NJDOT REPORT NO. 74-006-7708

RAISED REFLECTIVE PAVEMENT MARKERS

INTERIM REPORT

by

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prepared by

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HPR Study Number - 7708

Prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration

November 5, 1973

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SUMMARY

The principal aim of the study is to evaluate the endurance, visual effectiveness, cost and spacing of raised reflective pavement markers that are designed to resist hard-blade snowplow forces. This interim report covers the development and snowplow testing of the markers to date in New Jersey.

Several versions of a "Stimsonite 99" snowplowable raised reflective pavement marker have been installed and tested for their ability to resist the action of snowplowing on Routes N.J. 29 and I-95 in the suburban Trenton area since 1967. Four major installations were monitored over four winters. Two interim tests were made leading to the development of these markers.

Results of the testing indicate that:

1. The castings and reflectors, as currently developed, are not affected by either the tungsten carbide or carbon steel snowplow blades.
2. The effectiveness of the reflectivity is found to increase with a worsening of the nighttime driving conditions.
3. The tungsten carbide insert of the snowplow blade is damaged by the casting, but no damage is incurred by the carbon steel blade.

A final major installation will involve three and four lanes in each direction passing through a full cloverleaf interchange. Markers will be placed as a supplementary marking system for yellow median lines, lane lines and exit gores and basic driver behavior studies will be attempted on wet

nights. The purpose of this planned installation is twofold: verify the roadway configuration of the design and verify the adequacy of the reflectors' visibility.

INTRODUCTION

Pavement markings are a primary source of information to the motorist for safe vehicle control and guidance under almost all circumstances of driving. The importance of their use is, evidently, being realized in more widespread application, more complex coding standards, and higher quality and more durable materials in greater variety. Evidence of this expanding field of application is the beaded, quick-drying paint, two-color rural road striping, thermoplastic striping, ceramic and acrylic lane markers, and the incorporation of varying stripe widths and skip line lengths into new standards, just to mention a few.

One of the toughest to solve problems put to researchers in recent years has been the development of an economical pavement marking system that would adequately delineate the roadway both day and night, regardless of whether the pavement is dry or wet. This problem seems to have been solved for the most part in warmer climates with the advent in 1965 of raised ceramic and raised reflective acrylic markers.

An equivalent and durable marker system for areas where snowplowing is prevalent has only recently led to the manufacture of a raised reflective marker after eight years of cooperative testing.

BACKGROUND IN OTHER STATES

The California Division of Highways tested the Stimsonite 88 non-snowplowable raised reflective pavement markers along with raised concrete markers and with ceramic buttons and found them to be more visible during both day and

night with both wet and dry pavement, more durable, and more economical in the long run than painted lines. Other benefits noted from experience with the system included a rumble effect produced by the raised markers when changing lanes and good visual delineation in moderate to heavy rainfall. This marking system has been used in non-snow areas of California's highways since 1965. The system has also been standard in Texas since 1966 and is used widely in Florida.

A snowplowable version of the raised reflective markers ("A" version) was installed in Philadelphia on the Schuykill Expressway in 1968 and was shown to resist the action of a roadway grader. The same marker was tested in California more intensively, showing little damage from normal plowing and excessive damage from a 14-ton grader after four passes.

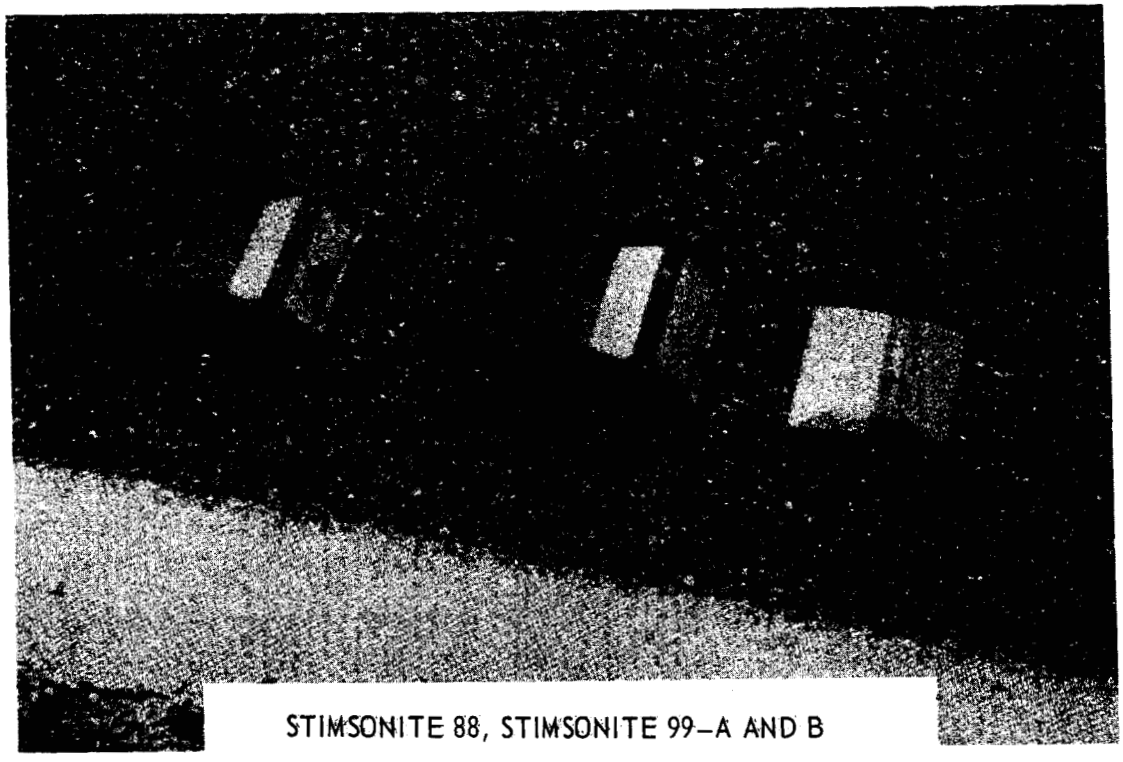
Stimsonite has lettered all versions of the raised marker from "A" through "K" with the exception of "I." Versions "D" through "G" were never produced in any quantities.

The latest version has been installed on a trial basis in New Jersey, New York, Tennessee, Virginia, and West Virginia and the Texas Transportation Institute is conducting an NCHRP study within which installations of several types of raised markers are being evaluated.

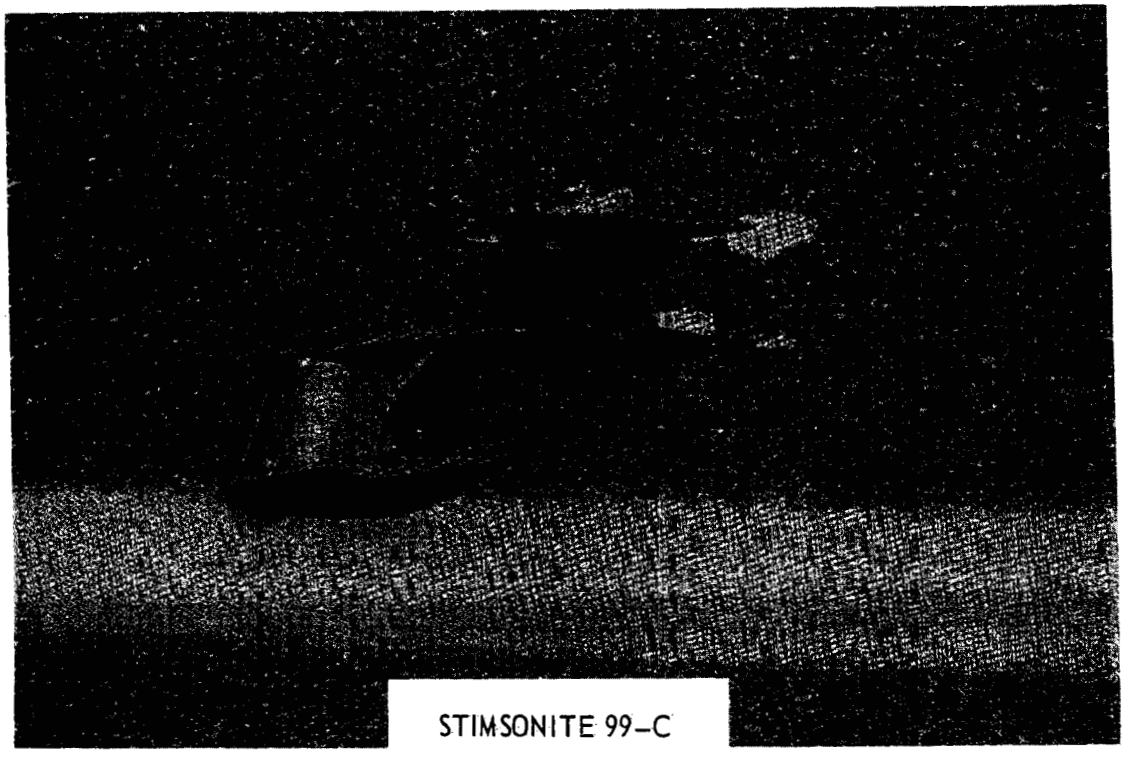
RESULTS OF MARKER TESTING IN NEW JERSEY

"A" AND "B" VERSION

In May 1967, "Stimsonite 88's" and both "A" and "B" versions of "Stimsonite 99's" (Figure 1) were installed at six test sites on Route N.J. 29 near Trenton. Vertical grooves were made in the pavement with dual radial saws and the "A" and "B" version markers were set in these grooves with epoxy.



STIMSONITE 88, STIMSONITE 99–A AND B



STIMSONITE 99–C

FIGURE 1

From visual observations of the test sites, it was felt that the installations of the non-snowplowable markers had better reflective qualities than the normal striping that they supplemented and the snowplowable markers enhanced the delineation of the center line on a dry night. After the first snowfall of the 1967-8 winter, all the non-snowplowable markers were virtually destroyed or caused to be ineffective. Where the "A" version markers were installed, 70 percent of the reflectors were damaged or missing (with their castings intact at one site); while at another site, where an improved reflector adhesive was used, in the "B" version markers, 10 percent of the castings were removed, but the reflectors remained intact and undamaged.

"C" VERSION

The marker's design was modified to incorporate a one piece, two direction reflector, thus reducing the vulnerability of the casting's top and in November and December of 1970, another installation was made of over 1,100 snowplowable markers - "C" version (Figure 1) on Route N.J. 29 near Trenton. The six-mile installation included four layout patterns:

1. Median and lane line marker spacing - 120 feet.
2. Median and lane line marker spacing - 80 feet.
3. Median marker spacing - 40 feet.
   Lane line marker spacing - 80 feet.
4. Median marker spacing - 40 feet.
   Lane line marker spacing - 40 feet.
   Exit gore line spacing - 10 feet.

Arrows were installed on at-grade ramp to ramp intersections with 15 castings per arrow. Reflectors were not included in any of the patterns of the installation, with the exception of the eight arrows which had non-directional red reflectors aimed for wrong-way travelers only. Fifteen percent of the castings were lost after the first snowfall, and seventy percent were lost during the

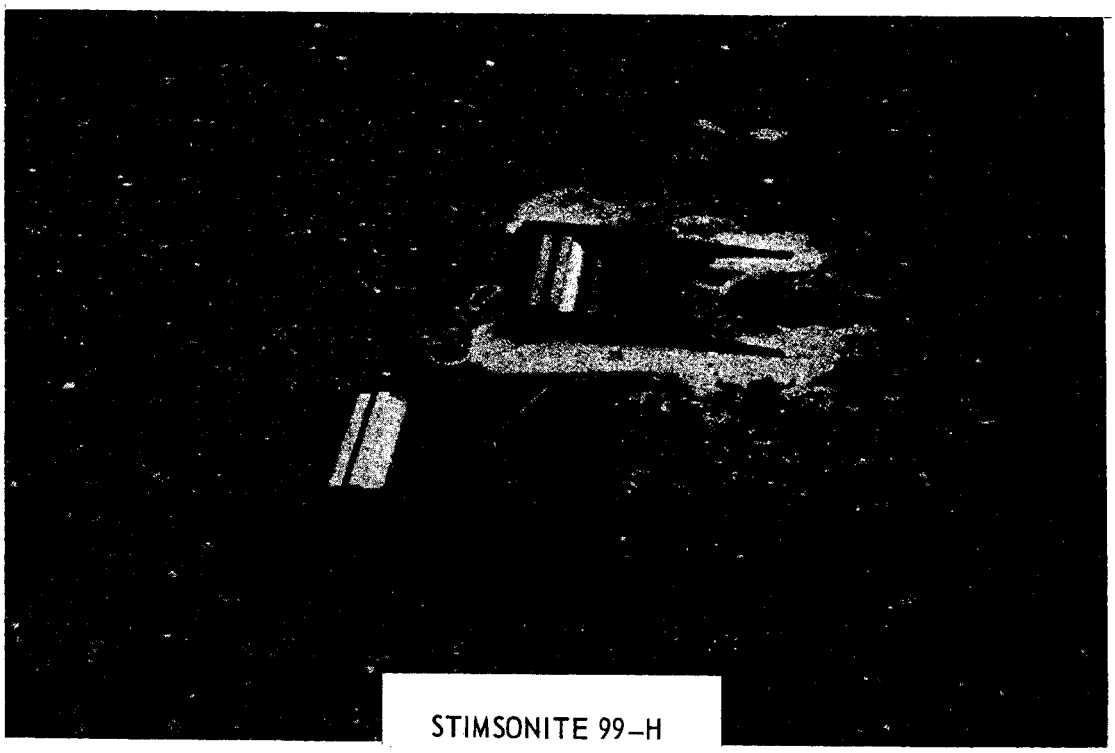
winter. The loss of castings was attributed to low rail (Figure 4) hardness, lack of adhesion of epoxy to the castings from a prior coating applied to the casting for retarding rust in storage, and the use of tungsten carbide inserts in snowplow blades.

"D" THRU "G" VERSIONS

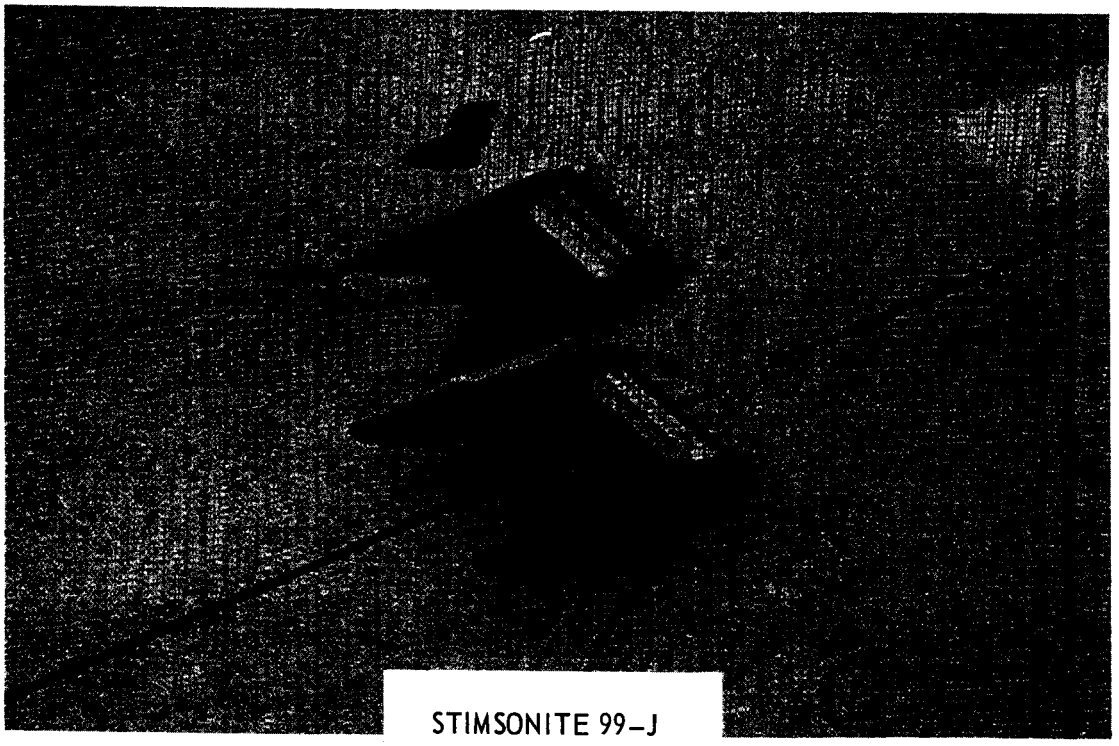
In July 1971, a test of several different prototypes for a new design marker was conducted. A heavy carbon steel plow resting fully on dry pavement was driven many times at 25 to 30 miles per hour over the markers. The test results, along with accumulated recommendations from prior installations, effectuated a casting change with a work hardening manganese steel and a 6° slope to the front end of the marker on the rail instead of the 10° slope incorporated in versions "A," "B," and "C." The change also included a solid reflector platform that could not allow the accidental passage of epoxy during installations.

"H" VERSION

The new castings were referred to as the "H" version (Figure 2) and 101 of these with a new type, but smaller, reflector were installed on I-95. After seven snowfalls during the winter of 1971-1972, 50 percent of the reflectors were found to be missing, and 6 percent were cracked. Two percent of the castings had been removed. Snowplow blades used at the site during that winter were examined. Those with tungsten carbide inserts were found to have an irregular edge with some of the inserts shattered. Carbon steel edged plows and graders suffered no damage. It was hypothesized that the reflector loss was due to the irregular edge developed on the tungsten carbide blades from impacting the castings. Further design recommendations were thus made to the manufacturer.



STIMSONITE 99–H



STIMSONITE 99–J

FIGURE 2

"J" VERSION

A revised casting, referred to as the "J" version (Figure 2), incorporated wider rails with impact pads at the base, a change in alloy, and more deeply inset reflectors. Twenty of these markers were plowed during the summer of 1972 by a carbon steel edged plow, a tungsten carbide insert edged plow, and a carbon steel edged heavy grader. After ten passes with the full weight of the carbon steel edged plow on the concrete pavement, no more than a polishing effect was produced on the markers and no significant roughness was noticed on the plow blade edge. After eleven passes with the full weight of the tungsten carbide insert edged plow, a step was produced on the left rail of the first marker with a piece of the web cracked off at that point. Less noticeable effects were produced on the other 19 markers.

The tungsten carbide insert was shattered where it hit the markers, the holding steel was turned up at the leading edge, and three holding bolts were parted from the blades.

After about seven passes with the grader, using full down pressure, no noticeable damage to either blade or castings was found beyond blade edge grooves from passing over the step in the first marker.

"K" VERSION

The "K" version (Figure 3) is the latest type produced by the manufacturer. The only difference from the "J" version is that it has a thicker web. In November 1972, 300 markers of the "K" version were installed on the northbound roadway of I-95. Two hundred yellow markers were installed next to the median edgeline every 40 feet and 100 clear markers were installed between every other lane line, every 80 feet. A tire stud shield (Figure 4) was placed

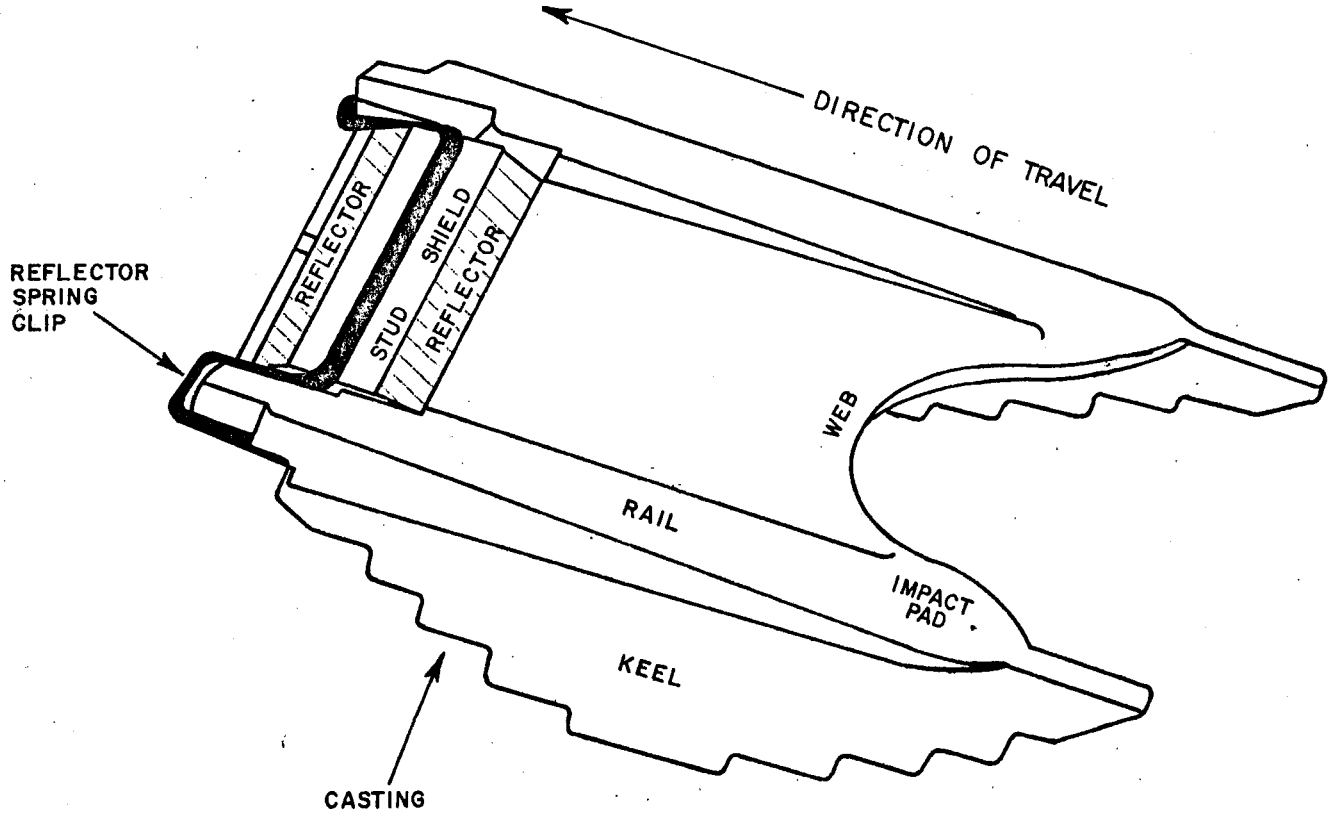
STIMSONITE 99–K

STIMSONITE 99–K

FIGURE 3

FIGURE 4

MARKER DETAILS



on every other reflector. During the winter of 1972-3, there were no accumulating snowfalls and no snow removal operations. The only effect that could be checked on this installation was on the effectiveness of the stud shield. In March 1973, two successive reflectors at four locations were removed from the lane line and observed for damage from studded tires to see how the stud shield performed. More than one-third as many additional stud marks were found on non-shielded reflective surfaces. The tops of the non-shielded reflectors were chipped to a large extent, while the tops of the shielded reflectors were not affected. The reflective area is not reduced by using a stud shield.

PLOW TESTING OF "H" AND "K" VERSIONS

One hundred markers of each version were included in these tests. The purpose of the tests was to get an indication of what would happen to the castings, reflectors, plow blades and pavement when plowed by carbon steel and tungsten carbide insert blades at 30 to 35 miles per hour. The plowing was conducted during the summer.

The results of the testing are summarized as follows:

1. Two passes with carbon steel blade, on "H" version:
    a. No castings were removed or damaged.
    b. One reflector was removed.
    c. The plow blade was not significantly affected.
    d. The pavement was not affected.
2. Two passes with carbon steel blade, on "K" version:
    a. No castings were removed or damaged.
    b. No reflectors were removed.
    c. The plow blade was not significantly affected.
    d. The pavement was not affected.

3. One pass with tungsten carbide insert, on "K" version:
   a. No castings were removed. Some scraping, but no gouging of the castings, was noticed.
   b. No reflectors were removed.
   c. The tungsten carbide inserts were shattered and the holding steel was turned forward and irregular near the center of the plow.
   d. Scrape marks were left on the pavement.
4. One pass with tungsten carbide inserts, on "H" version:
   a. No castings were removed. Scraping and noticeable gouging was noticed on eight castings.
   b. Four additional reflectors were removed from within the latter half of the installation.
   c. The tungsten carbide inserts were shattered and the holding steel was turned forward and irregular near the center of the plow.
   d. Scrape marks were left on the pavement.

VISUAL OBSERVATIONS

The reflective surface of the reflector was reduced significantly from the "A" version thru the final "K" version. This reduction has produced comments on the effectiveness of the reflectors in the roadway. However, this report will be limited to the following comments made during nighttime driving conditions on progressively worsening driving conditions. In dry conditions, when the painted lines were fully visible, the reflectors, when in a clean condition, were judged to be comparatively as effective as the

painted lines. In light rain, when the painted lines' visibility was reduced, the reflectors were again judged to be as effective as the painted lines. When the rain was so heavy that the painted lines were no longer visible, the reflectors were judged to be the only visible guidance on the pavement.

METHOD OF INSTALLATION

The installation method used was straight forward, involving three basic steps: (1) cutting slots in the pavement, (2) cleaning the slots and placing the castings into the slots with epoxy, and (3) attaching the reflectors and stud shields onto the castings with a spring clip.

Two 3/8 inch thick, 14 inch radial blades should be used to cut double 1-3/4 inch deep slots in the first step. A special adaptor was used to space the slots off one side of the cutting machine. Abrasive blades were used for bituminous concrete and these barely lasted through 300 cuts. Diamond blades were used for 1,141 cuts in concrete and will probably be good for several thousand more cuts before replacement will be needed. Water must be fed under pressure to keep the diamond blade cool, but this is not necessary for an abrasive blade.

CONCLUSIONS

As a result of the testing to date, the following tentative conclusions are made:

1. The castings and reflectors, as currently developed, are not affected by either the tungsten carbide or carbon steel snowplow blades.
2. The effectiveness of the reflectivity is found to increase with a worsening of wet night driving conditions.

3. A tungsten carbide insert snowplow blade is damaged by the castings, but no damage is incurred by a carbon steel snowplow blade.
4. The stud shield was found to be an effective protection for the reflector against the action of studded tires.

FUTURE PLANS

An 800 marker installation is planned for a section of U.S. 1 near New Brunswick. The installation is earmarked for durability evaluation over the 1973-4 winter and a wet night evaluation using traffic behavior variables by the Spring of 1974.

Questionnaires have been sent to States with other test installations of the "K" version marker. The results of this survey will be included in the final report along with the durability evaluation results.