INSTALLATION REPORT

STATE DEMONSTRATION PROJECT: LOOP DETECTORS

by

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(The opinions, findings, and conclusions expressed in this report are those of the authors and not necessarily those of the sponsoring agencies.)

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ABSTRACT

The Virginia Department of Highways and Transportation frequently utilizes induction loops in its vehicle detector systems. Although not documented, there have been many instances of loop failure; therefore, the practices and materials used by the Department in installing loop detectors were investigated. Two field tests were undertaken — the encasement of the loop wires by PVC conduit and vinyl tubing and the performance of different types of loop sealants. This report documents the installation of these two field demonstrations. Findings based on the installation are given; however, further findings, conclusions, and recommendations will be developed after an appropriate evaluation period.

ACKNOWLEDGEMENTS

A number of individuals were helpful to the authors during the course of this study. Thanks go to Wayne Rimmer of the Equipment Division for his cooperation in and supervision of installation of the test loops in the field; to Ben Cottrell, Neal Robertson, and Ed Galloway for their review of the draft report; to Susan Kane and Jan Kennedy for typing the draft report; and to Harry Craft and his staff for editing and producing the final report.

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INTRODUCTION

A common type of vehicle detector system utilized by the Department is the induction loop detector. Typically, the system is installed in conjunction with a traffic signal system or an isolated signal where vehicle detection is needed for actuation; however, it can also be used for other purposes such as volume counting. In fact, the Department plans to utilize loop detectors in its count program at permanent count stations.

The sensing element of a loop detector consists of a number of turns of wire (usually two to four) installed in a slot sawed in the pavement and covered with a sealant. The ends of the loop are brought out to the roadside and run to the associated electronic equipment, which generally is installed in a controller cabinet. The loops can range in size from 4 x 4 ft. to 20 x 100 ft. There are several different types of electronics associated with the system; however, all are designed around the principle of a change in inductance caused by the passage or presence of a vehicle.

Detector systems may fail to operate properly after some period of time. The most common cause of this problem is a failure in the loop sensing element, either within the pavement or in the length between the pavement and the electronics. Pavement deterioration through displacement, shoving, freezing and thawing, and snow-removal efforts can cause loop wires to snap or become wet and eventually short out. While the seriousness of this problem in Virginia has not been documented, the replacement of loops is not a rare event. As more loops are installed, it is anticipated that the problem and its ramifications will increase.

PURPOSE AND SCOPE

This project was undertaken to investigate the current practices and materials used by the Department in the installation of loop detectors. Two field tests were conducted — an investigation of the feasibility and value of encasing the loop wires in PVC conduit or vinyl tubing and of the performance of various loop sealants.

This report documents the installation and initial findings of the two field demonstrations. A final report summarizing further findings, conclusions, and recommendations will be developed after an appropriate test period.

DEMONSTRATION 1

The first demonstration site was at the intersection of Staples Mill Road (Route 33) and Bethlehem Road in Henrico County, just south of the Route 33/I-64 interchange and north of the Richmond city limits. An existing 8 x 40 ft. loop in the left-turn lane in the southbound direction had failed, and the controller had been switched to automatic recall for that phase. Stopping traffic coupled with a slight decline and a relatively large number of heavy trucks, especially ready-mix concrete trucks, had caused extreme pavement distortion. An approximately 40-ft. long section beginning at the stop bar had been shoved by traffic and exhibited washboarding. Significant displacements in the saw cuts for the existing loop indicated that the pavement deformation had caused the loop to fail.

The purpose of the first demonstration was to test the feasibility of encasing the standard loop wire (12 gauge, Type XHHW, 600 volt) in plastic tubing or rigid PVC conduit prior to installing it in the pavement. (See Figure 1 at the end of this section.) Current Department procedures call for inserting the loop wire directly into 3/8 in. saw cuts with no additional protection except for loop sealant.

The Illinois Department of Transportation has been very successful in reducing loop failures by encasing the detector wire in 1/4-in. OD vinyl tubing. Although it does provide some minimal physical protection, the primary advantage of the tubing is that it provides a space in which the insulated wire can move to adjust to pavement failure. The tubing helps to prevent a rupture of the insulation as sections of pavement shift.(1) On the other hand, the rigid conduits should provide physical protection of the loop wire.

Procedure

The existing loop was replaced with four, 3-turn, 7 x 8 ft. loops beginning just in front of the stop bar and spaced 2 ft. apart. Pavement deterioration was relatively uniform throughout the area of the

4 loops. The first and last loops were installed according to normal Department procedures and materials (except the saw cuts were 1/4 in. wide), whereas the middle 2 loops were test loops. Lead-in wires for each loop were embedded in separate cuts and run back to the splice box located in the median approximately 12 to 15 ft. beyond the last loop. Installation was begun on the morning of Thursday, November 5, 1981, continued through Friday, and finished in the morning on Monday, November 9, 1981. The weather was generally very mild with temperatures in the upper 60's and low 70's.

The detector wire in the test loop closest to the stop bar was encased in standard 1/2 in. PVC, nonmetallic, rigid conduit. The conduit was precut in the shop; however, the loop was formed, the wire inserted, and the loop glued together in the field. The preformed loop was then placed in the saw cut in the roadway. The cut was approximately 4 in. wide and ranged in depth from approximately 2½ to 5½ in. due to the pavement deformation. It had been made by sawing parallel cuts and using a jackhammer to break out the middle. The open end of the PVC loop where the lead-in wires emerged was packed with duct seal to keep moisture out. The Department's standard loop sealant, a two-component epoxy resin, was used to fill in around and over the PVC conduit, with the remainder of the cut being filled with hot asphaltic plant mix after the sealant had hardened. Figures 2 through 11 at the end of this section illustrate the installation of the PVC test loop.

The detector wire in the second test loop was encased in a low cost, flexible, high temperature vinyl tubing having a nominal inside diameter of 0.208 in. and a nominal wall thickness of 0.020 in. The wire was inserted in the tubing in the shop and placed in the saw cut just as any detector wire. The cut had been made with a single pass of a 1/2 in. saw blade, and the depth ranged from 1½ to 2½ in. due to the pavement deformation. The cut was filled with standard loop sealant. Figures 12 through 15 at the end of this section illustrate the installation of the vinyl tubing loop.

The 4 loops were wired together in series and then into the amplifier at the splice box. The amplifier is the type that will fail to put a call into the controller if the loop detector system fails. Accordingly, motorist complaints on not receiving a green signal should alert the Department immediately if a loop fails. Upon failure, the wiring can be separated and each loop can be tested to determine if it has failed. Thus a quantitative measure of performance will be obtained.

Findings

As indicated earlier, conclusions and possible recommendations concerning the encasements will be made in a later report after an appropriate evaluation period; however, documentation of several findings regarding the first demonstration and the Department's current procedures are warranted at this point. These are summarized in the following paragraphs.

1. The width of the saw cut for the PVC loop does not need to be 4 in. It should be slightly larger than the approximate 7/8 in. outside diameter of the PVC conduit to allow encapsulation by the sealant. A narrower width may be impossible, however, because of the size of the blade on the jackhammer or of other tools used.

2. In practice, the lead-in wires should also be encased in order to afford them the same benefits afforded the loop.

3. When a two-component sealant is used, the Department should specify that it be packaged in ready-to-mix quantities or that the mixing ratio be one that can be practically measured in the field. For example, the sealant used in the first demonstration called for a mixing ratio of 7 parts sealer to 1 part activator, with the base sealer coming in 5-gal. cans and the activator coming in 1-gal. cans. As is common practice in the field, the sealant needed to be mixed in a 2-gal. bucket having a pouring spout. Additionally, the base sealer was too thick and sticky to be easily measured utilizing the empty quart cans available. The practical problems and resulting "measuring estimates" arising from this situation are obvious.

   In recognition of this finding, the Purchasing Division has recently begun requesting epoxy suppliers to submit bids on sealants that will have a 1:1 mix ratio.

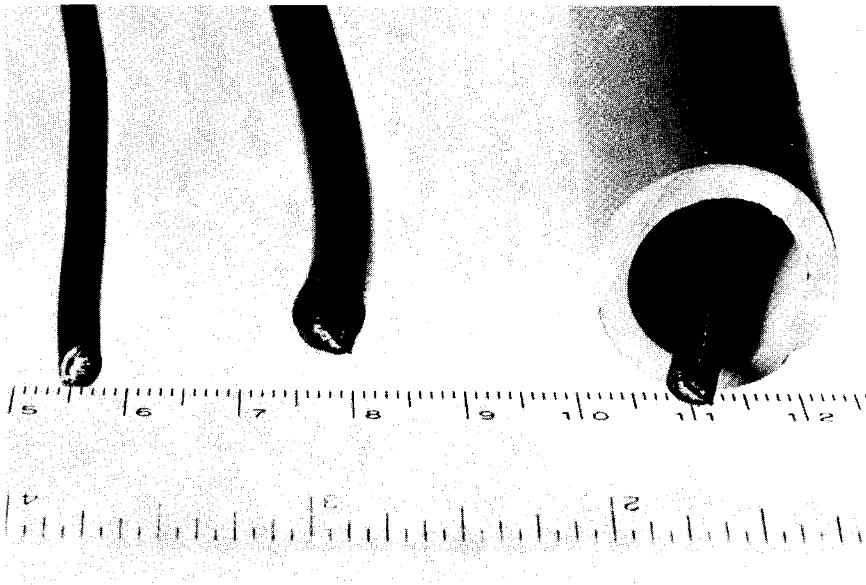

Figure 1. Loop wire encasements.

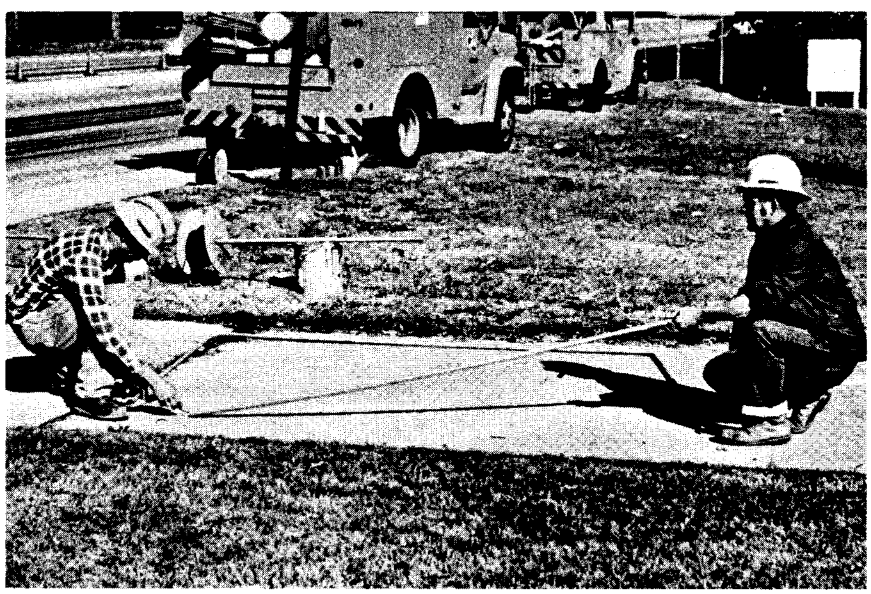

Figure 2. Formation and wire insertion for PVC loop.

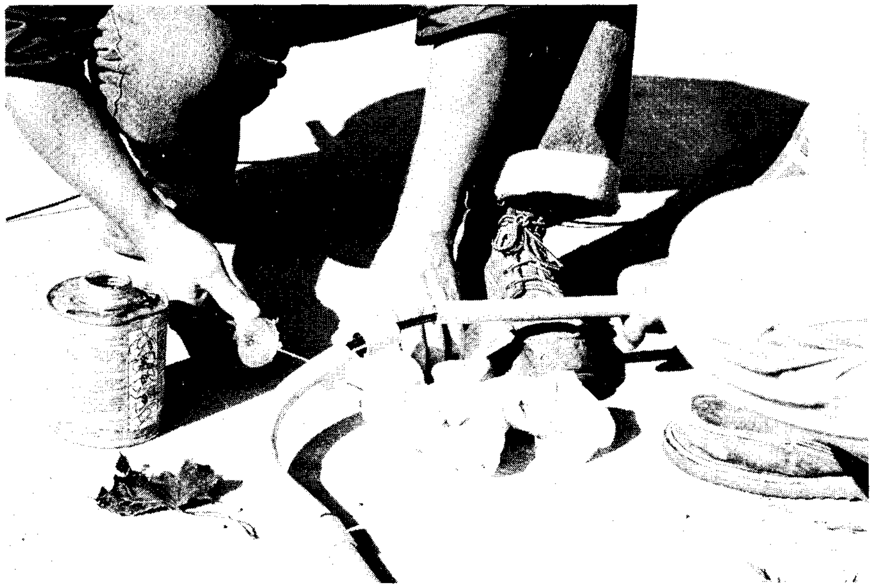

Figure 3. Gluing PVC loop.

Figure 4. Parallel saw cuts for PVC loop.

Figure 5. Breaking out the saw cuts for PVC loop.

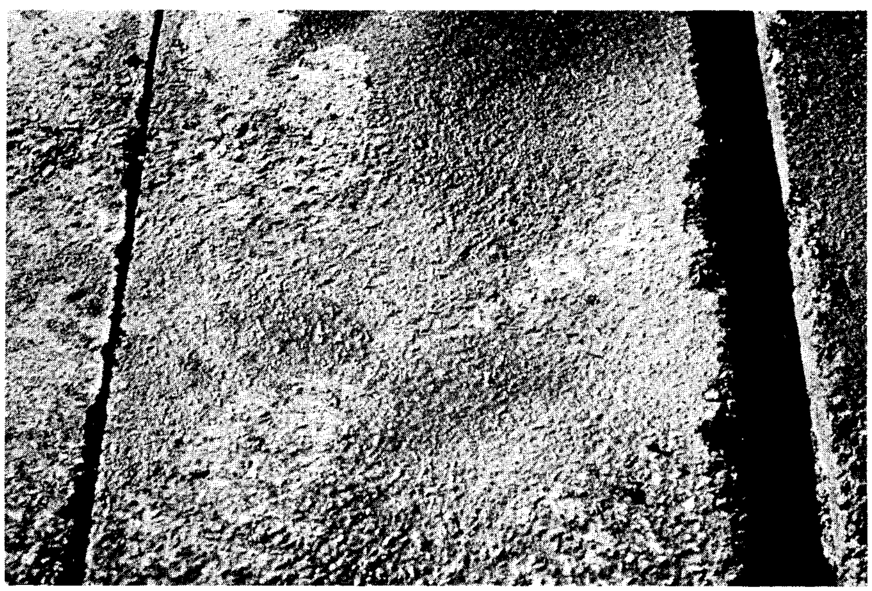

Figure 6. Comparison of saw cut for PVC loop (right) with typical saw cut.

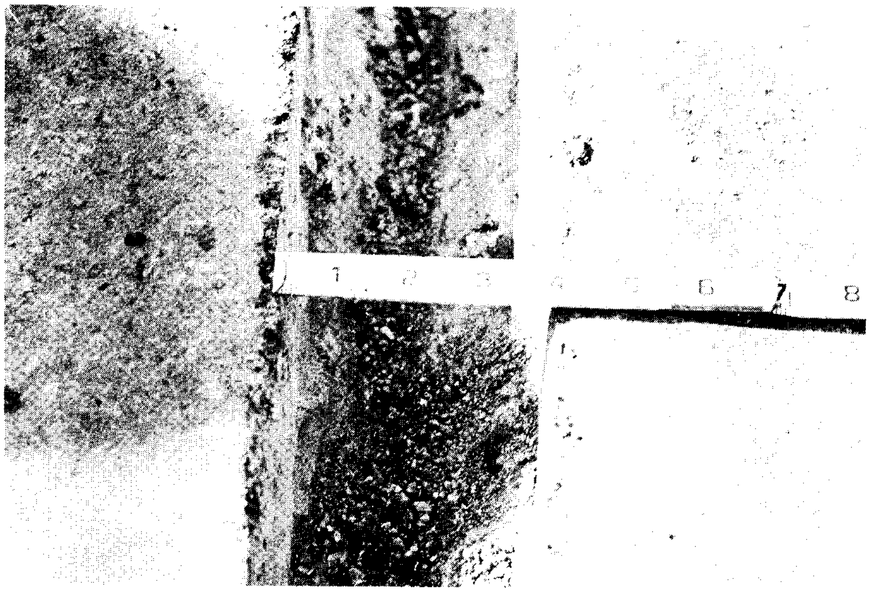

Figure 7. Four-in. saw cut for PVC loop.

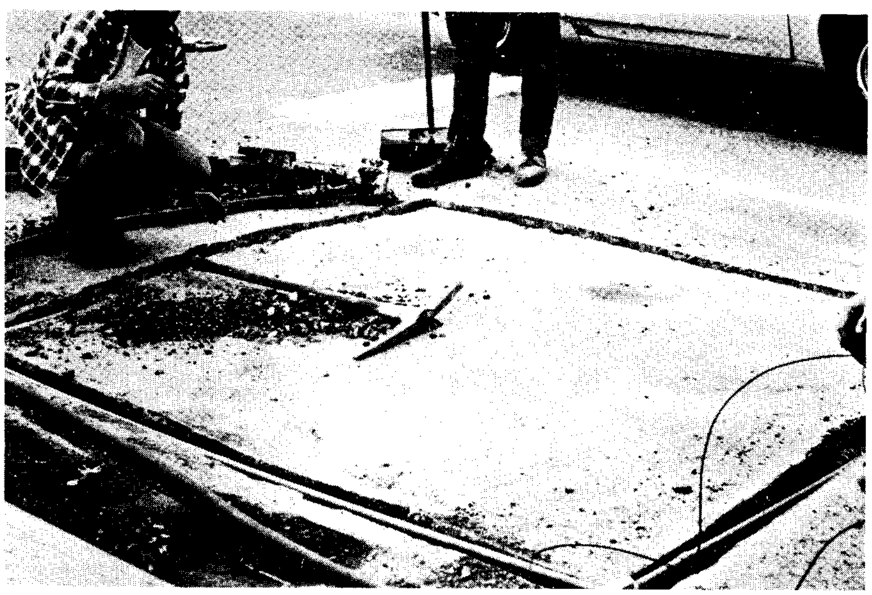

Figure 8. PVC loop in saw cut.

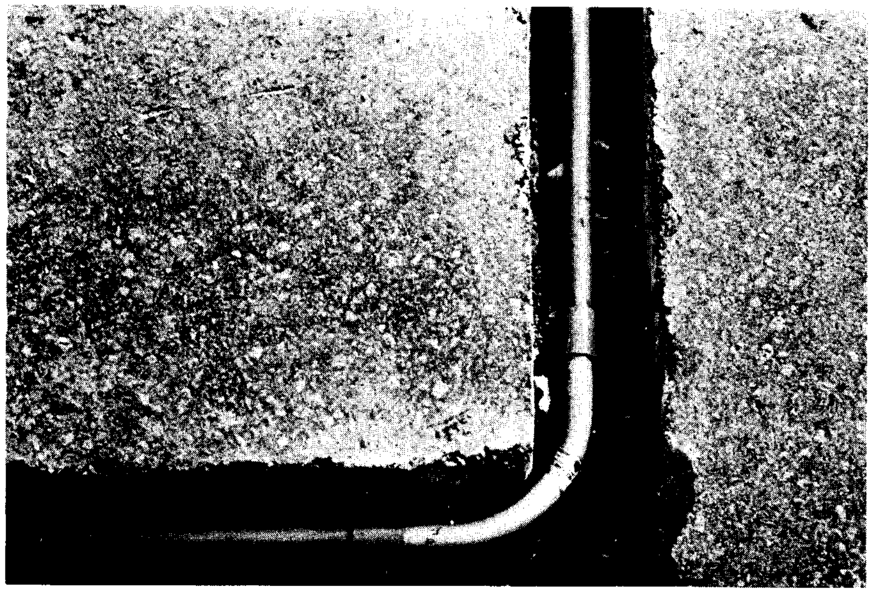

Figure 9. Typical corner on PVC loop.

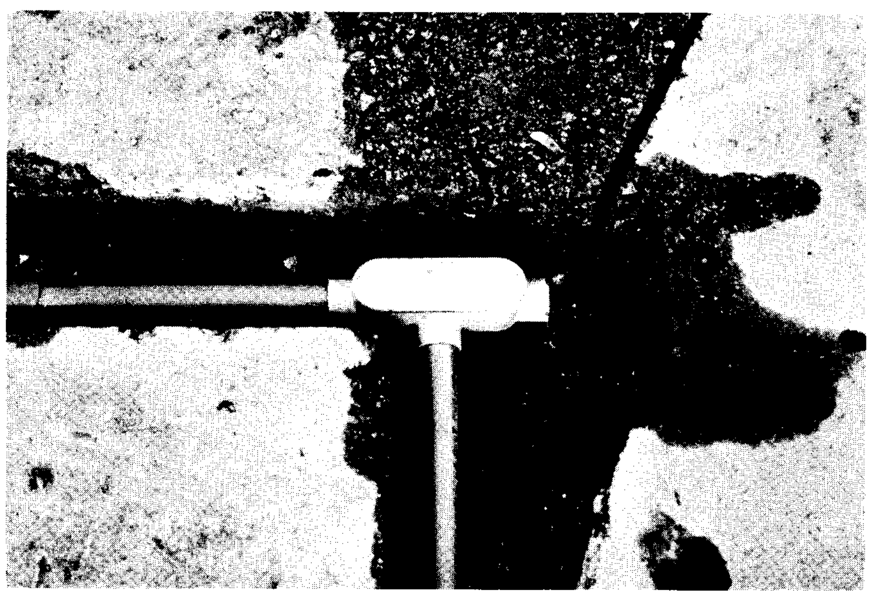

Figure 10. Corner with wire lead-in for PVC loop.

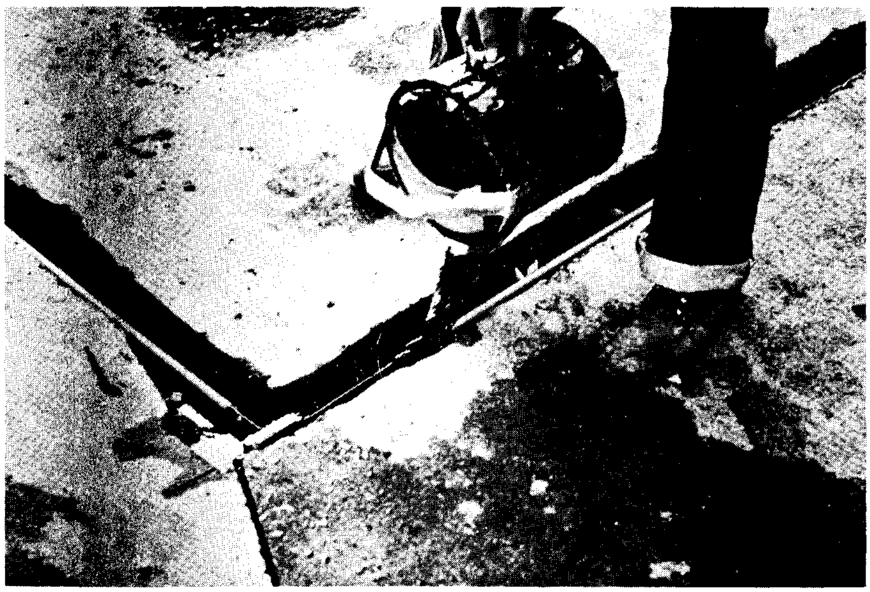

Figure 11. Filling cut for a PVC loop with sealant.

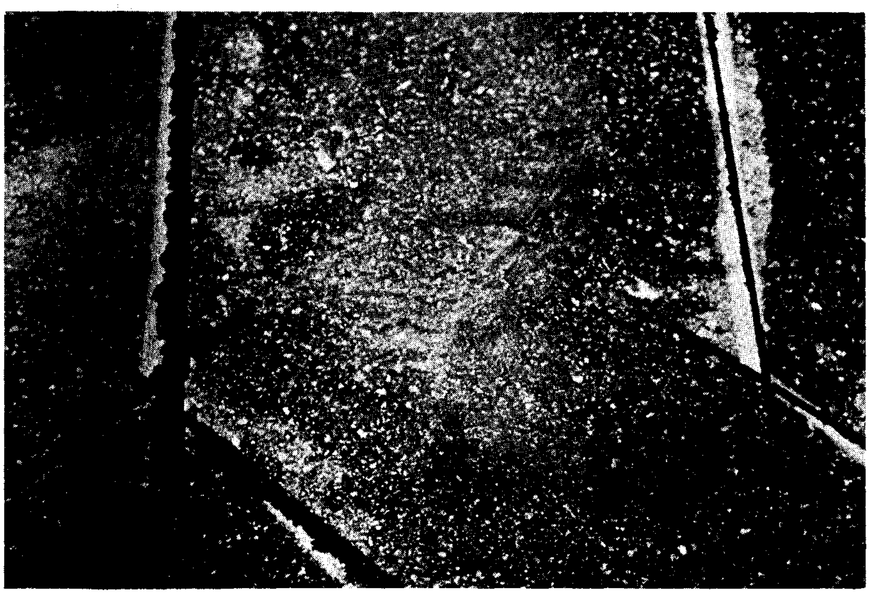

Figure 12. Comparison of saw cut for plastic loop (left) with typical saw cut.

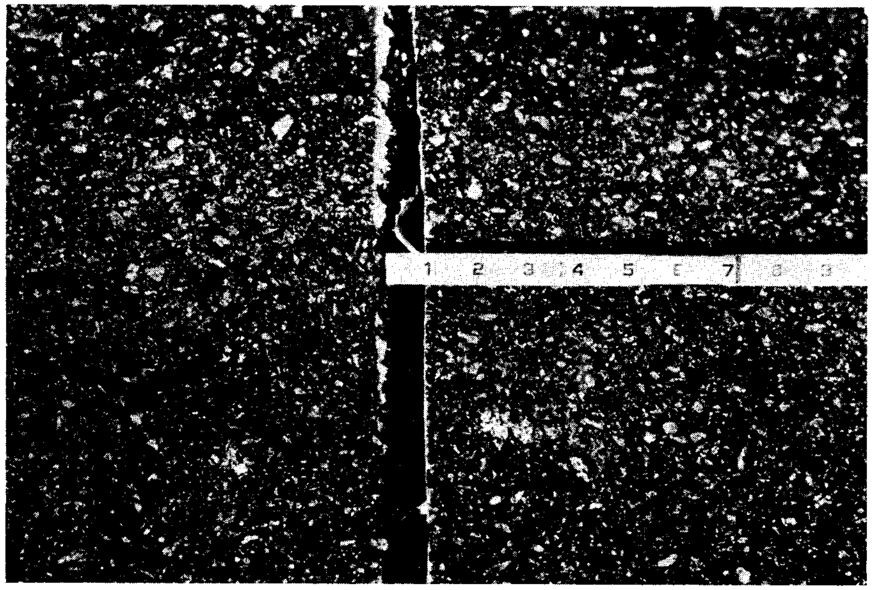

Figure 13. Half-in. saw cut for plastic loop.

Figure 14. Placing plastic loop in cut.

Figure 15. Filling cut for plastic loop with sealant.

DEMONSTRATION 2

The purpose of the second demonstration was to field test different types of loop sealants. The sealant is extremely important in maintaining a properly functioning loop detector system as, ideally, it should encapsulate the loop wires and prevent them from breaking. To perform that role, a sealant must be hard enough to resist penetration by roadway debris and yet flexible enough to provide expansion and contraction with temperature changes. It should be resistant to weather, abrasion, oil, gasoline, antifreeze, brake fluid, and road salt. Further, it should retain the aforementioned characteristics for a long period of time. The sealant must bond to the sides of the saw cut in both asphalt and concrete pavement, and should be applicable to damp surfaces as the slots for the loop wire are often cut with a water-cooled blade. Finally, a sealant should cure rapidly such that traffic can be allowed on it as soon as possible.(2)

Many types of sealants and installation procedures are used throughout Virginia and the country. The Department's standard procedure is to insert the loop wire directly into the saw cut and then fill the slot with the loop sealant. The slot is cut with a water-cooled or dry blade and measures 3/8 in. wide by 1½ to 3 in. deep, depending on whether the pavement is asphalt or concrete and on the number of turns of wire. An epoxy resin of polyester system is specified for the loop sealant, and the current specification is shown in Figure 16. It is noted that the combination of hardness and elongation specified typically results in a sealant which is relatively hard and brittle when cured. The most recent sealants appearing on the market are flexible, which to some extent reflects the latest thinking that the sealant should flex with the pavement. (This is especially true in the case of bituminous concrete.) Further, there is at least one single-component sealant. Neither the flexible nor one-component types meet the Department's current specification.

VIRGINIA DEPARTMENT OF HIGHWAYS AND TRANSPORTATION
SPECIAL PROVISION FOR
TRAFFIC LOOP SEALANT

Rev. October 23, 1981

Section 213 of the Specifications is amended to include the following:

Sec. 213.13 Traffic Loop Sealant Material shall be an epoxy resin or polyester system designed specifically to meet the physical properties for sealing traffic loop pavement cuts. The epoxy resin system shall be an unfilled system intended to be used with an equal volume of clean, oven-dry sand. The system shall bond to either portland cement concrete or bituminous concrete, shall be unaffected by environmental conditions and shall have a dielectric strength sufficient to allow the traffic loop to operate as intended. Viscosity of the mixture shall be such that it is easily pourable into the saw slot and sufficiently flowable to encase the electrical wiring.

(a) Epoxy Resin System shall be a two component material conforming to the following requirements based on the epoxy without sand, except for the pot life requirement:

PROPERTY	TEST METHOD	REQUIREMENT
Pot Life at 77°F w/sand (minute)	ASTM C881; Para. 11.2	12 min.
Initial Cure Time at 77°F (hour)		1 max.
Hardness, Shore D	ASTM D2240	25 to 65
Elongation (percent)	ASTM D638	50 min.
Water Absorption, 24 hrs. (percent)	ASTM D570	0.5 max.
3% NaCl Absorption, 24 hrs. (percent)	ASTM D570	0.5 max.
ASTM#3 Oil Absorption, 24 hrs. (percent)	ASTM D570	0.1 max.
Gasoline Absorption, 24 hrs. (percent)	ASTM D570	1.0 max.

(b) Polyester System shall be a two component material conforming to the following requirements:

PROPERTY	TEST METHOD	REQUIREMENT
Pot Life at 77°F (minute)	ASTM C881; Para. 11.2	12 min.
Initial Cure Time at 77°F (hour)		0.75 max.
Hardness, Shore D	ASTM D2240	25 to 65
Elongation (percent)	ASTM D638	15 min.
Water Absorption, 24 hrs. (percent)	ASTM D570	0.2 max.
3% NaCl Absorption, 24 hrs. (percent)	ASTM D570	0.2 max.
ASTM#3 Oil Absorption, 24 hrs. (percent)	ASTM D570	0.02 max.
Gasoline Absorption, 24 hrs. (percent)	ASTM D570	0.8 max.

Figure 16. Current loop sealant specification. (Source: Road and Bridge Specifications, Virginia Department of Highways and Transportation, Revised October 23, 1981.)

Procedure

Nine field test loops utilizing six types of sealants were installed. Standard practices were followed, except the saw cuts were 1/4 in. These loops are all 6 x 6 ft. and serve as volume-sampling detectors in a signal system on Broad Street (Route 250) in Henrico County, just west of the Richmond city limits. Details of installation are shown in Table 1. It is noted that one loop has been eliminated because of a problem in mixing the sealant, as explained in the next section.

The installation of each test loop was informally evaluated based on the criteria and rating scheme shown in Figure 17. This evaluation form was reproduced on the front and back of a card measuring approximately 8-1/2 in. wide by 7-3/4 in. long to facilitate its use in the field. The evaluations of the loops were obtained from various numbers of persons, depending on who was at the site; however, one of the authors (E. D. Arnold, Jr.) and the foreman of the signal crew evaluated all the loops.

The test loops will be monitored for an appropriate period to evaluate the performance of the sealants. It is noted that the original scope of the work has been expanded to include laboratory testing of the sealants.

Although not a formal part of the study, some testing was conducted at a site on Wilmer Avenue at its intersection with Route 1 in Henrico County, just north of the Richmond city limits. A replacement loop for a failed 6 x 40 ft. loop was installed, and various mixtures of sealants and filler were tested for ease of mixing and pourability.

Findings

Although final conclusions regarding the performance of the sealants, and possible recommendations, are reserved for a later report after an appropriate evaluation period, findings from the installation can be reported at this point. The results of the evaluation procedure are presented in Table 2 and discussed in general below.

Table 1

Installation Details for Loop Sealant Field Test

Loop No.	Date	Weather Condition	Sealant	Location
1	---------- Deleted Due to Mixing Problems ----------			
2	3/17/82	65^o-70^o F Sunny	Bondo P-606	Middle lane, westbound, Route 250, at entrance to K-Mart, Just west of Glenside Drive
3	3/17/82	65^o-70^o F Sunny	Sealex	Median lane, westbound, Route 250, at entrance to K-Mart, just west of Glenside Drive
4	3/18/82	50^o-55^o F Sunny	E-Bond 1260 with Saunders sand	Curb lane, westbound, Route 250, at entrance to Hechinger's, at Skeet Street
5	3/18/82	45^o-50^o F Cloudy	Gold Label Flex	Middle lane, westbound, Route 250, at entrance to Hechinger's, at Skeet Street
6	3/18/82	45^o-50^o F Cloudy	MagnoLoop I with play sand	Median lane, westbound, Route 250, at entrance to Hechinger's, at Skeet Street
7	3/19/82	55^o-60^o F Sunny	MagnoLoop I with Saunders sand	Curb lane, eastbound, Route 250, just east of Hungary Spring Road
8	3/19/82	45^o-50^o F Sunny	E-Bond 1260 with glass beads	Middle lane, eastbound, Route 250, just east of Hungary Spring Road
9	3/19/82	45^o-50^o F Sunny	3M	Median lane, eastbound, Route 250, just east of Hungary Spring Road

Evaluation of Loop Sealant Installation

Sample: ______________________ Name: ______________________

Instructions: Please circle the correct response for your opinion of the following installation activities.

Key: N = not satisfactory (below average)
S = satisfactory (average)
E = excellent (above average)

1. Ease of mixing

Overall ease of procedure	N	S	E
Time involved	N	S	E
Mixing proportions	N	S	E
Ease of stirring	N	S	E
Heat of mixture	N	S	E

Comments: ______________________

2. Typical quantity mixed N S E
Comments: ______________________

3. Ease of application

Overall ease of procedure	N	S	E
Consistency or viscosity	N	S	E
Control of sealant on grade	N	S	E
Encapsulation of loop wire	N	S	E
Expected coverage vs. actual coverage	N	S	E

Comments: ______________________

4. Pot life N S E
Comments: ______________________

5. Cure time N S E
Comments: ______________________

6. Clean-up N S E
Comments: ______________________

7. Overall evaluation of installation N S E
Comments: ______________________

Figure 17. Form for evaluating field installations.

Table 2

Results of Evaluation of Loop Sealant Installation

Loop No.	Sealant	Ease of Mixing	Quantity Mixed	Ease of Application	Pot Life	Cure Time	Clean-up
2	Bondo P-606	N	S	S	S	S	S
3	Sealex	E	S	S	S	S	S
4	E-Bond 1260 w/ Saunders sand	N	S	N	N	N	S
5	Gold Label Flex	S	S	S	S	S	S
6	MagnoLoop I w/ play sand	S	S	S	S	N	S
7	MagnoLoop I w/ Saunders sand	N	S	N	N	N	N
8	E-Bond 1260 w/ glass beads	S	S	S	S	N	S
9	3M	N/A	N/A	N	S	S	S

KEY: N = not satisfactory (below average)
S = satisfactory (average)
E = excellent (above average)

Bondo P-606

The Bondo P-606 flexible embedding sealer is a two-component polyester system consisting of a synthetic base resin to which a specific reaction initiator or hardener must be added for curing. The Department allows the use of Bondo; however, as is the case with all sealants, each batch must be laboratory tested to ensure compliance with the specification.

The instructions on the can indicate that the hardener, which comes in a 40 ml., clear plastic tube, should be added to the 1 gal. can of base sealer and mixed thoroughly. It is also noted that the proportion of hardener to sealer is not critical in obtaining a complete cure. Thus the rate of cure can be controlled for a wide range of ambient temperatures by varying the amount of hardener. Low temperatures retard curing, but additional hardener can be added to compensate. The opposite is true of higher temperatures. Unfortunately, absolutely no guidance is provided as to how much hardener should be added; not even an average or typical amount is indicated. A technical bulletin on Bondo does suggest that a 2 oz. bottle of hardener should be added. Accordingly, the entire 40 ml. tube of hardener was mixed with 1 gal. of base sealer. This proportion was apparently wrong for the existing temperature, as the mixture cured very rapidly and hardened in the pouring can before the entire loop could be finished. Thus the initial test loop was deleted and a second batch of Bondo using only about half the tube of hardener was mixed. The pot life for this mixture was satisfactory. It is obvious that better instructions on the proper mixing ratio are needed.

Usually sealant mixtures can be mixed by hand; however, Bondo did require the use of an electric paddle for proper mixing. Although not a problem, additional set-up and clean-up time was required.

All other aspects of installation were satisfactory, and the completely cured sealant is relatively hard.

Sealex

Sealex is a two-component loop sealant consisting of a base compound and activator. It does not meet the Department's current specification for loop sealants as personnel in the materials testing laboratory indicate that the cured product is too soft to obtain hardness and elongation readings.

Mixing is facilitated as the two components are packaged in premeasured quantities for ideal curing. A 4-oz. can of activator is simply added to 124 oz. of base compound contained in an imperial gallon container to allow room for mixing.

All other aspects of installation were satisfactory. The cured sealant is very soft and pliable, and small gravel, pieces of glass, or other road debris may penetrate the material and damage the loop wire.

E-Bond 1260

E-Bond 1260 is a two-component epoxy system which requires the mixing of 1 part A, 1 part B, and 2 parts filler. It meets the Department's specification for loop sealants.

Since the components are packaged in gallon containers, which is too much for direct mixing, the proper portions were measured using quart cans and mixed in a pouring bucket. The filler was a dry, relatively coarse sand provided by the sealant supplier. It should be noted that sand is important not only because it increases the coverage, but also because it absorbs some of the heat of the chemical reaction between parts A and B. Otherwise, the heat could possibly damage the loop wires or cause the sealant to crack.

The mixture derived from 2 qt. of part A, 2 qt. of part B, and 4 qt. of sand was not satisfactory. It was very thick, hard to stir, and difficult to pour. The sand settled out in the bottom of the pouring bucket, and the pot life was too short. Ths mixture was so thick that it is questionable whether the loop wires were fully encapsulated.

Even though the pot life was short, the sealant took a long time to fully cure. It was very sticky after 1 hr.; however, the lane had to be opened to traffic at that time. It was still sticky even after traffic had been on it for another 3/4 hr. When the sealant finally set up, it had settled within the saw cut, was relatively hard, and had a rough surface texture.

A second test loop was installed using 1 part A, 1 part B, and 1 part glass beads (half the recommended amount of filler). It is noted that glass beads, while likely more expensive than sand, are stocked in the Department's district offices and thus may be more readily obtained than the special sand. This mixture performed satisfactorily in all aspects of installation, except that it also took a relatively long time to completely cure. It was still tacky approximately 1½ hr. after installation. The cured sealant is relatively hard.

One final mix with E-Bond was tried at the site of the replacement loop on Wilmer Avenue. Equal parts of A and B were mixed with the recommended 2 parts of glass beads; however, the mixture was similar to that at the first E-Bond test loop. It was too thick and too hard to stir and, accordingly, parts A and B were added to yield a 1:1:1 proportion as used in the second E-Bond test loop.

Gold Label Flex

Gold Label Flex traffic loop embedding sealer is a two-component polyester system that meets the Department's specification. It is unique among the sealants being tested as one of the components is in powder form. It is packaged in a large bucket that contains 20 lb. of the powder and 1 gal. of liquid resin.

Instructions for mixing call for pouring 1/2 gal. of the liquid into a clean container and adding powder (approximately 7.5 lb.) until a uniform consistency similar to that of pancake batter is achieved. It is noted in the advertising that set-time and ultimate strength are virtually unaffected when the consistency is varied. This fact proves advantageous when installing a loop on a grade in that a stiffer mix to prevent flow of the sealant can be prepared by adding extra powder. The above instructions were followed and a pourable mix with sufficient pot life was obtained; however, it is felt that more precise instructions would be beneficial.

All other aspects of installation were satisfactory, and the cured sealant is slightly softer than the epoxy sealants yet seems to be hard enough to resist penetration.

MagnoLoop

MagnoLoop sealer is a two-component epoxy resin system that comes in two grades — MagnoLoop I and MagnoLoop II. The latter requires no filler, whereas the former, which was used in the field test, requires a mixture of 1 part A, 1 part B, and 2 parts filler. The material meets the Department's specification for loop sealants.

The two components are packaged in 1 gal. cans, which is too much for direct mixing; therefore, quart cans were used to measure the proper proportion of parts A and B and the filler. In this case, the filler was a fine and relatively wet play sand apparently purchased from a local building supply store and provided by the sealant supplier. The mixture was relatively thick and viscous but did pour satisfactorily. Approximately 10 minutes after filling the saw cut, the sealant settled below the top of the cut. Also, the mixture was still tacky about 2 hr. later. The cured sealant is relatively hard.

A second test loop using MagnoLoop I and the dry, relatively coarse sand provided by the E-Bond supplier was installed. The recommended mix ratio of 1 part A, 1 part B, and 2 parts sand was used. The mixture was too stiff and sandy, with sand settling in the pouring bucket; both the pot life and curing time were too short. The mixture was so thick and hardened so rapidly that it was difficult to fill the saw cut. The sealant set up on the surface of the pavement at the edge of the cut, causing a serious clean-up problem. The cured sealant is relatively hard and has a rough surface texture.

Three other test mixtures were tried at the Wilmer Avenue site. In all three cases the recommended amount of filler was halved; i.e., the mix ratio was 1 part A, 1 part B, and 1 part filler. Both types of sand and the glass beads were used as the filler, and all three mixtures poured satisfactorily. However, the mix using the dry, relatively coarse sand was very thick, was noticeably harder to pour, and had sand settling out in the pouring bucket.

3M

The 3M detector loop sealant is a one-component system that cures when exposed to moisture. In addition to eliminating the mixing process, a single-component system avoids the waste that often results from having to mix prescribed amounts of components in order to prepare the sealant. The Department's testing laboratory has not evaluated the material for compliance with the loop sealant specification; however, it appears from the data provided by 3M in its advertising that the product is soft.

The 3M sealant is packaged in either quart cartridges, which are then applied by a conventional cartridge gun, or 5-gal. pails, which are then applied by bulk handling pump equipment. The test loop was installed using a trial installation kit containing a manual caulking gun, a special applicator nozzle, and sealant. The sealant flowed smoothly into the saw cut; however, the manual application procedure was very time consuming when compared to pouring the sealant from buckets. As the cartridge was emptied, squeezing the caulking gun became more and more difficult and tiring. It appeared that in at least one of the cartridges the sealant had hardened prematurely at the bottom. The instruction calling for the slot to be filled within 1/8 in. of the top was not closely followed, and the sealant expanded and overflowed the saw cut. The sealant was still very viscous after 2 hr.; however, vehicles did not track it when allowed on the roadway. The lengthy curing time is normal due to the curing process.

Other aspects of installation were satisfactory, and the cured sealant is very flexible and rubbery; however, it seems to resist penetration by sharp objects.

General

Based on the findings from the test installations and on general information obtained about the Department's loop installation procedures, the following general findings regarding loop sealants are in order.

1. Standard practice in the field is to mix the sealant in a 2-gal. bucket having a pouring spout. In the case of an epoxy sealant, this means mixing several quarts of part A with equal portions of part B. In terms of stirring each part prior to mixing and physically handling the parts during the mixing, gallon containers of parts A and B are ideal. In the case of a polyester sealant where a hardener is added to a base component, a gallon of base works very well in view of the standard mixing practice mentioned above. Although the amount of sealant needed depends on the size of loop being installed, it appears that 1-gal. units of sealant mix are optimum for best utilization and least waste.

   In recognition of this finding, the Purchasing Division has recently begun requesting suppliers to submit bids in which the sealant is provided in 1-gal. containers.

2. In a two-component system, instructions for mixing the proper proportions should be as precise as possible. Guidelines should be provided even if the proportions are not critical for proper curing. In this regard, premeasured packaging is ideal.

3. Of the six sealants tested, the two epoxy systems caused the most problems in installation. This might be expected as epoxy sealants require a third component, the filler, which adds another variable to the mixture. Thus, there are three variables to consider in trying to explain the problems encountered — the sealant, the type of filler, and the amount of filler. Table 3 shows the combinations tested and whether a problem occurred. The following general observations can be made.

a. Problems in curing occurred at all test loops using an epoxy system. None of the other sealants tested presented this problem.

b. Problems occurred in all tests where the relatively coarse, dry sand was used.

c. Very few problems occurred when the relatively moist, fine sand was used.

d. Few problems occurred when glass beads were used.

e. Considerably fewer problems occurred when the sealant mixture contained 1 part filler rather than 2 parts.

Table 3

Summary of Test Results for Epoxy Systems

Test Mix	Problems with Installation: Mix	Pour	Pot Life	Cure	Shrink
E-Bond 1260/Saunders Sand/1 part	NT	NT	NT	NT	NT
E-Bond 1260/Saunders Sand/2 parts	Y	Y	Y	Y	Y
E-Bond 1260/Play Sand/1 part	NT	NT	NT	NT	NT
E-Bond 1260/Play Sand/2 parts	NT	NT	NT	NT	NT
E-Bond 1260/Glass Beads/1 part	N	N	N	Y	N
E-Bond 1260/Glass Beads/2 parts	Y	Y	NT	NT	NT
MagnoLoop I/Saunders Sand/1 part	Y	Y	NT	NT	NT
MagnoLoop I/Saunders Sand/2 parts	Y	Y	Y	Y	N
MagnoLoop I/Play Sand/1 part	N	N	N	NT	NT
MagnoLoop I/Play Sand/2 parts	N	N	N	Y	Y
MagnoLoop I/Glass Beads/1 part	N	N	N	NT	NT
MagnoLoop I/Glass Beads/2 parts	NT	NT	NT	NT	NT

NOTES: Saunders Sand = relatively coarse, dry sand
Play Sand = relatively moist, fine sand
1 part = 1 part filler mixed with 1 part A and 1 part B
2 parts = 2 parts filler mixed with 1 part A and 1 part B
Y = Yes, there was a problem
N = No problem
NT = Not tested

FUTURE EVALUATIONS

As indicated throughout this installation report, a future report will present the results of evaluations of the performance of the test loops in both demonstrations. All loops will be monitored to ensure they are working, and periodic field inspections will be made to qualitatively assess the condition of the loops.

For the test loops in which the wires were encased, particular attention will be given to their performance versus the performance of the standard loops installed at the test site. The most important evaluation involving loop sealants will be a comparison of the performance of hard, rigid sealants and soft, flexible sealants. Cost information will also be collected for the various sealants. Finally, it is noted that laboratory testing of the sealants has been undertaken(3) to complement the field evaluation.

RECOMMENDATIONS

1. The award of the contract for the loop sealant used by the Department is based on the lowest cost per gallon of sealant. In order to account for the increased coverage expected by the addition of sand to the epoxy systems, the quantity of polyester sealant requested in the inquiry is increased by 66%. The cost of the required sand is also considered in developing a cost per gallon for the epoxy systems. For example, a recent inquiry requested bids for 800 gal. of epoxy or 1,328 (1.66 x 800) gal. of polyester. After adding a dollar amount to the epoxy bids to account for the cost of sand, all bids were divided by 1,328 to obtain the cost per gallon. The derivation of the 66% factor is suspect and, although suppliers are required to confirm that factor on the bid, the Department should investigate its validity.

2. With regard to state force work, the Department currently installs loop detectors year-round. The manufacturers of most of the sealants tested set minimum temperatures below which the sealants should not be applied. The Department should immediately investigate the feasibility of changing its loop sealant specification to include the requirement that the sealant must be capable of being applied year-round.

3. In the case of epoxy sealants, the type and quantity of sand added seemed to affect the performance of the sealant. These factors were discussed previously for the test loops. Further discussions with Department field personnel resulted in the

finding that in two instances so-called "blasting sand" stocked by the Department did not mix at all with epoxy systems; the sand settled to the bottom of the mixing bucket. For this reason sand was omitted from the mixture. The Department should undertake an investigation to determine the appropriate type and quantity of sand to be added to epoxy sealants and advise the field forces of the findings.

REFERENCES

1. Burmeister, D. L., and Parsonson, P. S., "Installation Innovations for Environmental Protection of Inductive Loops", Compendium of Technical Papers, Institution of Transportation Engineers, 49th Annual Meeting, 1979.

2. Excerpt from draft report on traffic detectors being prepared by Diaz, Sechinger, & Associates for the Federal Highway Administration.

3. Arnold, E. D., Jr., and G. L. Munn, "Addendum to Working Plan, State Demonstration Project — Loop Detectors," Virginia Highway and Transportation Research Council, VHTRC 82-WP8, June 1982.

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