltic concrete on Howard Co. Rd. V-58 in the fall of 1975. It is performing well to date except that it is worn off at bridge approaches, driveways, and curves due to traffic wear. Scotchlane is a temporary marking material, but the "inlay" effect has protected this material against snowplow damage.

Low Profile Markers For

Wet/Night Visibility

By Battelle Columbus Laboratory

These recessed reflectorized elements were installed on I-80 westbound from the U.S. 65 interchange westerly one mile in October 1974. In September 1976 some of the markers were extensively damaged, but no markers were completely gone. No daytime delineation is provided by these markers, and they are only visible at night by straddling the line in which they are placed. The installation method of this product is time consuming and costly.

Stimsonite's Model 99
Raised Pavement Marker

This raised pavement marker is blunt on one end and can be snowplowed in one direction only. Castings were ripped from the pavement when hit by snowplows on the blunt end which protrudes about 3/4 inch. This did considerable damage to the snowplows on several occasions. Reflector elements must be periodically replaced since as much as 12% of these elements may be removed yearly.

Stimsonite's Model 96
Raised Pavement Marker

The Model 96 raised pavement marker is definitely an improvement over the old Model 99 since it can be snowplowed from either direction. Snowplows still remove some castings from the pavement, and many reflector elements are damaged every winter. Snowplow blades are also damaged while removing snow from raised pavement marker installations. Raised pavement marker survivability may be increased by installing these markers on centerline only where they will be subjected to fewer snowplow repetitions. Raised pavement markers should also be installed on sound pavement only, since they are not retained well on deteriorated pavements such as spalled joints, severe rutting or uneven surfaces. These markers have high reflectivity and good delineation properties when reflector elements are intact and in good condition.

Conclusions:

1. ERMA was not effective in evaluating reflective quality of pavement marking materials. There is not enough range in the machine between the reflectivity of good and poor marking materials or between the reflectivity of marking materials and background portland cement concrete. Also, the ERMA device could not be calibrated to black and white standards statewide.
2. Pavement marking materials are being continually improved by the manufacturers. Bad past experience should not necessarily prevent further consideration of a brand name product. 3M's "Stamark", for instance, lasted one year or less with the old spray-applied adhesive, but has been substantially improved by roller-applied adhesive.
3. Pavement marking materials evaluated generally performed better on asphaltic concrete pavement than on portland cement concrete pavement.
4. Preformed cold-lay marking materials (3M's Stamark, Prismo's Plastix, and Scotchlane) are generally performing well, especially when rolled into new asphaltic concrete.
5. Hot-lay extruded thermoplastics (Perma-Line and Pave Mark) and non-extruded, hot-lay thermoplastics (Prismo and Pave Mark products) have not performed well to date. They crack and chip badly and are generally gone in one year or less. These products are not currently any better than conventional painting methods except when applied to very new asphaltic concrete where they may perform satisfactorily.

6. H. B. Fuller's epoxy resin product has high durability when applied to properly cleaned and sandblasted pavement. It is a slow process to apply epoxy marking material, but when done correctly, it may last several years.
7. Stimsonite's Model 96 low-profile raised pavement marker is the best raised pavement marker used to date. It has high reflectivity when reflector units are intact and in good condition. The major disadvantages of this product are: (1) Damage done to snowplow blades by raised pavement markers and, (2) Damage done to raised pavement marker castings and reflector units by snowplow blades.

Recommendations:

1. Modify ERMA to increase the range between black and white standards and to read the same on black and white standards at all times. If this cannot be accomplished, the machine should be abandoned since readings are not meaningful at present.
2. Alternates to traffic paint which have been used to date should not totally replace conventional painting methods.
3. Preformed cold-lay marking materials have generally performed well and should be investigated further. This is being accomplished this year in Buena Vista County on U.S. 71 and Iowa #7. Stamark and Scotchlane were rolled into new asphaltic concrete resurfacing on centerline and edgeline.
4. Hot-lay extruded and non-extruded thermoplastics should not be considered further except on very new asphaltic concrete or when these products are improved.

5. H. B. Fuller's epoxy resin product is performing well in Cedar Rapids and should be given further consideration.
6. Raised pavement markers have been damaged by snowplows and have damaged snowplow blades, but they should still be considered at high accident locations for their safety value. These products are being improved and may eventually be snowplowable without damage. In the meantime, raised pavement marker installations must be properly maintained (i.e. broken and missing reflector units replaced and missing castings replaced) to be effective.
7. New pavement marking materials should be evaluated as they become available. One promising new product is Safeline, a thermosetting unsaturated polyester, which has been used successfully in Ohio. This product claims increased service life, increased night and wet visibility, and cost competitiveness as compared to conventional traffic paint but also has slow curing time (8 to 30 minutes). (See Page D-38).

APPENDIX "A"

WORK PLAN

WORK PLAN FOR EVALUATION

OF

REFLECTIVE PAVEMENT MARKING MATERIALS

I. Determine the performance level of each marking system at each location by visual observation.

   A. Evaluation by a rating panel with a minimum of 3 raters.

   B. Each location shall be visually classified by percentage into:

      1. Marking gone
      2. Marking unacceptable
      3. Marking performing satisfactorily
         (3 classes must total 100%)

II. Determine the reflective quality of each marking system at each location.

   A. Obtain a minimum of five stationary spot checks with the ERMA device, uniformily spaced through the length to be evaluated.

      1. On intermittent centerline, obtain readings at midpoint of selected stripes.
      2. Clean surface by:
         a. brushing with a stiff bristled push broom
         b. brushing clean with a soft nylon push broom
      3. Obtain and record reading.

III. Observe and note any special conditions that may have affected the performance of the marking system. Note any other remarks pertinent that may assist in properly evaluating the marking.

APPENDIX "B"

PAVEMENT MARKING
INSTALLATION
LOCATIONS

IOWA DEPARTMENT OF TRANSPORTATION

COPY

Office of Director of Highways

June 27, 1978

D. E. McLean

451.13
Pavement Markings

Harold C. Schiel

Urban Systems

Tracking the Effectiveness and Durability of Pavement Marking Materials

At a recent staff meeting there was a brief discussion concerning pavement markings. A part of the discussion touched on the need to keep track of the effectiveness and durability of hot and cold thermoplastics and epoxy based materials placed through special test projects and as a part of the pavement marking demonstration program. This information is required on which to base future decisions as the manufacturers continue to pressure for more use of these materials in pavement marking programs.

This office has assembled a list of city installations which might be of use to the Materials Department in tracking installations of these materials for information purposes.

The limited feedback that is filtering in seems to indicate the cold lay materials are still not doing well, but I am especially interested in how well the epoxy resin product will do on the First Ave. project in Cedar Rapids.

dwm
cc: R. H. Given
C. H. Huisman
F. O. Bloomfield
Ray Gustafson

THERMOPLASTIC PAVEMENT MARKING MATERIAL
USAGE IN CITIES
FEDERAL DEMONSTRATION PROGRAM

June 1978

City	Marking Material	Street Locations Where Applied in City *	Date of Application
Burlington	Cold-Lay thermoplastic, 3M "Stamark" product	1. Approx. 100 school crosswalks - various locations 2. 10 RR x-ings-various locations 3. 4th, 5th, & 6th Sts. between Valley St. and Spring St. 4. Division St. east of Central Ave. 5. Central Ave. between Valley St. and Osborn St.	Fall 1976, Spring & Summer 1977
Cedar Rapids	Cold-lay epoxy resin, product from HB Fuller Co., St. Paul, Minn.	1. First Ave. (Us 151) from "L" St. SW to Cedar Memorial Cemetery 2. CBD area 3. Approx. 200 school crosswalks-various locations 4. Approx. 100 traffic signal location crosswalks	Summer of 1978
Charles City	Hot-lay extruded thermoplastic, product from Perma-Line Corp., Chicago, Ill.	1. 19 crosswalks on Main St., school x-ings, and CBD area	August-September of 1977
Council Bluffs	Cold-lay thermoplastic, 3M "Stamark" product	1. Approx. 125 school and pedestrian crosswalk intersections-various locations 2. Broadway St. (US 6) in CBD area	Spring and Summer of 1977
Davenport	Cold-lay thermoplastic, Prismo product	1. Six intersections in CBD (Harrison @ 4th and @ River Drive, Brady @ 4th, 3rd, and @ River Drive, Perry @ 3rd)	Summer of 1977

City	Marking Material	Street Locations Where Applied in City *	Date of Application
Decorah	Cold-lay thermoplastic. 3M "Stamark"	1. Crosswalks on Water St., Broadway St., and State St. in CBD area	Summer of 1977
Des Moines	1. Hot-lay extruded thermoplastic on all lane lines & C.L., product from "Pave Mark", Marietta Georgia 2. Cold-lay Thermoplastic on crosswalks stop lines, and words-symbols, 3M "Stamark" product	1. 6th Ave. from University Ave. to Euclid Ave. 2. University Ave. from W. 24th St. to W. 32nd St. 3. Extensively in CBD area	Summer of 1977
Harlan	Cold-lay thermo-plastic, 3M "Stamark" product	1. Cyclone Ave. thru city 2. 6th-7th-12th-19th Streets 3. Pine St. and Baldwin St. 4. CBD area	August-September of 1977
Sioux City	Hot-lay extruded thermoplastic, product from Perma-Line Corp., Chicago, Ill.	1. Approx. 55 RR x-ings and 105 school cross-walks-various locations	September-October of 1976
Webster City	Hot-lay extruded thermoplastic, product from "Pave Mark", Marietta, Georgia	1. Second St. (US 20) from Prospect St. to Superior St. 2. 8 RR x-ings-various locations	Summer of 1977

* Contact City for more specific information

Maintenance July 5, 1978

Fay O. Bloomfield 451.13

John Moody

Maintenance COPY

Pavement Marking

This is in response to your request for a summary of loacations and various types of pavement markings which have been tried over the past several years.

The following list of references is the result of digging into files and memory. There are undoubtedly some I have missed, and if so, those should be added to the list so that it might be kept current as a ready reference to those methods which have been attempted in the past.

If you are aware of locations I have missed, please advise.

JHM:csa
Attachment

1. Indianola - Approximately 1 mile on Iowa #92 within the Corp. Limits of Indianola. Applied by contractor during resurfacing in September 1975. (See memo-Moody to Bloomfield Code 601.1 - 6/11/75, Moody to Bloomfield Code 451.13 - 3/25/76 & 3/27/76.

2. Howard County - County Road used as a detour in 1975. Scotchlane tape applied in fall of 1975. (See memo Bloomfield to Browning Code 451.13 - 7/20/76. Box of slides in filepocket 451.13-1976).

3. Sac County - At No. & So. Jct. of U.S. #71/US. #20. Raised pavement markers - Stimsonite - Mod. 99. Placed 223 units in July 1973. (See memo coded 451.13 - 5/20/75).

4. Hamilton, Wright, Franklin & Cerro Gordo Counties from U.S. #20 north to Iowa #106. Thermoplastic pavement marking applied in summer of 1976 by "Century Fence." (On I-35)

5. Polk County - Thermo plastic pavement marking applied by the Prismo Company in the fall of 1974 to the following sections of highway: (See memo coded 601.1 - 5/19/75) (a) U.S. #69 from north part of Ankeny south to Jct. Iowa #160. (b) U.S. #69 (E. 14th St. - Des Moines) from just north of I-80 south to Army Post Road and north from Army Post Road to I-235. (c) I-235 westbound from E. 15th St. to I-35/80 (west junction) (d) I-235 eastbound from I-35/80 (west junction) to I-35/80 (north junction) (e) I-80 from I-235 eastbound to Hubbell Avenue (U.S. #65) (also see memo - S.E. Roberts to Iowa Highway Research Board Code 773.172 - 5/15/75).

6. Polk County - I-235 in Des Moines. H. B. Fuller Epoxy paint applied in spring 1976. See correspondence and brochures in 1976 file pocket coded 601.1.

7. Polk County - I-80 from Jct. U.S. #65 (Hubbell Avenue) to 1 mile west - Wet-Night Visibility - Low Profile pavement markers applied in 1974 and 1975. See various correspondence in file code 451.13 (1975 and 1976). Especially memo Moody to Bloomfield coded 451.13 4/1/76 and "Final Report on HR-1005" entitled "Low Profile Marker for Wet/Night Visibility" dated April 1977.

8. Buena Vista County - On U.S. #71 & Iowa #7 from the south jct. of Iowa #7 northwesterly to the Corp. Line of Storm Lake (2.68 mi.) present plans are to apply center and barrier lines by inlaying a pliant pollymer material produced by the 3-M Company and known as "Sta-Mark." Also to apply "Sta-Mark" as edgelines on both sides of 1 mile with the remaining 1.68 miles having scothlane applied as edgelines. All the above mentioned traffic line marking materials will be pressed into the upper lift of asphaltic concrete with the final rolling.

9. Statewide - Raised pavement markers at twelve (12) different locations installed during last summer of 1977. (See memo Jacobs to Walker Code 454.1 - 5/30/78 with attached tabulation).

10. Sta-Mark on I-235 westbound from 2nd Ave. almost to Keo-Way (1977).

11. Scotchlane on U.S. 69 from N.C.L. of Ames to county road intersection at Moose Lodge (1977).

APPENDIX "C"

PAVEMENT MARKING PERFORMANCE ON PMS PROJECTS

BY MAX SHEELER

IOWA DEPARTMENT OF TRANSPORTATION

To Office Chief Engineer — Date July 11, 1978

Attention R. H. Given — Ref. No. 435.193

From M. I. Sheeler

Office Materials

Subject Pavement Marking Materials

The performance of thermoplastic marking materials used by cities for PMS projects has generally been less than satisfactory. A list of the materials used in various locations with comments on their present status is attached.

Hot extruded thermoplastics have not been successfully used in any northern state. Their performance on AC pavement is usually better than on PC pavement but the durability in either case has not been sufficient to make them cost effective. Performance was poor when the material was used by the D.O.T. on the Des Moines freeway and on I-35.

Preformed thermoplastics have had varying success because of some adhesion problems and a susceptibility to traffic wear. Prismo's product, which has a precoated asphalt adhesive, appears to be the most successful although use has been limited. Spray application of the adhesive used with 3M's product did not work and the company now recommends roller application for satisfactory performance. This spring the 3M product was applied to a short section of the Des Moines freeway for trial.

At the present time, conventional paints remain the standard material for pavement marking but this could change rapidly as environmental standards become more restrictive. The new EPA classification for solvents essentially states that all paint solvents are photochemically reactive and therefore contribute to smog. This will eventually result in the elimination of organic solvents from all paints which I predict will happen in Iowa by 1985.

We must continue our evaluation of solvent-free materials such as epoxy paints, tapes, thermoplastics, reflective markers, and water-based paints as they become available. The most promising material is the epoxy paint currently being applied in Cedar Rapids. It will be tried on the Des Moines freeway later in July. Another promising alternative is to roll preformed thermoplastic into new AC pavement while the pavement is still warm. This will be tried on a Buena Vista county project and on the resurfacing of the Dubuque bridge.

In the future, we may not be able to use one type of marking material for all service conditions. To date most trials of these alternative materials have been limited to problem areas of high traffic volume where service conditions are severe and the material is most likely to prove cost effective. Future investigations should include low traffic volume areas and applications on both AC and PC pavements.

OK

cc: D. E. McLean
H. C. Schiel
C. L. Huisman

PERFORMANCE
OF
PAVEMENT MARKING MATERIALS
ON PMS PROJECTS IN CITIES

JULY, 1978

MARKING MATERIAL	CITY	APPLICATION DATE	COMMENTS ON PERFORMANCE
Preformed Thermoplastic 3M's "Stamark"	Burlington	Fall 1976, Spring & Summer 1977	60% gone in 1976 with spray applied adhesive. Adhesion OK with rolled-on adhesive used in 1977. Material wears thru over top of pea gravel particles and wears off on cross-walks where subjected to turning action.
	Council Bluffs	Spring & Summer 1977	About 80% gone at present time. Adhesive was spray applied. Being replaced using roller application.
	Decorah	Summer 1977	Adhesion OK. Adhesive rolled on. Excessive wear in wheel track area of crosswalk lines.
	Des Moines	Summer 1977	8% of arrows and 24% of 6" barrier lines gone by April 1978. Adhesive spray applied.
	Harlan	August & Sept. 1977	70% unacceptable including use on new asphalt. Both roll-on and spray application of adhesive used. To be completely replaced this year.
Preformed Thermoplastic Prismo's "Plastix"	Davenport	Summer 1977	Performance generally acceptable. Small loss due to snow plowing & asphalt paving cracks. Some movement of line in hot weather where subjected to turning action and some tracking of asphalt adhesive.
Hot Extruded Thermoplastic Perma-Line	Charles City	August & Sept. 1977	Several lines 100% gone. Other lines 30 to 70% gone.
	Sioux City	Sept. & Oct. 1976	With high traffic volume, 20% loss on old AC, 10% loss on new AC, and 95% loss on PC. With low volume, 10% loss on old AC and 25% loss on PC.

PERFORMANCE
OF
PAVEMENT MARKING MATERIALS
ON PMS PROJECTS IN CITIES

MARKING MATERIAL	CITY	APPLICATION DATE	COMMENTS ON PERFORMANCE
Hot Extruded Thermoplastic Pave-Mark	Des Moines	Sept. & Oct. 1977	Poor performance on new AC and on PC. 40% loss of white and 24% loss of yellow. Best on seal coat.
	Webster City	Summer 1977	90% gone at present time. Started coming off within 30 days after application and before snowplowing. Most applied to AC with some on PC.
Epoxy Paint H.B. Fuller	Cedar Rapids	Summer 1978	Being applied at present time. Initial appearance good. Some application problems with old equipment. Contractor has new equipment coming.

APPENDIX "D"

INDIVIDUAL PAVEMENT MARKING INSTALLATION DATA SHEETS

Location: Burlington. Approximately 100 school crosswalks at various locations; 10 railroad crossings at various locations; 4th, 5th and 6th Streets between Valley Street and Spring Street; Division Street east of Central Avenue; Central Avenue between Valley Street and Osborn Street.

Marking Material: 3M's Stamark, a cold-lay preformed marking material.

Date of Application: Fall 1976, Spring and Summer 1977.

Present Level of Performance:

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/9/79	Washington St. Between 6th and 7th	1.30 5.80	4.65(White Arrow) 3.40(Plain A.C.)	1%	9%	90%	High Volume. School X-ings Seem to Last Longer Than Arrows. Chunks of 3M Arrows Gone.
4/9/79	School X-ing at 4th & Court		5.50(White Diagonal X-ing) 5.00(Plain A.C.)	2%	8%	90%	Chunks of Marking Gone From Snowplows. Marking Gone In Wheel Tracks.
4/9/79	School X-ing at 4th & Spring		5.30(White Marking) 4.60(Plain P.C.)	85%	5%	10%	High Volume. Placed On P.C. Original Marking Was Applied With Spray Adhesive and Was Replaced by 3M After One Year. 90% Turning Traffic.

Burlington (Continued) Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/9/79	School X-ing at 8th & Spring		5.55(White Marking) 4.60(Plain P.C.)	10%	7%	83%	Marking Is Worn Off Where Traffic Has Turned.
4/9/79	RR X-ing at 8th St. Between Jefferson & Valley		5.35(White Marking) 5.05(Plain A.C.)	1%	9%	90%	Low Volume Traffic. 6000 ADT.
4/9/79	RR X-ing at Main St. Between Valley & Market		5.05(White Marking) 4.90(Plain A.C.)	30%	3%	67%	High Volume. Pea Gravel Asphaltic Concrete. Marking Is Gone In Wheel Tracks.
4/9/79	RR X-ing at Main St. Between Division & Market.		5.40(White Marking) 4.35(Plain A.C.)	17%	10%	73%	High Volume. Where Street Is Cracked Moisture Loosens Adhesive.
4/9/79	School X-ing At Parkway and 14th St.	1.25 6.00	5.60(White Marking) 5.00(Plain A.C.)	5%	5%	90%	Low Volume Snow Route.
4/9/79	School X-ing At Parkway & 14th Street		5.55(White Marking) 4.90(Plain P.C.)	10%	5%	85%	Low Volume Snow Route.

Background Information: Ralph Kalsem, Materials Tech. 3, talked to Mr. Dudley from Burlington Street Department who showed the field crew the pavement marking installations. Markings are completely gone where water or sand stands on the street. Markings are completely gone in wheel tracks where stripes are placed in turning lanes. More stripes are chipped on P.C. concrete than asphaltic concrete, probably from snowplows. Mr. Spooner thought this product would last for years if used for centerline or edge line markings. Dickinson Construction Company used spray-applied adhesive originally, but replaced everything the following year with roller-applied adhesive. When markings are placed over cracks, moisture loosens the adhesive. All stripes were placed during sunny days only, and surface temperature was between 80°- 100°F.

Location: Council Bluffs. Approximately 125 school and pedestrian crosswalks; intersections at various locations; Broadway Street (U.S. 6) in the central business district.

Marking Material: 3M's Stamark, a cold-lay preformed marking material.

Date of Application: Spring and Summer of 1977.

Present Level of Performance:

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/19/79	16th St. & Broadway (Turn Arrow)		5.90(White Marking) 5.20(Plain A.C.)	30%	23%	47%	High Volume.
4/19/79	16th St. & G St. (Turn Arrow)		5.90(White Marking) 5.50(Plain A.C.)	15%	72%	13%	High Volume.
4/19/79	16th St. & G St. (Stop Bar)	3.80 6.05	5.85(White Marking 5.14(Plain A.C.	40%	17%	43%	High Volume.
4/19/79	Grand & Trail Ridge (Stop Bar)		5.90(White Marking 5.50(Plain P.C.)	2%	7%	91%	Low Volume.

Council Bluffs (Continued) Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/19/79	Grand & Trail Ridge (Crosswalk)		5.90 (White Marking) 5.60 (Plain P.C.)	37%	13%	50%	Low Volume.
4/19/79	20th St. & G St. (Crosswalk)		5.89 (White Marking 5.40 (Plain A.C.)	37%	8%	55%	Medium Volume.

Background Information: Ralph Kalsem, Material Tech. 3, talked to Lee Ault of the Council Bluffs Street Department. All markings were replaced in 1978 using a roller-applied adhesive supplied by the producer. The pavement surface was broomed and air blasted before marking application. Mr. Ault felt studded snow tires had badly damaged markings, but that snowplows had done no damage.

Location: Decorah. Crosswalks on Water Street, Broadway Street, and State Street in the central business district.

Marking Material: 3M's Stamark, a cold-lay preformed marking material.

Date of Application: Summer of 1977.

Present Level of Performance:

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/16/79	Broadway & Washington (Crosswalk)	0.70 5.70	4.75(White Marking 3.80(Plain P.C.)	21%	5%	74%	High Volume.
4/16/79	Broadway & Winnebago (Crosswalk)		4.20(White Marking 3.70(Plain P.C.)	22%	8%	70%	High Volume.
4/16/79	Winnebago & Broadway (Stop Bar)		4.00(White Marking) 2.63(Plain A.C.)	0%	7%	93%	Low Volume.
4/16/79	Washington & Broadway (Stop Bar)		4.60(White Marking) 4.00(Plain P.C.)	60%	20%	20%	High Volume. This Stop Bar Is Completely Worn Off In Wheel Tracks.

Decorah (Continued)

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/16/79	State & Water (Crosswalk)		4.50 (White Marking) 3.80 (Plain P.C.)	87%	8%	5%	High Volume.

Background Information: Ralph Kalsem, Materials Tech. 3, talked to Charles Coffen. His opinion was that it would be much cheaper to paint every year if this product lasts less than two (2) years. 3M said it would last two (2) years. This product will not last in very rough areas. Much wear in wheel tracks was noticeable after only nine (9) months. Most of the marking material was gone before winter, so little damage was done by snowplows. All material was placed in August 1977 using spray-applied adhesive. Mr. Coffen noted little difference between A.C. & P.C. installations. Streets were broomed before applying adhesive. All markings were gone on Water Street in wheel tracks due to high traffic volume. On most P.C. installations, markings are completely gone in wheel tracks. 3M Company is replacing this material in Decorah. This product conforms to the pavement surface, but Mr. Coffen feels it will adhere better to a smooth surface.

Location: Des Moines. 6th Avenue from University to Euclid Avenue; University Avenue from West 24th Street to West 32nd Street; Used extensively in central business district area.

Marking Material: 3M's Stamark, a cold-lay preformed marking material.

Date of Application: Summer of 1977.

Present Level of Performance:

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/24/79	6th Ave. N. of University (Turning Arrow)	4.00 6.05	5.90(White Marking) 5.70(Plain A.C.)	20%	13%	67%	High Volume. Placed in 1977.
4/24/79	4th & Grand (Stop Bar)		5.90(White Marking) 5.60(Plain A.C.)	23%	8%	69%	High Volume. Placed in Summer 1978.
4/24/79	Keosauqua & 6th Ave. (Stop Bar)		5.95(White Marking) 5.55(Plain A.C.)	3%	5%	92%	Very High Traffic Volume. Placed In 1978.

Background Information: Ralph Kalsem, Materials Tech 3, talked to Bill Snyder of the Des Moines Street Department. Mr. Snyder said he is very satisfied with the cold-lay marking material (Stamark with roller-applied adhesive). All present hot-lay thermoplastic intallations will be replaced with cold-lay preformed markings. Mr. Snyder felt that about 90% of all cold-lay marking material was still in place, and about 90% of all hot-lay thermoplastic was missing. Cold-lay markings placed on crosswalks in the summer of 1978 are about 98% intact. Cold-lay markings will show some wear in the wheel paths on very heavily traveled streets. Stamark was rolled onto the pavement surface, and adhesive was applied to both the pavement and the marking. Snowplows did not damage Stamark.

Location: Harlan. Cyclone Avenue through Harlan; 6th, 7th, 12th, and 19th Streets; Pine Street and Baldwin Street; Central business district area.

Marking Material: 3M's Stamark, a cold-lay preformed marking material.

Date of Application: August and September 1977.

Present Level of Performance:

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/23/79	6th St. (Centerline)	4.60 6.10	6.00(White Marking) 5.90(Plain A.C.)	8%	12%	80%	High Volume.
4/23/79	6th St & Cyclone (Turn Arrow)		5.85(White Marking) 5.70(Plain A.C.)	10%	13%	77%	Medium Volume.
4/23/79	19th & Willow (Yellow C_L)		6.00(Yellow Marking) 5.80(Plain A.C.)	1%	3%	96%	Medium Volume.
4/23/79	16th St. & Pine (Yellow C_L)		6.00(Yellow Marking) 5.70(Plain A.C.)	1%	3%	96%	Low Volume.

Harlan (Continued)

Date	Location	Calibration On Standard Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/23/79	7th St. & Court (Turn Arrow)		5.90(White Marking) 5.80(Plain A.C.)	12%	13%	75%	High Volume.
4/23/79	7th St. & Baldwin (Stop Bar)		5.90(White Marking) 5.80(Plain A.C.)	3%	7%	90%	Low Volume.
4/23/79	7th & Court (Stop Bar)		5.90(White Marking) 5.80(Plain A.C.)	2%	5%	93%	High Volume.

Background Information: Ralph Kalsem, Materials Tech 3, talked to Steve Salvo, Engineering Tech., for the City of Harlan. Most marking material was replaced in 1978 using the new roller-applied adhesive. All old markings were removed and the pavement broomed before new marking material was installed. All markings were placed on asphaltic concrete. Harlan is satisfied with replaced marking material. Markings were not damaged by snowplows this past winter. Markings used for centerline are performing very well. Some crosswalks were painted at the same time Stamark was applied. Paint was judged to be 80% gone, while markings are in good condition.

Location: Davenport. Six intersections in the central business district; Harrison and 4th, Harrison and River Drive, Brady and 4th, Brady and 3rd, Brady and River Drive, Perry and 3rd.

Marking Material: Prismo's "Plastix", a cold-lay preformed marking material.

Date of Application: Summer of 1977.

Present Level of Performance:

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/10/79	West River & Harrison (Crossing)	1.10 5.90	4.80(White Marking) 3.45(Plain P.C.)	22%	5%	73%	Low Volume.
4/10/79	River & Brady (Crossing)		5.50(White Marking) 4.20(Plain P.C.)	23%	7%	70%	High Volume. Prismo Has Slipped By Cars Stopping. Prismo Placed In Hot Weather. Heavy Truck Traffic. More Wear In Straight Through Traffic Than Turning Lane.
4/10/79	Brady & 3rd (Crossing)		5.40(White Marking) 4.30(Plain P.C.)	5%	23%	72%	Heavy Traffic.
4/10/79	3rd & Perry (Crossing)		5.60(White Marking) 4.40(Plain A.C.)	13%	15%	72%	Low Volume. High ERMA Reading On White Marking Due to Uneven Surface.

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
Davenport (Continued)							
4/10/79	3rd & River (Turning Arrow)		5.65 (White Marking) 5.19 (Plain A.C.)	0%	5%	95%	Medium Volume. 3M Stamark At This Location.
4/10/79	Locust & Harrison		5.25 (White Marking) 4.00 (Plain A.C.)	5%	5%	90%	90 Mil Prismo Placed Aug. 9, 1977. 80° - 85°F & Clear.
4/10/79	Locust & Harrison		4.90 (White Marking) 4.00 (Plain A.C.)	95%	5%	0%	60 Mil 3M Stamark Placed Sept. 1, 1977. 3M Was Rolled Down. 80° - 85° F & Clear.

Background Information: Ralph Kalsem, Material Tech 3, talked to Mr. Saladino of the Davenport Traffic Engineering Department. Mr. Saladino does not like 3M's Stamark because it takes more time than Prismo to put down. All installations were put down between 80° - 95° F. Mr. Saladino feels Prismo will outlast 3M's Stamark. Both Prismo and 3M's Stamark seem to stay in place better on A.C. than P.C. Marking slippage was caused by opening to traffic before adhesive was completely set. 3M Company replaced some of 3M product with a new type of adhesive after original marking came loose. On very high traffic volumes both 3M and Prismo had a tendency to slip at intersections where they were used as crosswalks.

Location: Charles City. 19 Crosswalks on Main Street; school crossings; and central business district area.

Marking Material: Perma-Line, a hot-lay extruded thermoplastic.

Date of Application: September and October of 1977.

Present Level of Performance:

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/17/79	Clark In Front of City Hall	0.85 5.70	4.25(White Marking) 3.90(Plain P.C.)				ERMA Device Broke Down After This Reading. Crosswalks, Stop Bars, Etc., Were Visually Inspected And Found To Be 50% to 100% Missing.

Background Information: Ralph Kalsem, Material Tech 3, talked to Dennis Willemssen of Charles City. Most damage to Perma-Line occurred within a two (2) month period after placement. The pavement was broomed before adhesive was put down. Perma-Line bonds better to A.C. than P.C. Snowplows did little damage since much of the marking was gone before winter. All markings were put down in September and October, and the streets were dry. Epoxy was sprayed on. Most intersections were 100% gone.

Location: Sioux City. Approximately 55 railroad crossings and 105 school crosswalks at various locations.

Marking Material: Perma-Line, a hot-lay extruded thermoplastic.

Date of Application: September and October of 1976.

Present Level of Performance:

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/19/79	West 3rd & Market (School Crosswalk)	4.60 6.05	6.00(White Marking) 5.80(Plain A.C.)	7%	10%	83%	Medium Volume.
4/19/79	Hamilton N.B. Across From Maint. Garage (RR. X-ing)		6.00(White Marking) 5.70(Plain A.C.)	63%	8%	29%	High Volume. Older A.C. Pavement.
4/19/79	Hamilton S.B. Across From Maint. Garage (RR X-ing)		6.00(White Marking) 5.90(Plain P.C.)	73%	18%	9%	High Volume.
4/19/79	West 7th (School Crossing)		6.00(White Marking) 5.80(Plain A.C.)	75%	15%	10%	Low Volume. Very Old A.C. Pavement.
4/19/79	West 6th (School Crossing)		6.00(White Marking) 5.90(Plain A.C.)	30%	23%	47%	Low Volume.

Sioux City (Continued)

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/19/79	Ross & 16th (Crosswalk)		6.20 (White Marking) 6.00 (Plain A.C.)	39%	38%	23%	Very Old A.C. Pavement. Low Volume & Very Bad Road Condition. Much Pavement Cracking, And Some Pavement Pieces Missing.

Background Information: Ralph Kalsem, Material Tech 3, talked to Ron Choquette, Sign & Signal Supervisor, for Sioux City. This product is being replaced year to year. This product will last quite well when rolled into A.C. Pavement which is no more than than three (3) years old. Most markings placed on P.C. are completely gone, and Mr. Choquette said they would not replace any of this product on P.C.C. Pavement. This product has a tendency to roll flush into the A.C. pavement, but not into the P.C.C. pavement so snowplows do more damage to markings on P.C. than on A.C. Where this product is rolled well into fairly new A.C. pavement, snowplows do very little damage. There is a considerable amount of cracking with this product. Mr. Choquette said paint would last one year, and most of this marking product the same. Streets were broomed before applying adhesive, and Mr. Choquette was satisfied with application. Mr. Choquette felt that traffic volume and road condition greatly influenced this product. This product was applied to cobblestone material, and the Perma-Line crystallized and was completely gone within a few months.

3M's Stamark and Scotchlane were placed on two (2) test sections in Sioux City. Both products were rolled onto A.C. pavement one year old and two years old respectively. Scotchlane temporary pavement marking was not rolled into hot A.C. pavement. Both products appear to adhere to the street about the same. Both sections were rated as 95% satisfactory and 5% not satisfactory. No marking material was loose, cracked, or chipped off on this high volume street.

Location: Des Moines. 6th Avenue from University Avenue to Euclid Avenue; University Avenue from West 24th Street to West 32nd Street; Used extensively in the central business district area.

Marking Material: Pave Mark, a hot-lay extruded thermoplastic.

Date of Application: September and October 1977.

Present Level of Performance:

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/24/79	5th St. & Court (Lane Marking)	4.00 6.05	6.00(White Marking) 5.81(Plain A.C.)	22%	21%	57%	Placed in 1977.
4/24/79	6th St. & Court (Centerline)		6.00(Yellow Marking) 5.90(Plain A.C.)	28%	22%	50%	Placed in 1977.
4/24/79	6th Ave. N. of University (Centerline)		6.00(Yellow Marking) 5.80(Plain A.C.)	5%	5%	90%	Placed in 1978. All Hot-Lay Thermoplastic Was Used For Centerline or Lane Markings.
4/24/79	Keosauqua & 6th Ave.		6.00(White Marking) 5.60(Plain A.C.)	55%	27%	18%	Placed in 1974 On Very New A.C. Lasted Approximately 5 Years As Compared to 3 Months For Paint On This Very Heavily Traveled Street.

Des Moines (Continued) Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks

Background Information: Ralph Kalsem, Material Tech. 3, talked to Bill Snyder of the Des Moines Street Department. All existing hot-lay thermoplastic will be replaced by cold-lay marking material. He felt that 90% of all cold-lay marking material is still in place, and about 90% of all hot-lay thermoplastic is missing. Hot-lay thermoplastic will not stay on P.C.C. pavement. All streets were broomed first, and Pave Mark was applied at 450° F. This was the recommended temperature. All hot-lay thermoplastic was primed prior to placement on both A.C. and P.C. pavement. Mr. Snyder felt it need not be primed on A.C. pavement. Mr. Snyder felt that hot-lay thermoplastic was not any better than conventional paint. No damage was done to Pave Mark by snowplows.

Location: Webster City. Second Street (U.S. 20) from Prospect Street to Superior Street; Eight (8) Railroad crossings at various locations.

Marking Material: Pave Mark, a hot-lay extruded thermoplastic.

Date of Application: Summer 1977.

Present Level of Performance:

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/12/79	Second St. & Seneca St.	1.20 5.80	6.00(White Marking) 5.12(Plain P.C.)	85%	15%	0%	High Traffic Volume.
4/12/79	Stockdale St. (Stop Bar)		5.48(White Marking) 5.00(Plain P.C.)	73%	27%	0%	Medium Traffic Volume.
4/12/79	Stockdale St.		5.40(Yellow Marking) 4.69(Plain P.C.)	63%	37%	0%	Medium Traffic Volume.
4/12/79	Frank St. & Des Moines St. (Stop Bar)		5.55(White Marking) 4.60(Plain P.C.)	50%	40%	10%	Medium Traffic Volume.

Webster City (Continued) Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks

Background Information: Pave Mark was laid 1/4" thick, and opened to traffic within one hour. The street was swept prior to application, and adhesive was applied with a machine. The marking material was very thick in appearance and had alligator cracking. All material was placed in 1977 in good weather. The contractor stated that Pave Mark was guaranteed not to chip and not to be damaged by snowplows. The contractor also told city personnel that Pave Mark would not last. City personnel stated that Pave Mark could be chipped off easily with a shovel.

Location: Cedar Rapids. First Avenue (U.S. 151) from "L" Street SW to Cedar Memoral Cemetery; central business district area; approximately 200 school crossings at various locations; approximately 100 traffic signal location crosswalks.

Marking Material: H. B. Fuller's epoxy marking, a cold-lay epoxy resin product.

Date of Application: Summer of 1978.

Present Level of Performance:

Date	Location	Calibration On Standards Black White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/11/79	1st Ave. West	3.30 6.00	5.45(White Marking) 4.79(Plain P.C.)	8%	12%	80%	High Volume.
4/11/79	1st Ave. (Lane Marking Over Bridge)		5.50(Yellow Marking) 4.10(Plain A.C.)	3%	5%	92%	High Volume.
4/11/79	1st Ave. & 5th St. (Crosswalk)		5.55(White Marking) 4.60(Plain A.C.)	4%	9%	87%	High Volume. Some Bleeding Noted In Wheel Tracks.
4/11/79	1st Ave. & 5th St. (Arrow)		5.50(White Marking) 4.70(Plain A.C.)	0%	3%	97%	High Volume.
4/11/79	B Ave. & 17th St. (Crosswalk)	2.90 6.00	5.50(White Marking) 5.10(Plain A.C.)	5%	15%	80%	Low Volume.

Cedar Rapids (Continued)

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/11/79	Elmhurst K. Ave. N.E. (Crosswalk)		6.00 (White Marking) 5.20 (Plain P.C.)	5%	22%	73%	Low Volume.
4/11/79	Maplewood & K. Ave. N.E. (Crosswalk)		6.00 (White Marking) 5.30 (Plain A.C.)	7	22%	71%	Low Volume.

Background Information: Ralph Kalsem, Material Tech. 3, talked to Joe Nicholson from Cedar Rapids Traffic Engineering Department. A fast-setting epoxy was first used, and it came loose in about one month. This fast-setting epoxy set up too quickly and did not soak into the pavement surface. Most of the fast-setting epoxy used last year will be replaced this summer. Epoxy marking was used as centerline marking on a bridge deck which had been sealed with linseed oil about 2 to 3 months earlier. The epoxy marking did not adhere well to the bridge deck. Epoxy marking adheres better to A.C. than P.C. pavement. Epoxy marking was placed on a smooth 2 year old section of P.C.C. pavement and all marking came loose. It was replaced in the fall, and the marking came loose again. Lanes were washed with hot water and air blasted dry prior to placing epoxy. All crosswalks were sandblasted before placing epoxy. Epoxy can be placed on a damp pavement surface, but not a wet surface. Epoxy was spray-applied with a two component mix which was heated on a truck prior to application. Glass beads were poured on the epoxy marking with a sprinkle can, and excess beads were swept off after the epoxy marking had set up. It is a slow process to apply epoxy marking material. Snowplows have done very little damage to this product. All stripes became gray in color about 3 weeks after placement, but they seem to have good reflectivity at night.

On a test location, 3M's Stamark, Prismo's Plastix, and H. B. Fuller's product were used. After 3 months, Stamark was completely gone. Prismo's Plastix was placed about 2 months earlier than Stamark and is about one-half gone at this time. H. B. Fuller's product is still intact presently. The test location was an old smooth and well polished P.C.C. Pavement.

Location: Indianola. Approximately 1 mile on Iowa #92 within the corporation limits of Indianola.

Marking Material: 3M's Scotchlane, a cold-lay preformed marking material.

Date of Application: September 1975.

Present Level of Performance:

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
5/18/79	Iowa #92 Within Corp. Limits (Centerline)			100%	0%	0%	No Scotchlane Markings Visible at Present.

Background Information: Scotchlane was rolled into the hot asphaltic concrete resurfacing by the contractor. A steel roller was used to press Scotchlane into the surface. A string-line guide was necessary to obtain a straight line. This consumed additional time and labor for Scotchlane application. Scotchlane was in very good condition in February 1976. Centerline was painted in this location in 1976, 1977 and 1978. Yearly centerline painting is routine in District #5, and the service life of Scotchlane in this installation could not be determined. References: Memo from Moody to Bloomfield Code 601.1 dated 6/11/75, and memo from Moody to Bloomfield Code 451.13 dated 3/25/76.

Location: Howard County. Howard County Road V-58 used as a detour in 1975.

Marking Material: 3M's Scotchlane, a cold-lay preformed marking material.

Date of Application: Fall of 1975.

Present Level of Performance:

Date	Location	Calibration On Standards Black	White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/17/79	Curve S.B. (Double Centerline marking)	1.70	5.90	5.40(Yellow Marking) 4.90(Worn Yellow marking) 4.55(Plain A.C.)	0%	58%	42%	
4/17/79	Steve Linderbaum's Driveway			5.30(Yellow Marking) 4.80(Plain A.C.)	0%	55%	45%	Worn Due To Turning Traffic.
4/17/79	Near Telephone Cable Box #100-14 On E.Side of Road			5.40(Yellow Marking) 4.30(Plain A.C.)	0%	42%	58%	
4/17/79	Near Telephone Cable Box #100-12 On E.Side of Road			5.30(Yellow Marking) 4.30(Plain A.C.)	0%	45%	55%	

Howard County (Continued) Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/17/79	Just North of Bridge		4.80 (Yellow Marking) 4.30 (Plain A.C.)	0%	53%	47%	
4/17/79	Just South of Bridge		4.50 (Yellow Marking) 4.05 (Plain A.C.)	0%	60%	40%	

Background Information: This marking was placed on very new asphaltic concrete in the fall of 1975. None of the Scotchlane is loose or gone at present. More wear is apparent at driveways due to turning traffic, and at bridge approaches due to traffic moving toward centerline. Also, marking material was worn badly on the curve in less than one year due to traffic wear. Scotchlane at all other locations appears to be in good condition. Snowplows have done no damage to this product, probably due to the inlay effect.

Location: Sac County. At the north and south junctions of U.S. 71 and U.S. 20.

Marking Material: Stimsonite Model 99 raised pavement markers.

Date of Application: July 1973.

Present Level of Performance:

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/18/79	South Jct. of U.S. 71 & U.S. 20 (South of U.S. 20)	3.20 6.05	5.90(Marker) 5.90 (Plain P.C.)				No Good Readings With ERMA Due To Light Entering Under the Machine. 25 Reflector Units Missing South of U.S.20, And 29 Reflector Units Missing North of U.S. 20. One Casting Completely Gone North of U.S. 20. Reflector Units Are Red On One Side And Orange On The Other.

Background Information: Missing reflector elements increased from 12% in 1974 to 25% in 1975. No broken castings were noted in 1974, but 2 broken castings were found during the 1975 inspection. Missing castings increased from 9 in 1974 to 14 in 1975. Missing castings were probably caused from snowplows hitting the blunt end of the casting, which protrudes about 3/4 inch. This occurred at or near island ends where there is little distance between markers installed in opposite directions. Snowplows were damaged on several occasions from hitting the blunt end of markers. The installation seems effective, especially at night when the pavement is wet.
Reference: Memo from Moody to Bloomfield Code 451.13 dated 5/20/75.

Location: Hamilton, Wright, Franklin & Cerro Gordo Counties. On I-35 from U.S. 20 North to Iowa 106.

Marking Material: Pave Mark, a hot-lay thermoplastic (non-extruded).

Date of Application: Summer 1976.

Present Level of Performance:

Date	Location	Calibration On Standards Black White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks

This installation was painted by maintenance forces in the summer of 1978. Pavement marking condition could not be evaluated at this time.

Background Information: Pave Mark was spray-applied to this portland cement concrete section of I-35 in the summer of 1976. Maintenance forces painted this installation in the summer of 1978. At that time pavement marking condition was generally poor. Little or no marking material was visible in many locations. The best ratings noted were medium to good. The following notes were taken from an ERMA survey conducted 8/16/78:

I-35 Southbound

Milepost	Remark	Milepost	Remark
191		161	Quite Spalled
190		160	
183		159	Poor
182	Little Paint	156	Poor
181		155	
180	Faint Paint	149	Medium To Good
179	Little or No Paint Visible	148	
173		147	
172	Little Paint Left	146	Medium To Poor
163		145	
162	Good Paint, Some Spalling	144	Medium To Good

Location: Polk County. U.S. 69 from the north part of Ankeny south to Jct. Iowa 160; U.S. 69(E. 14th St.-Des Moines) from just north of I-80 south to Army Post Road and north from Army Post Road, to I-235; I-235 westbound from E. 15th St. to I-35/80 (west junction); I-235 eastbound from I-35/80 (west junction) to I-35/80 (north junction); I-80 from I-235 eastbound to Hubbell Ave. (U.S. 65).

Marking Material: Prismo's hot-lay thermoplastic (non-extruded).

Date of Application: Fall 1974.

Present Level of Performance:

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks

Markings are completely gone, and maintenance forces have painted these locations several times since 1975.

Background Information: Markings were almost completely worn away when inspected in May 1975. The thermoplastic markings chip or flake off in patches. The result is a broken or dotted line in some cases with the width being about 1/3 or 1/2 of the original 4½ inches. Thermoplastic lane lines were lost due to traffic use rather than to snowplow operations. The thermoplastic paint, including application, costs about three times as much as the conventional paint applied by maintenance personnel.

References: Memo from Moody to Bloomfield Code 601.1 dated 5/19/75, memo from S.E. Roberts to Iowa Highway Research Board Code 773.172 dated 5/15/75, and "Final Report on HR-172" entitled "Thermoplastic Pavement Markings" dated July 1975.

Location: Polk County. I-235 in Des Moines.

Marking Material: H. B. Fuller's Epoxy marking material.

Date of Application: Spring 1976.

Present Level of Performance:

Date	Location	Calibration On Standards Black White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
5/18/79	I-235 WB From University to Des Moines River			65%	5%	30%	Placed On P.C.C. Pavement. Epoxy Markings Are Visible Although Maintenance Forces Have Painted This Location Several Times Since 1976.

Background Information: Where this product was applied to properly cleaned and sandblasted pavement, it is still visible today although maintenance forces have painted I-235 several times since 1976. The success of epoxy lane marking depends greatly on the equipment used to mix and apply it. The epoxy lane marking material, if properly mixed and placed on a clean surface, has the durability required to withstand a high traffic volume and frequent lane changes for at least one year. All old paint, oil and road film must be removed from the pavement surface so that the epoxy will adhere to the surface. Glass beads were flooded over the fresh epoxy paint for reflectivity. Reflectivity was not checked on I-235 epoxy markings when this installation was field surveyed on 5/18/79, so no conclusions can be made about reflectivity as affected by age and wear.

References: "Final Report HR-180" entitled "An Evaluation of an Epoxy Pavement Marking System" dated November 1978.

Location: Polk County: I-80 from the junction of U.S. 65 (Hubbell Avenue) to one mile west.

Marking Material: Low profile markers for wet/night visibility developed by Battelle Columbus Laboratory.

Date of Application: Fall 1974 and Summer 1975.

Present Level of Performance:

Date	Location	Calibration On Standards Black White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
5/18/79	I-80 From Jct. U.S. 65 1 Mile West						Placed on P.C.C. Pavement. Two Markers Were Completely Gone From The East End of The Project, and Two Markers Were Gone From The Middle Of The Project. 94 Markers Were Rated Good(0%-10% Missing). 14 Markers Were Rated Fair (20% Missing). 9 Markers Were Rated Bad (50% or More Missing). 4 Markers Were Gone (100% Missing).

Background Information: At the date of the final inspection (9/8/76) there were no complete physical losses of markers. However, the condition of some markers was extensively deteriorated. The angularity of reflection of light from these markers appears to be very limited, and a driver can only see these markers when he straddles the pavement marker line with his vehicle. These markers provide no delineation during daylight hours and must be supplemented by paint or other marking materials. The installation method is time consuming and costly and needs to be mechanized.

References: "Final Report for HR-1005" entitled "Low Profile Marker For Wet/Night Visibility" dated April 1977.

Location: Statewide. Twelve different locations in Story, Wapello, Mahaska, Iowa, Buchanan, Grundy Black Hawk, Hardin, Webster, Hancock, Ida, Sac, and Montgomery Counties.

Marking Material: Stimsonite Model 96 raised pavement markers.

Date of Application: September and October of 1977.

Present Level of Performance:

Date	Location	Calibration On Standards Black	White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/6/79	U.S. 30 at Nevada, Story County	4.00	6.00	5.60(Yellow Reflector)				3rd Reflector East of Median W.B.L. Placed On Yellow Paint Line.
4/6/79	U.S. 30 at Nevada, Story County			5.60(Yellow Reflector)				1st Reflector East of Median E.B.L. Placed On Yellow Paint Line.
4/6/79	U.S. 30 at Nevada, Story County			4.00(White Reflector)				Sta. 2093 E.B.L. Placed On White Paint Line.
4/6/79	U.S. 30 at Nevada, Story County			5.50(White Reflector)				Sta. 2094 W.B.L. Placed On White Paint Line And Over Joint.
4/6/79	U.S. 30 at Nevada, Story County			6.00(Yellow Reflector)				5th Reflector West of RR Bridge Inside Lane.
4/6/79	U.S. 30 at Nevada, Story County			6.00(Yellow Reflector)				6th Reflector West of RR Bridge Inside Lane.

Statewide (Continued) Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
4/6/79	U.S. 30 At Nevada, Story County		6.00 (White Reflector)				4th Reflector From West End Going East In W.B.L.
4/6/79	U.S. 30 At Nevada, Story County		5.00 (White Reflector)				6th Reflector From West End Going East In W.B.L.

Background Information: The only field evaluation of Stimsonite Model 96 raised pavement markers consisted of a reflectivity check on the Nevada installation. All installations were field surveyed by Russ Jacobs of Road Design in April and May 1978. His findings were as follows:

Markers	Percentage	Condition
1245	67%	Grade A - The casting and reflector unit are basically as originally installed and not damaged from snowplowing activities or any other process.
210	11%	Grade B - The casting is intact, but the reflector unit has been marred either from snowplowing, studded tires or some other process, but the reflector is not broken and should be effectively functional.
326	18%	Grade C - The casting is intact, but the reflector unit is cracked, broken, completely missing or otherwise scarred so as to be at least partially non-effective from loss of some or all of the reflectivity.
80	4%	Grade D - The complete marker unit is entirely gone, having been either broken into pieces and lost; ripped from pavement surface by snowplowing operations, in some instances removing a chunk of asphaltic concrete from the pavement along with the marker; or in a few instances a failure in bond in the epoxy appears to have occurred allowing marker to apparently just slip away.
1861	100%	

General response from the travelling public is favorable regarding nighttime marker appearance. In a few instances people have been startled by the sudden appearance of markers, but not confused. Markers seem to add increased awareness of a particular highway condition. Russ Jacobs feels the best use of raised pavement markers is on centerline for definition of curvilinear alignment. Snowplows can avoid markers better on centerline, and the markers would get fewer snowplow repetitions on the centerline as compared to edgeline. Raised pavement markers are more susceptible to snowplow damage when applied

Statewide (Continued) Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks

to deteriorated pavement surfaces such as spalled joints, severe rutting, or uneven surfaces. When pavement marker installations are properly maintained (i.e. reflector elements and castings replaced), these installations have high reflectivity and are effective. The only major disadvantage of this product is damage done to markers by snowplows, and damage done to snowplow blades from hitting raised pavement markers. Raised pavement markers are being continually improved. The Model 96 raised pavement marker is greatly improved over the old Model 99, which could be snowplowed in one direction only.

Reference: Memo from Jacobs to Walker Code 454.1 dated 5/30/78.

Location: Des Moines. On I-235 Westbound from 2nd Avenue almost to Keo-Way.

Marking Material: 3M's Stamark, a cold-lay preformed marking material.

Date of Application: 1977

Present Level of Performance:

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
5/18/79	I-235 W.B. from 2nd Ave. to Keo-Way (White Lane Lines)			5%	0%	95%	Placed on P.C.C. Pavement.

Background Information: Stamark is visibly in better condition in the daytime than the lane lines painted in 1978 on both sides of this installation. Dashed white lane lines were painted by maintenance forces in 1977 and 1978. This Stamark installation was skipped by maintenenace forces during painting operations. Some snowplow damage is evident. Stamark markings at this installation had pre-coated adhesive, and a 3M marking applicator was used.

Location: Story County. On U.S. 69 from the north corporation limit of Ames to the county road intersection at the Moose Lodge.

Marking Material: 3M's Scotchlane, a cold-lay preformed marking material.

Date of Application: 1977

Present Level of Performance:

Date	Location	Calibration On Standards Black White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
5/18/79	Yellow Centerline			13%	32%	55%	On P.C.C. Pavement. Markings Are Completely Gone At Intersections.
5/18/79	Yellow Centerline			10%	22%	68%	On A.C. Pavement.
5/18/79	Yellow Centerline			0%	52%	48%	On A.C. Pavement. No Chipping On Any of These Sections of Yellow Centerline Tape, But Appears To Be Worn Some.

Background Information: No background information available except that 15 foot lengths of yellow Scotchlane were placed on centerline at this installation in 1977.

Location: Des Moines. Intersections at Euclid & Cornell and West 42nd and Grand Avenue.

Marking Material: 3M's Stamark, a cold-lay preformed marking material, and Scotchlane, a cold lay preformed marking material.

Date of Application: 1978

Present Level of Performance:

Date	Location	Calibration on Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
5/18/79	Euclid & Cornell (Yellow Centerline)			0%	5%	95%	Embedded Stamark Rolled Into Hot Asphaltic Concrete.
5/18/79	Euclid & Cornell			0%	5%	95%	Embedded Stamark Rolled Into Hot Asphaltic Concrete.
5/18/79	Euclid & Cornell (Stop Bar)			100%	0%	0%	Conventional Paint Used For This Stop Bar.
5/18/79	Euclid & Cornell (Crosswalk)			0%	72%	28%	Embedded Stamark Rolled Into Hot Asphaltic Concrete.
5/18/79	42nd & Grand Ave. (Yellow Centerline Marking)			0%	5%	95%	Embedded Scotchlane Rolled Into Hot Asphaltic Concrete.
5/18/79	42nd & Grand Ave. (Arrows)			0%	5%	95%	Embedded Stamark Rolled Into Hot Asphaltic Concrete.

Des Moines (Continued)

Date	Location	Calibration On Standards Black-White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
5/18/79	42nd & Grand Ave. (Stop Bar)			0%	40%	60%	Embedded Stamark Rolled Into Hot Asphaltic Concrete.

Background Information: No background information available except that Scotchlane and Stamark were rolled into hot asphaltic concrete at these Des Moines street intersections in 1978. Except for crosswalks and stop bars, all markings look extremely good after one winter. Crosswalks and stop bar Stamark markings are extremely worn, especially in wheeltracks, due to traffic.

Location: Dubuque. Julien Dubuque River Bridge.

Marking Material: Prismo's Plastix, a cold-lay preformed marking material.

Date of Application: Summer 1978.

Present Level of Performance:

Date	Location	Calibration On Standards Black	Calibration On Standards White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
6/5/79	Julien Dubuque Bridge (Centerline)				3%	0%	97%	

Background Information: This marking material was rolled into very new asphaltic concrete resurfacing in the summer of 1978. None of the marking material edges have come loose to date. Missing marking material was probably due to snowplows, studded snow tires, and chains. One section approximately 3 to 4 feet long was completely gone. Otherwise, this installation is in extremely good condition.

Location: Ames. On Elwood Drive at the Eastbound "On" Ramp to U.S. 30.

Marking Material: 3M's Stamark, a cold-lay preformed marking material.

Date of Application: August 1976.

Present Level of Performance:

Date	Location	Calibration On Standards Black White	Reflective Readings	Per Cent Missing	Per Cent Non Satisfactory	Per Cent Satisfactory	Remarks
6/28/79	Elwood Dr. at EB "On" Ramp to U.S. 30 (Turn Arrow)			0%	5%	95%	Shows Very Little Wear In Wheel Paths. Two Small Chips On Front Edge Of Arrow, Probably From Snowplows.

Background Information: This Stamark turn arrow was installed on portland cement concrete pavement in August 1976. It is in very good condition today with only minor damage which was probably done by snowplows.

Location: Not placed in Iowa to date.

Marking Material: Safe-Line's thermosetting unsaturated polyester marking material.

Date of Application: Not placed in Iowa to date.

Present Level of Performance: Not placed in Iowa to date.

Background Information: The following information on this new pavement marking material is provided by Max Sheeler, Chemical Tests Engineer, in the Office of Materials:

Thermosetting unsaturated polyester is a promising new pavement marking material that apparently offers some significant advantages over other materials. The Ohio D.O.T. has been experimenting with this product in conjunction with the Safe-Line company of Cleveland since 1973 and have now established it as a workable material.

The product is a two-component material with 100% solids and is applied in the conventional manner using drop-on reflective glass spheres. It requires conversion of standard marking equipment to handle the two-component system but this conversion still allows application of regular traffic paint. Ohio has converted their marking machines this year for application by their own people.

The advantages claimed for the material are as follows:

1. Increased service life. Ohio expects three years in rural areas and at least one year in high traffic urban areas.

2. Increased night and wet visibility. Material has exceptional ability to retain reflective glass spheres which permits visibility of markings even under wet conditions.

3. Cost is competitive with regular traffic paint. Cost of application is about equal to regular paint when the material is applied at an equivalent dry film thickness. On a cost per service year basis it is superior to regular paint.

The only apparent disadvantage of the material is it's relatively slow curing time. It cures to a "no track" condition in 8 to 30 minutes depending on ambient conditions. Coning is thus necessary.

It is recommended that this product be investigated as soon as possible by a trial installation. It should be tried in rural or other low traffic areas with a 7-1/2 mil dry film thickness application rate (roughly equivalent to regular traffic paint) and in a high traffic urban area at 15 mils dry film thickness.