IMPROVING MATERIALS AND METHODS FOR INSTALLING INDUCTIVE LOOP DETECTORS

FHWA-OR-RD 86-03
Final Report

by

Samuel A. Johnston
and
Keith R. Rudisil

OREGON DEPARTMENT OF TRANSPORTATION
Traffic Section
Salem, Oregon 97310

Prepared for

FEDERAL HIGHWAY ADMINISTRATION
Washington, D.C. 20590

June 1986

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-OR-RD 86-03	--	--

4. Title and Subtitle
Improving Materials and Methods for Installing Inductive Loop Detectors

5. Report Date
June, 1986

6. Performing Organization Code
--

7. Author(s)
Samuel A. Johnston
Keith R. Rudisil

8. Performing Organization Report No.
--

9. Performing Organization Name and Address
Traffic Section
Highway Division (O.D.O.T.)
Room 504 - Transportation Building

10. Work Unit No.
02-7611

11. Contract or Grant No.
HP&R 086-5166

12. Sponsoring Agency Name and Address
Oregon Dept. of Transportation & U.S. Dept. of Trans.
Research Section
Salem, OR

Fed. Hwy. Admin.
Office of Research
Washington D.C. 20590

13. Type of Report and Period Covered
Final
July 1983 - June 1986

14. Sponsoring Agency Code
--

15. Supplementary Notes

16. Abstract

This report is the final report of this research project. It describes a compiling of materials utilized by various agencies for use in formation of inductive loop detectors. It further lists methods by which different agencies install materials in order to obtain a resilient detection system. Tested were loop sealants, loop wire, preformed loops and loop sawslot cleanout methods. Included is a "Results of Survey" chart depicting materials and methods used by eight states.

It was found that though many different materials and methods are used to form inductive detector loops, there exist some major problems. These are, most commonly, loop sealant failure (loss of adhesion) and poor installation technique (inadequately cleaned sawslots).

17. Key Words
Inductive Loop Detectors, Detection System, Loop Sealant, Loop Wire, Preformed Loops, Sawslot Cleanout, "Results of Survey"

18. Distribution Statement
NO RESTRICTIONS

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	33	--

Form DOT F 1700.7 (8-69)

ACKNOWLEDGEMENTS

Our thanks to the Federal Highway Administration for providing the funds which made this project possible and to the Oregon State Highway Division Research Section for their assistance in project development.

Thanks also to those companies who supplied us with samples of loop sealant and loop detector wire.

Many thanks to the Traffic Engineering Sections of Alaska, California, Idaho, Montana, Nevada, Utah and Washington. They took the time to answer a rather long questionnaire and were generous in sending specifications and standard drawings to us.

We also appreciate the input received from city and county agencies throughout Oregon and from Oregon based electrical contracting companies.

Thanks to Metro Region, Region 2 and Region 4 personnel for their willingness to test new materials and methods. And finally, thanks to the Traffic Signal Unit for their expert help and advice.

INTRODUCTION

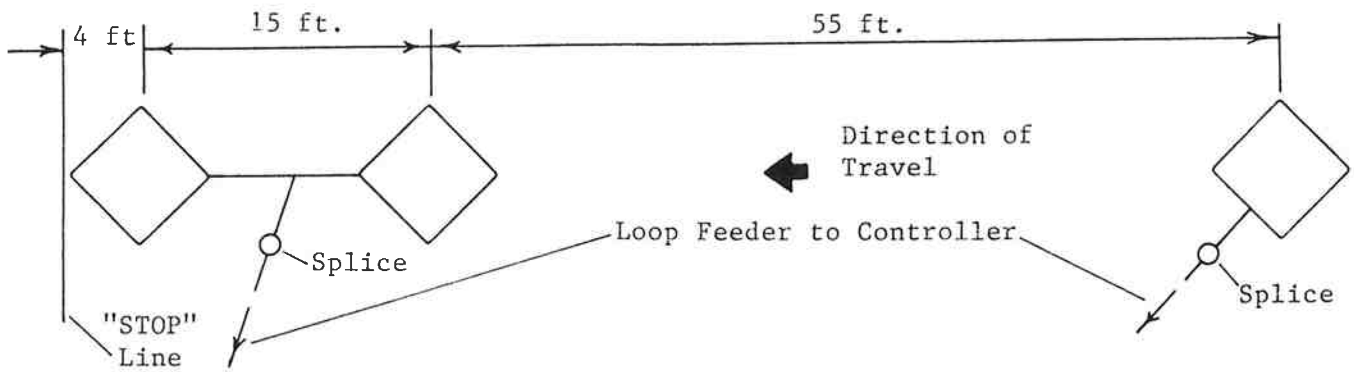
In November, 1983, when this project was initiated, Oregon vehicle detection consisted primarily of a 3 ft. by 3 ft. diamond vehicle detector loop, constructed of four turns of THWN wire. The loop was installed in a 1/4-inch wide saw cut and encapsulated in a preapproved sealant. The splice to the loop feeder cable was made as close as possible to the loop and was soldered, covered with heat shrinkable tubing and also encapsulated in a preapproved sealant. There were three preapproved sealants at the time. Two of them were of the epoxy base type and the third was a polyester base type. Loop feeder cable as specified was Belden No. 8720 or equivalent. The loop feeder cable was installed in a saw cut from the loop to the curb or edge of pavement near the controller and then in a conduit underground to the controller.

Standard loop configuration for pressure detection was two 3 ft. by 3 ft. loops in series in the field. These two loops were then placed in series in the controller cabinet to a third 3 ft. by 3 ft. loop. Spacing for presence loops from the 'STOP' line was 4 ft.-15ft.-55 ft. Presence operation was used on all left turn lanes and most side street lanes.

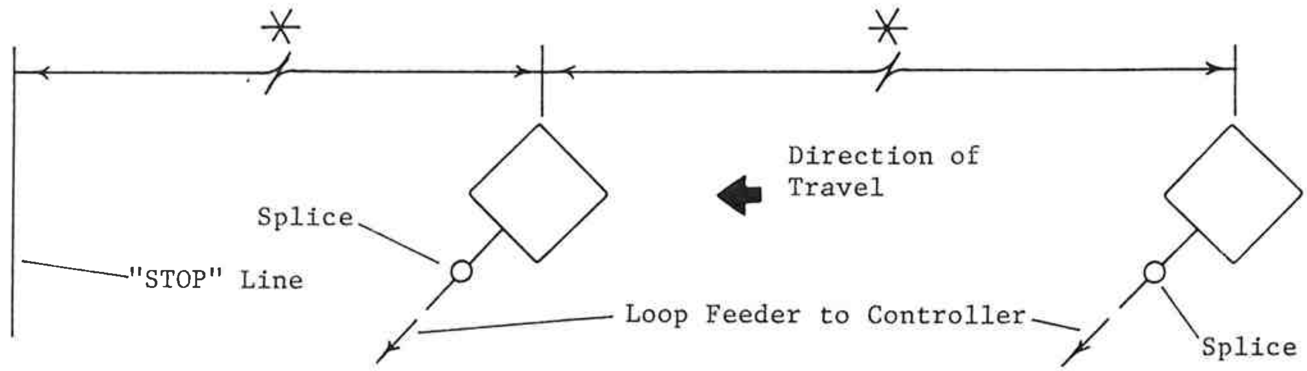
Density features were utilized on mainline through lanes where 3 ft. by 3 ft. loops were used to provide dilemma zone protection.

See Figure 'A' for 1983 standard loop placement.

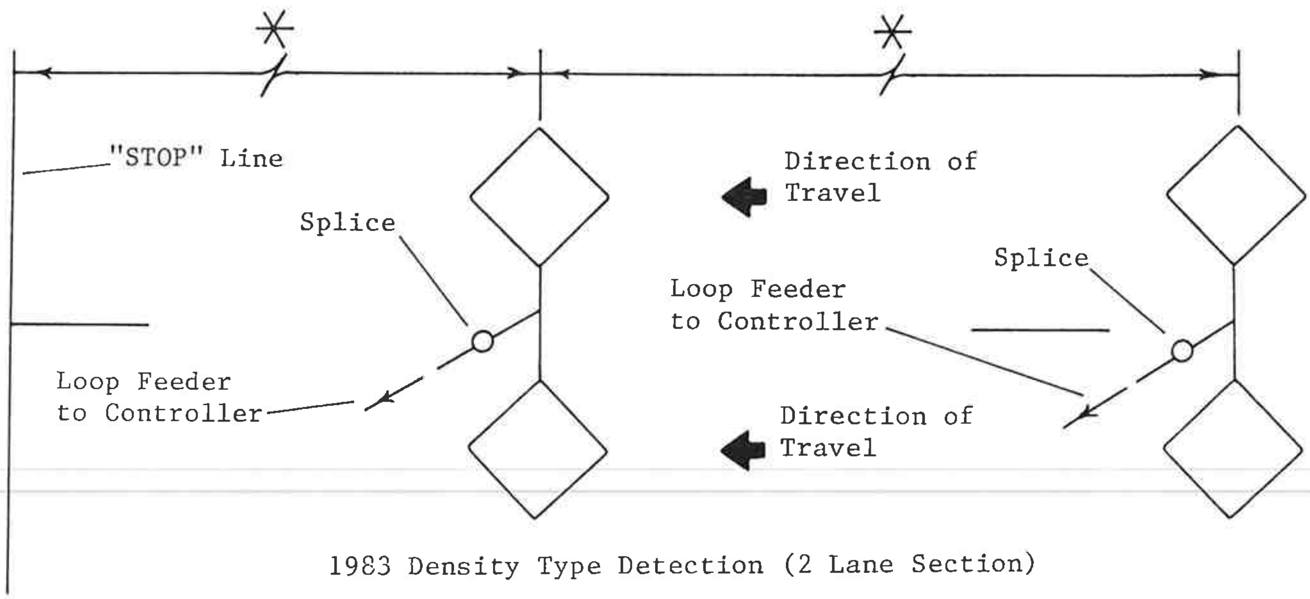
FIGURE A
All Loops 3 Ft. Diamonds
✳ Distance Varies With Speed



1983 Presence Loop Configuration



1983 Density Type Detection (Single Lane)



1983 Density Type Detection (2 Lane Section)

PURPOSE

The research project "Improving Materials and Methods for Installing Inductive Loop Detectors" originated with the purpose of identifying causes of loop system failures, assessing present methods utilized to remedy problems and to ascertain what materials and methods of installation provide the most dependable detection system.

Primarily we chose to conduct our research looking directly at the wire used to form loops, problems arising during loop installation, sealant related failures and maintenance problems that occur during the life of the loop.

We chose to conduct this project mainly by gathering related information from other state agencies as well as from Oregon county and city jurisdictions. We planned to assess accumulated data and perform testing on those materials and procedures that seemed most workable on our state system.

PROCEDURE

A large portion of this research project entailed gathering data from outside agencies that have direct involvement in inductive loop detector operations. The States of Alaska, California, Idaho, Montana, Nevada, Utah and Washington were sent a questionnaire containing thirty-five response opportunities. All states responded. This questionnaire was resubmitted to the same seven states approximately two years later in order to determine whether any changes in procedure or materials had evolved. During this period, Utah made no changes. California modified the sealant depth above the loop wire in the saw slot from 1/2" to 3/4" and has experimented with Overcoat Asphalt Emulsion loop sealant. This sealant failed at one location and California is currently re-evaluating its acceptability. Washington added RHH-RHW wire to its specified loop wire list. The other states did not respond.

Several larger Oregon cities and counties were contacted by phone as were three major contracting companies. Detailed information was also gathered from the Highway Research Information Service, from libraries and from studies performed by other agencies. Some of the reports and studies available are: Evaluation and Improvement of Inductive Loop Detectors (report FHWA/RR-84/119); Development of a Self-Powered Vehicle Detector (report FHWA-RD-79-89); A Status Report on Vehicle Detectors (report FHWA-RD-77-137); Electromagnetic Loop Vehicle Detectors (IEEE Transactions on Vehicular Technology, Vol. VT-19, No. 1, Feb. 1970); Installation of Vehicle Detector Loops (report FHWA/NY/SR-83/75); State Demonstration Project-Loop Detectors (Virginia report Nos. VHTRC 85-R21 and VHTRC 83-R15) and Study of Traffic Loop Failures (report FHWA/MN/RC-84/04).

The testing procedures carried out for the purpose of this research project focused on four areas which were perceived as probable elements where improvement could be made. Tested were; preformed loop installations, improved loop saw slot sealants, wire for loop formation and the procedure for loop saw slot cleanout.

FINDINGS

Sealant problems were by far the major reported cause of loop failures. Poor sealing caused by lack of adhesion to the sides of the saw slot or sealant cracking were often mentioned as concerns. Unclean or poorly cleaned saw slots as well as inadequately dried saw slots were widely noted as detrimental to long loop life. The State of Washington found that too many wires in a saw slot would act as a spring and gradually force the loop to the surface, thus promoting failure. Failure of loop sealant to set up or taking a long time to set up was mentioned by Montana as a sealant problem area.

Wire breakage caused by asphalt pavement deterioration was a common problem encountered by all agencies surveyed. The City of Albany, Oregon experiences pavement flexing and shoving which causes epoxy to pop out, thus necessitating re-epoxying of saw slot. Metro Region, which includes the Portland metropolitan area, has many problems in loop failure due to road wear down to loop wires. This occurs primarily in wheel rut locations. Many agencies also experience loop loss due to trenching for installation or maintenance of underground utility lines.

As might be expected, preference for loop wire size and type varied from agency to agency. Refer to Figure 'B' "Results of Survey" for loop wire preference information.

Alaska's exclusive choice for roadway installed vehicle detection is the preformed loop. Their preformed loop is composed of 1/2-inch and/or 1-inch PVC conduit, depending upon the number of loops required. The loop wire is placed in the conduit, which is then assembled to the specified loop dimensions. Alaska reports no loop failure using this system. Other states also use preformed loops, but not as extensively as does Alaska. Oregon uses preformed loops mostly in signalized gravel or dirt detour areas around bridge construction sites. California and Utah have experimented with preformed loops and have achieved satisfactory performance with no loop failures.

In September of 1984 the Region 4 electrical crew installed a preformed loop at Third Street and Wilson Avenue in Bend. This intersection is located on a section of The Dalles-California Highway (U.S. Route No. 97). Following are photographs and excerpts from the test report prepared by John Holcomb, Region 4 Traffic Operations Supervisor.

FIGURE B
RESULTS OF SURVEY

STATE	LOOP TYPE	LOOP WIRE	FEEDER CABLE	SPLICE TREAT.	SEALANT	SAWCUT WxD	CLEAN. METHOD	MAJOR FAILURE	AMP. TYPE	Inst. By. STATE	Inst. By. CONTR.	REMARKS
ALASKA	6'x6' sq. (3 Turns). 6'x20' Rect. (2 Turns)	#14 THHN Stranded	IMSA 50-2 or #12 Twist Pair, Shield & Drain	Solder & 3-M Kits or Equiv.	N/A	N/A	N/A	No Loop Failure	Det. Syst., Sarasota (Stand Alone)	10%	90%	Used preformed loops, exclusively.
CALIFORNIA	6'x6' Sq. or Dia. (3 Turns), 6'x6'-50' Quad. (2-4-2 or 1-2-1)	#12 RHW-USE (Neoprene or x-Link polyeth, Strn.	2-#12 Solid Unshielded, 2-#14 or 16 Strn.Shield, 4-#18 Strn. Shield	Solder, Pressure, connector, insulate & waterproof	3-M Sakrete, State Spec. Epoxy Overcoat (being reviewed)	W=¼"-½" D=3/4" Cover of Wire	Flush w/ H_2O, blow out w/air	Improper Sealing, Foreign Mat'l in Sawslot	2 & 4 Channel Digital (Rack Mount)	5%	95%	Used Preformed loops in poor pavement areas & dirt detours. Districts use different materials. Preco "Gold Label Flex" rejected by lab. "Crafco" being tested.
IDAHO	6'x6' Sq. (2 Turns of Cable)	Canoga 20002 Cable (Magnetometer Home Run, 4 Cond. #22)	Belden 8227	Solder, 3-M Splice Kit, or Heat Shrink Tube	"Gold Bond" (Black)	3/8"x1½" (Min.)	Blow Out w/air	Improper Sealing	Conoga 424 Sarasota 224 (Rack Mount)	10%	90%	Over 100 loops made w/ Conoga 20002, and no failures.
MONTANA	6'x6' Sq. 6'x20 Rect. Quadrupole (Various Turns)	#12 XHHW Stranded	Belden 8720	Solder, Waterproof	Preco or Bondo (both Work Well)	¼"x2" (Asph.) ¼"x1¼" (Conc.)	Blow Out w/air	Improper Sealing	Analog (Stand Alone)	10%	90%	Other sealants tried without success.
NEVADA	6'x6' Sq. (3 Turns) 6'x25' Rect. (2 Turns)	#12 RHW & XHHW (N. Nev.-Solid (S.Nev.-Strn.)	IMSA 19-2 (Paired Communication Cable w/ Shield	Solder, Wrapped	CalTran Spec (Hunts), 3-M, Gold Label Flex, Sakrete	¼"x2"	Blow Out w/air	Improper Sealing, Pavement Deterioration	Conoga, Det. Syst. ICC (Mostly Stand Alone)	5%	95%	Additional loops - 6'x70' Rect. (1 Turn), 6'x75 Quad. (1-2-1)
OREGON	4'x4' Dia. (Single Loop) 3'x3' Dia. (Series Loop) Both 4 Turns	#14 THWN Stranded	IMSA 50-2, Belden 8720 or Equiv.	Solder, Heat Shrink Tubing	Concresive 1064 & 1219 Dural 306-M EDOCO 2094	W=¼" D=1" Cover of Wire	Flush w/ H_2O, Blow out w/air	Improper Sealing	ICC, Det. System, Conoga, Sarasota (Rack Mount)	10%	90%	Additional Sealants- ELS 293, PG 3-52-1, EAS-14, Niklepoxy, 491-HP, Sealex.
UTAH	6'x6' Sq. (3 Turns) 6'x16' Rect. (x-Lane, 3 Turns)	#14 THHN or THNN Stranded	Belden 8720 or Equiv.	Splice Kit (Pad)	Bondo 606	¼"x2"	Blow Out w/air	Improper Sealing, Pavement Deterioration	ICC 38010, DS 811 (Stand Alone)	70%	30%	Some loops > 6'x16' used @ 2 Turns. Used some preformed loops with no failures.
WASHINGTON	6'x6' Sq. (4 Turns) 6'x50' Quad. (2-4-2)	#14 XLP, RHH, RHW or #12XLP Stranded	AIW 7311 or Belden 8718	Solder, Crimp Connection, Tape, Heat Shrink Tube	Crack Pouring Compound	¼'x2½" to 3"	Blow Out w/air	Improper Sealing, Foreign Mat'l. in Sawslot	Nema Grade, Conoga, ICC, Det. System (Rack & Stand Alone)	10%	90%	Better inspection of installations would improve performance.

NOTE: All states splice loop wire to feeder cable in junction box. Loop feeder runs to controller in conduit. Date of Survey: January 1984.

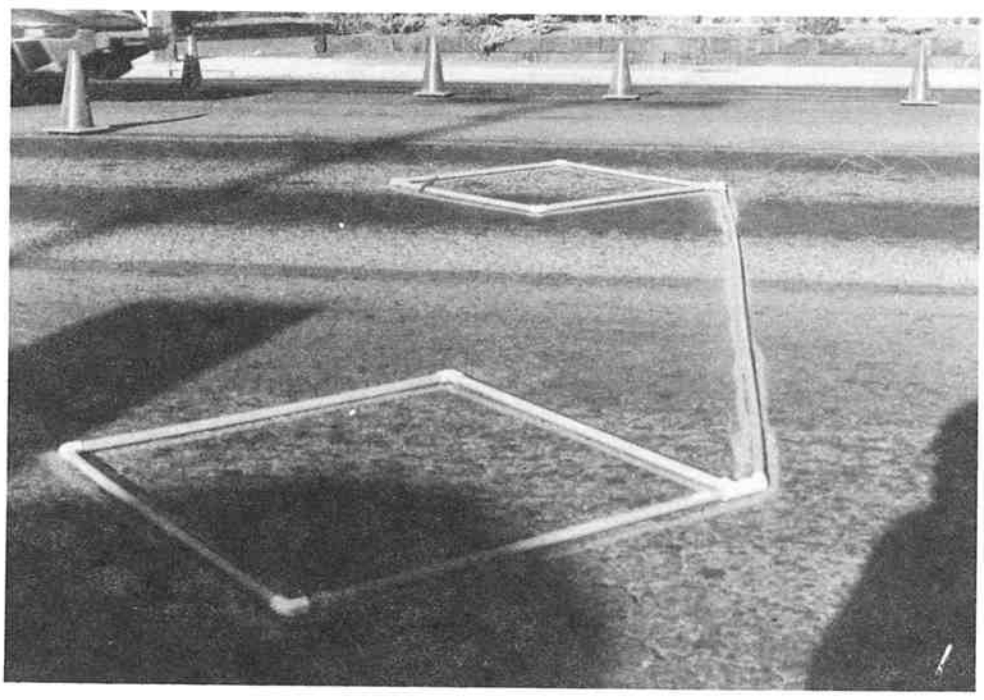
Preformed Traffic
Third St. at Wilson Ave. (Bend) Sec.
The Dalles--California Hwy.
Deschutes County
September 10, 1984

Description

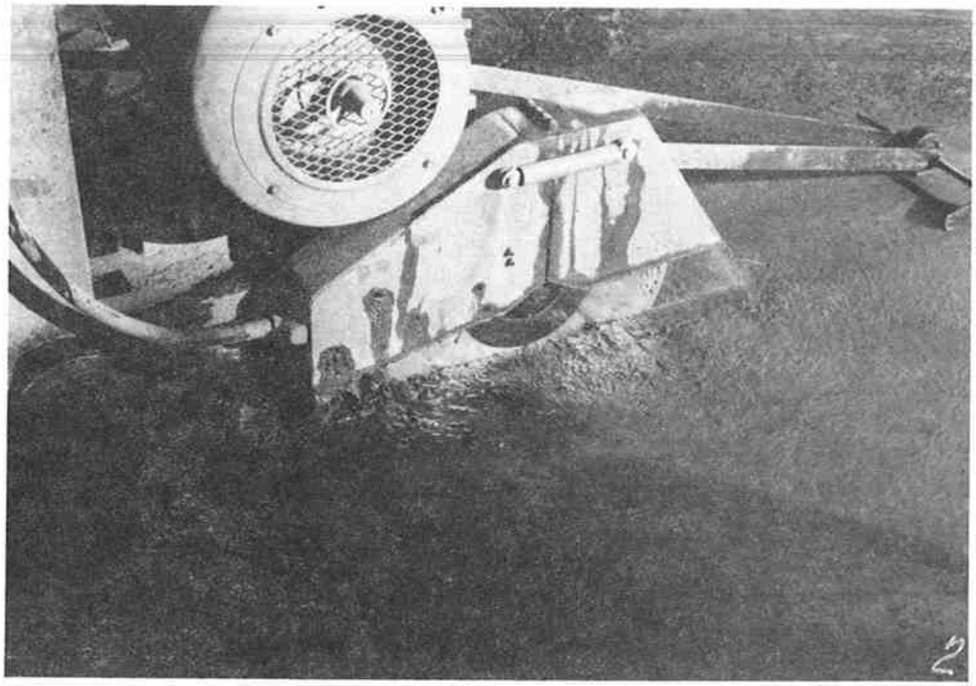
Distrct 10 used a large pavement grinder to repair several sections of Third Street. In the process, they ground up the existing detector loops in the inside lane of the south approach to this intersection. Their intent was to return and grind out the curb lane at a later date. One thing led to another and they were not able to return this season. In the interim, the signal has been operating on a "Max Recall" basis for the south approach. It is the District's intent to return next season and grind out the curb lane. The lanes are being ground out to a depth of two to three inches, and backfilled with a machine laid asphaltic concrete mix.

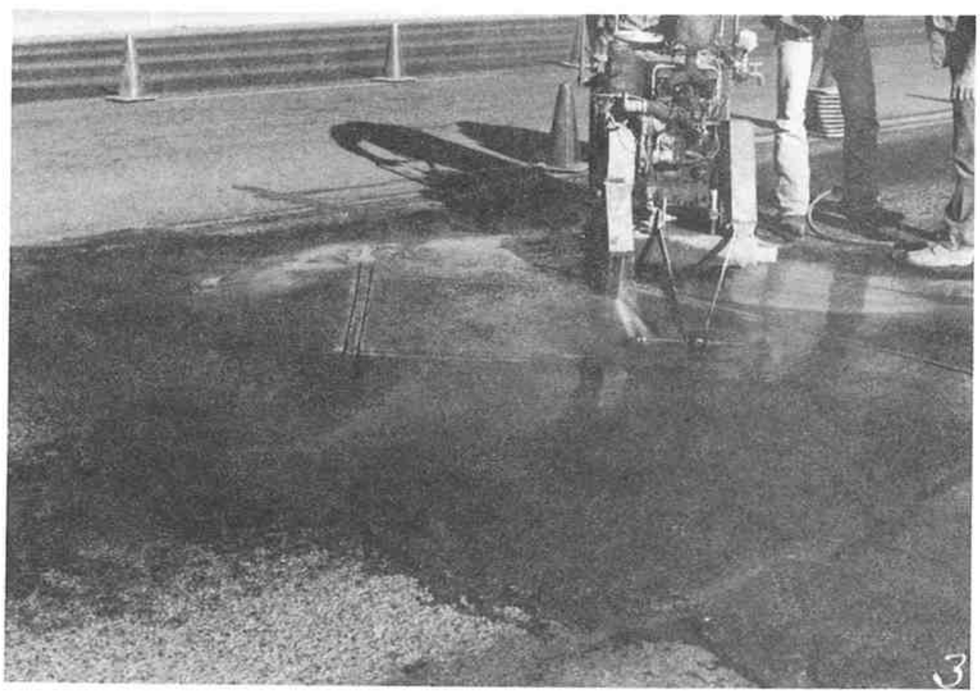
Just prior to the laying of the new A.C., a rigid conduit was placed containing the "lead-in" wires, and the new A.C. was laid over the top of the conduit. When the test loops were installed, the saw cut was made to a depth of two inches through the new A.C. and up to six inches deep in the old pavement that will be ground out at a later date.

The following is a pictorial description, in chronological order, of the installation.

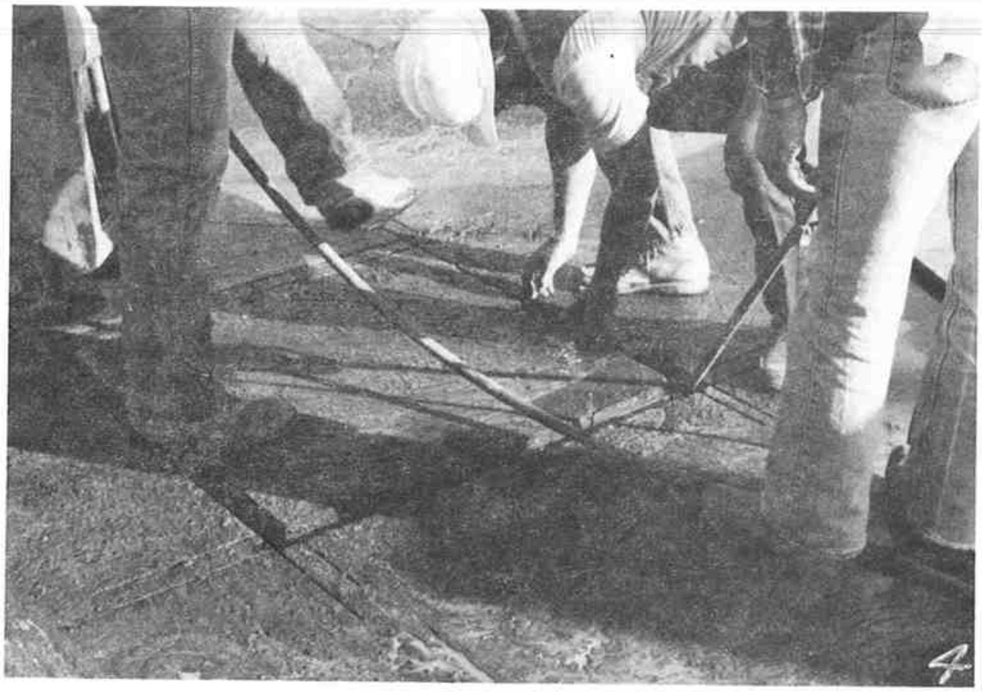


Picture 1: The preformed loop is laid out as a template and sprayed with aerosol paint. It is important to use the actual loop. This eliminates the possibility of small errors and distortions. It would be difficult to get an exact measure, either when forming the loops or laying out the pattern.



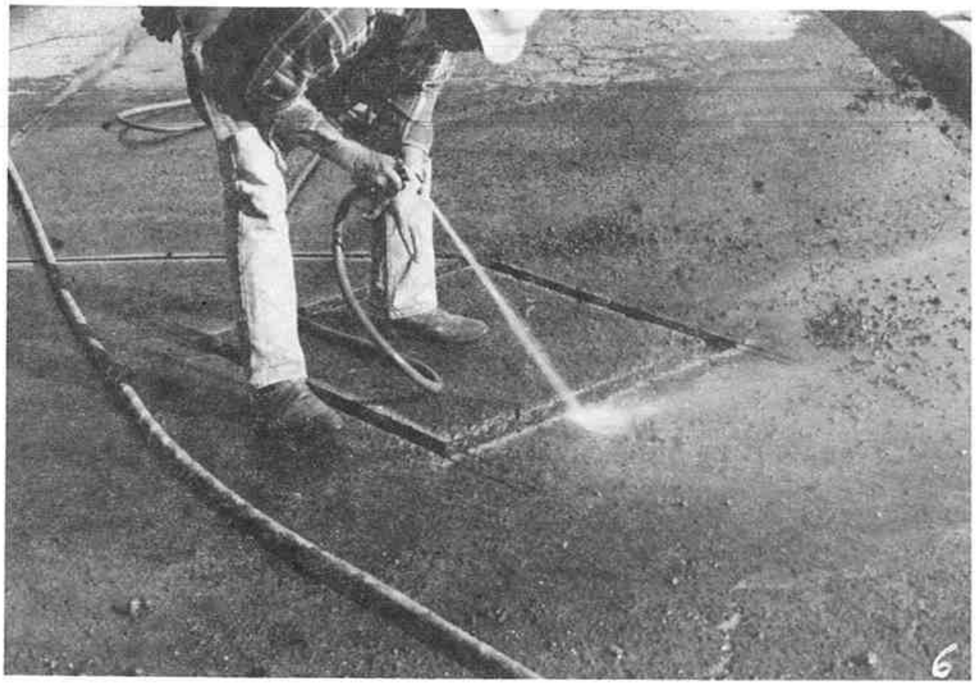


Picture 2: In order to obtain the extra depth required for the older pavement section, an 18" saw blade is used. The sawing machine is adjustable, and can be raised to a shallower depth as shown in Picture 3 .

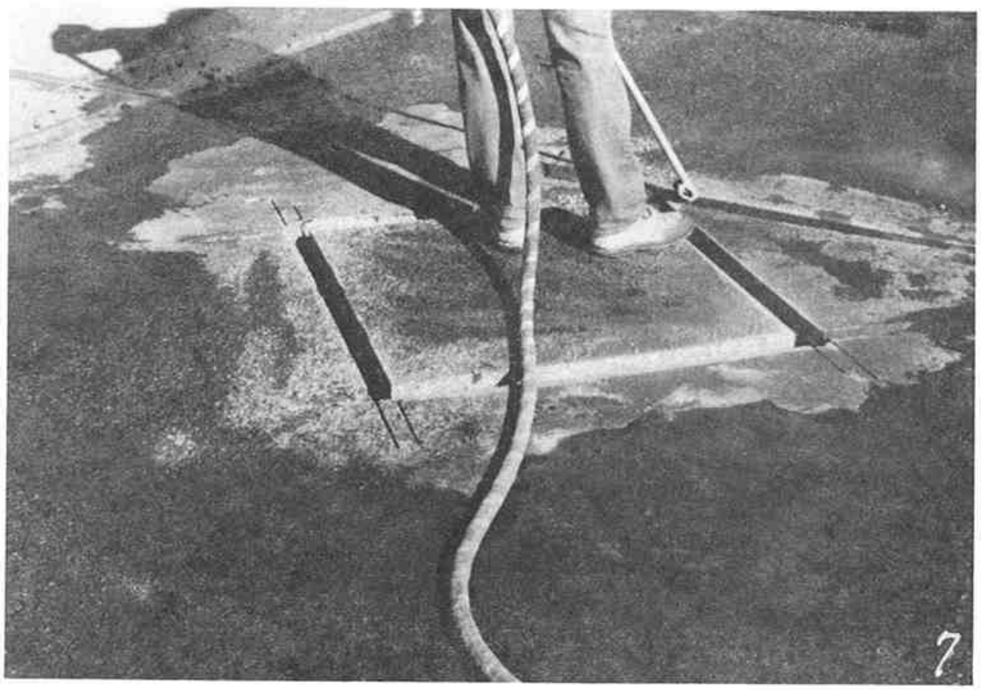


Picture 4: The pavement is easily pried loose from the sawed trenches.

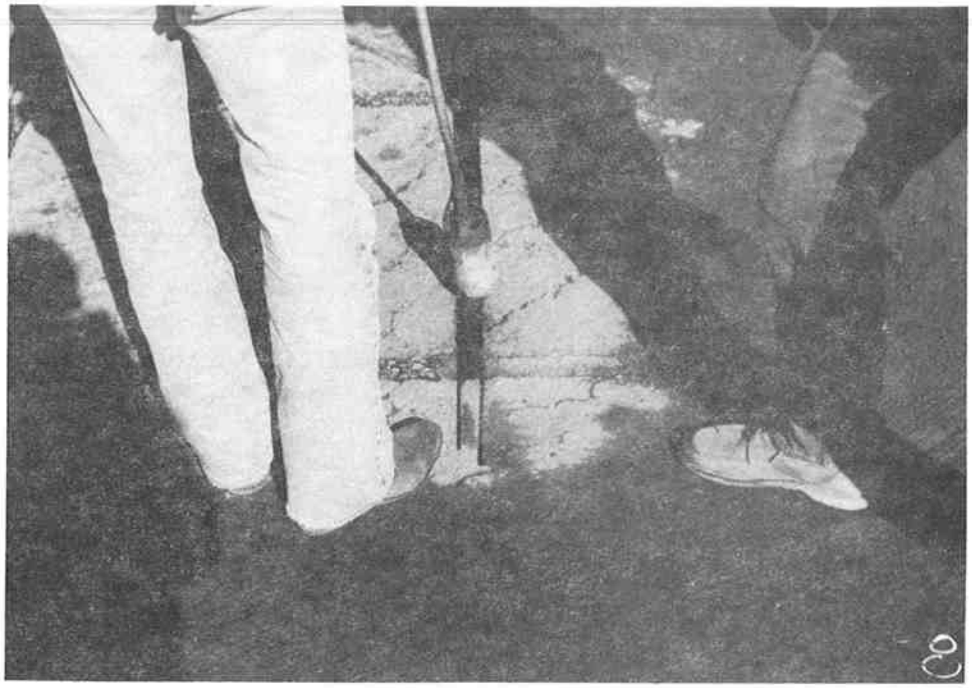
Picture 5: After the pavement has been removed, the trench is thoroughly flushed with a high-pressure water nozzle.



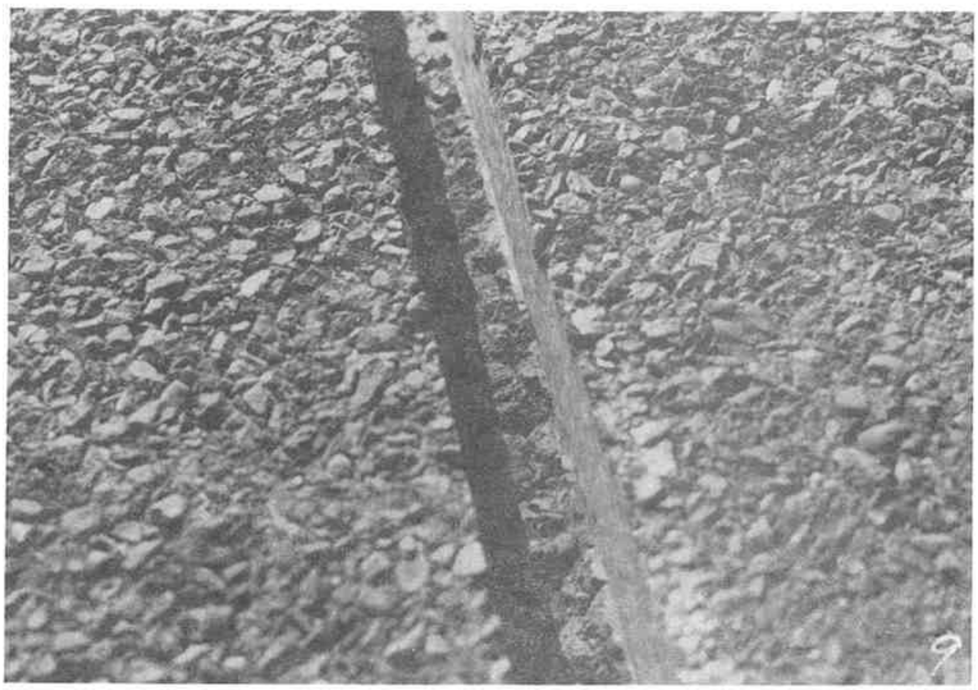
It is important to flush all mud and debris away from the work area, Picture 6.



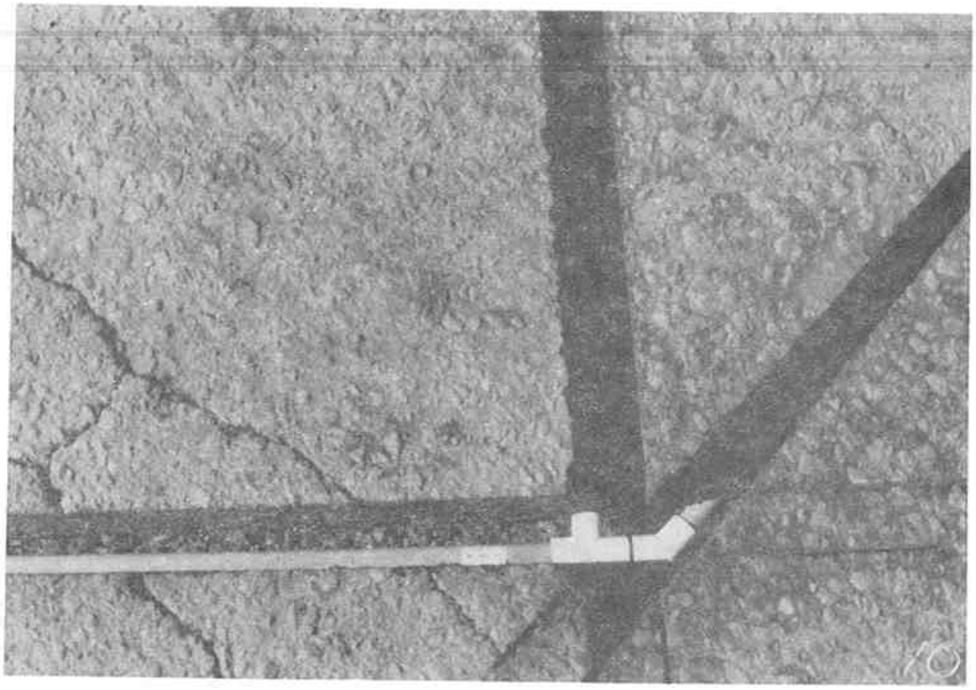
Picture 7: The trench and adjacent work area is thoroughly air dried. We find this step extremely important. It is the key to a good bond between the epoxy backfill, and the existing pavement. If the cut is not completely cleaned and dried, the epoxy will not bond. When the weather turns hot the pavement will expand, close in on the epoxy, and force the epoxy and loop wires up and out of the trench.



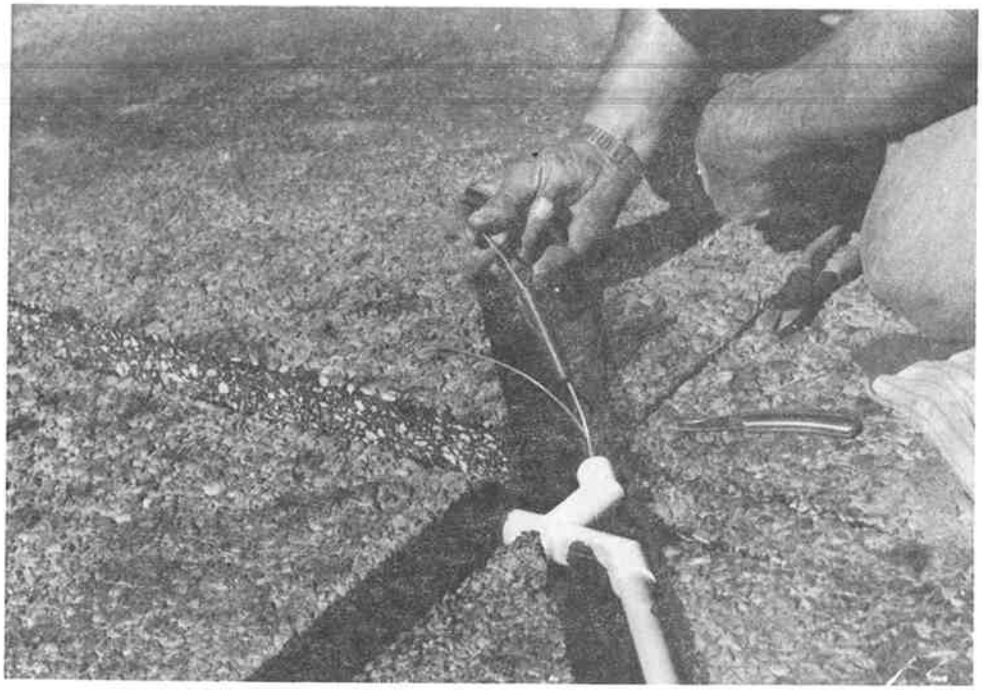
Picture 8: The old pavement is badly cracked and broken. It became necessary to dry the saw cut and the adjacent area with a gas torch.



Picture 9: The completed saw cut in the new pavement.

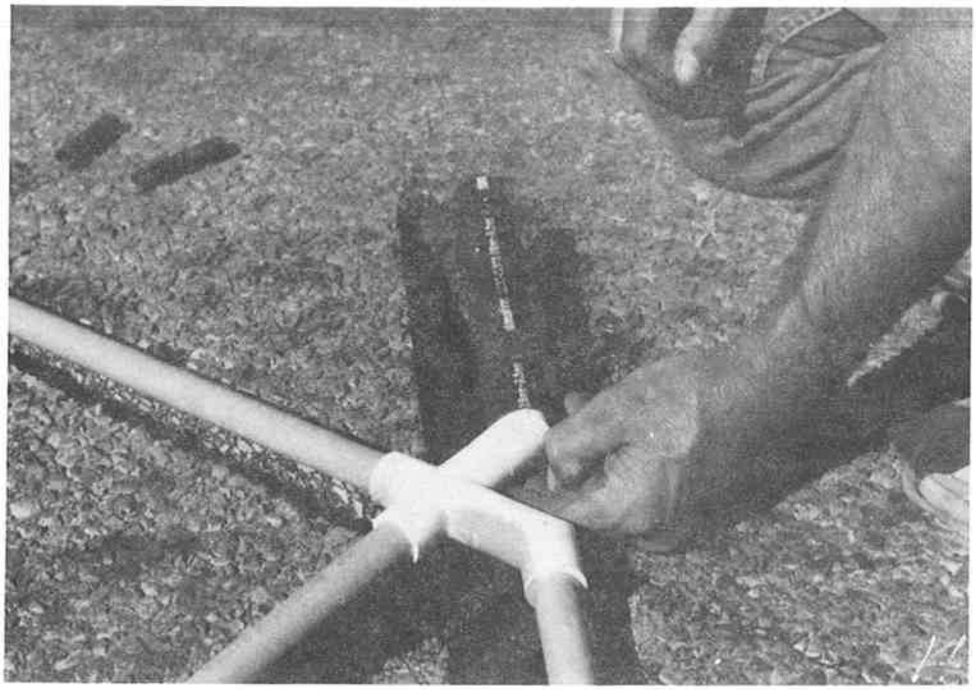


Pictures 10 and 11: The preformed loop is placed into the saw cut.



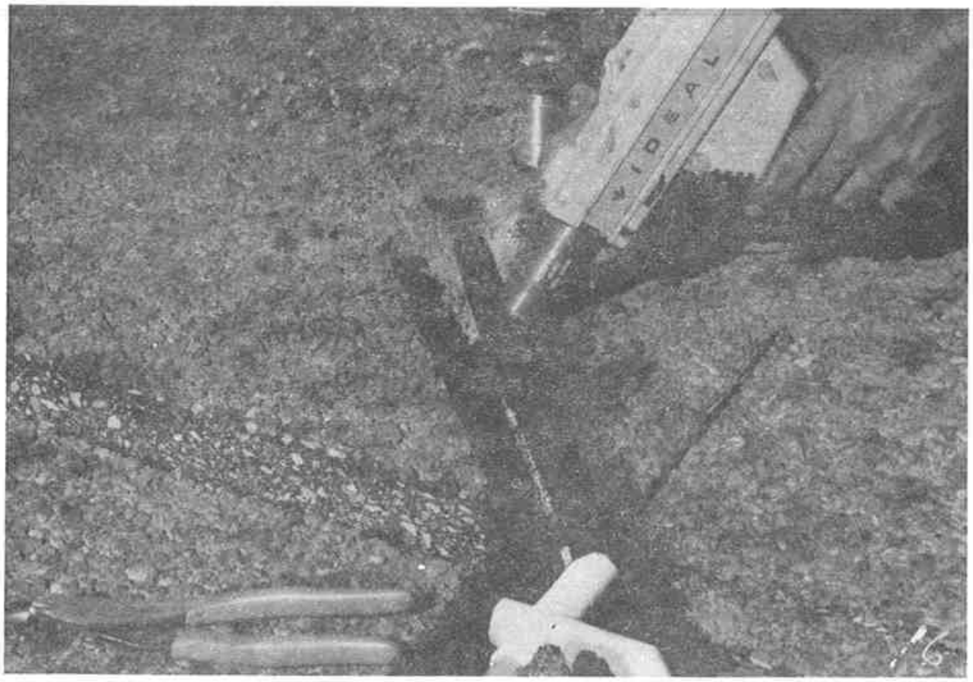
Picture 12: Heat shrink tubing is placed over the wires.

Picture 13: A large diameter heat shrink tubing is placed over the end of the conduit used to make the preformed loop. This turned out to be a problem and the sequence that follows involves two sets of loops. In the first, the heat shrink tubing was heated working away from the conduit. As it shrank, it began to slide off the conduit. In the second instance, the tubing was shrunk from the outer end towards the conduit. It also pulled away from the conduit, but not enough to endanger the seal.

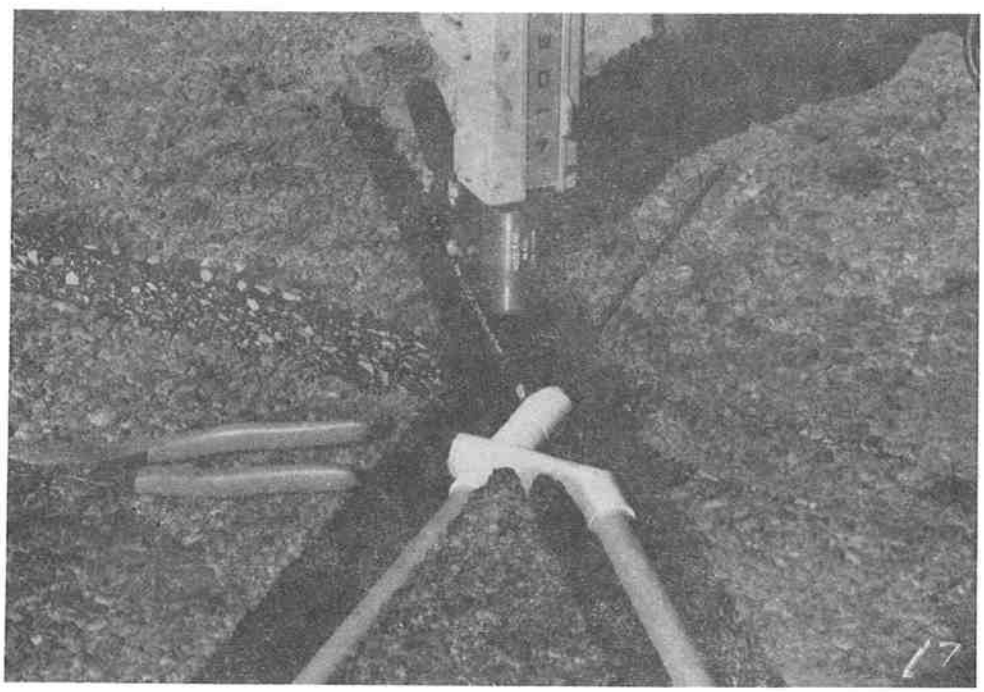


Picture 14: The largest tubing is slipped over the end of the conduit.

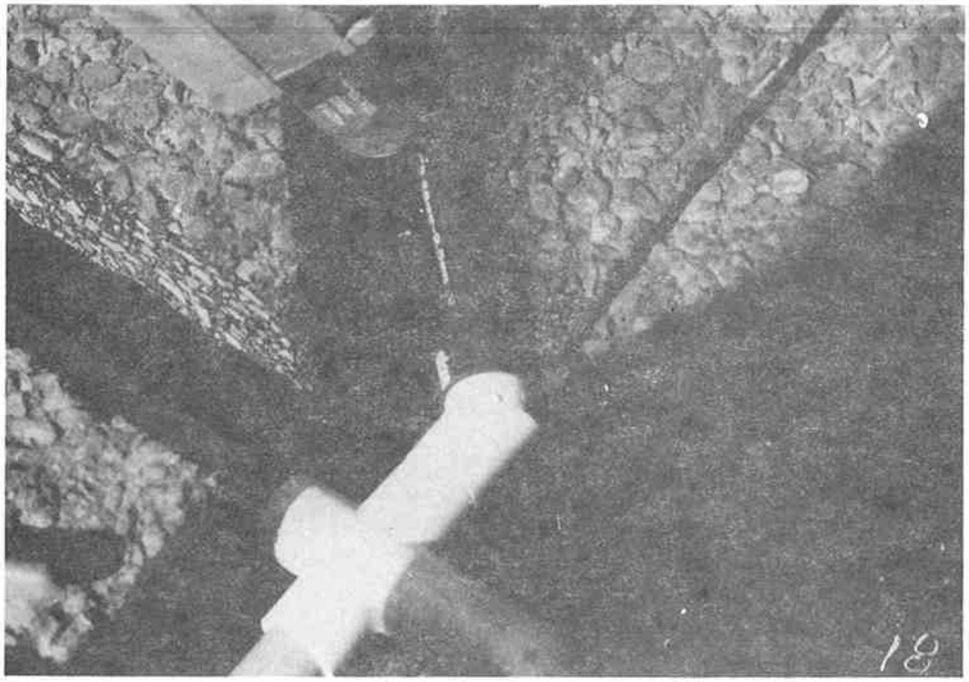
Picture 15: Splice is made between the detector and the lead-in wires.



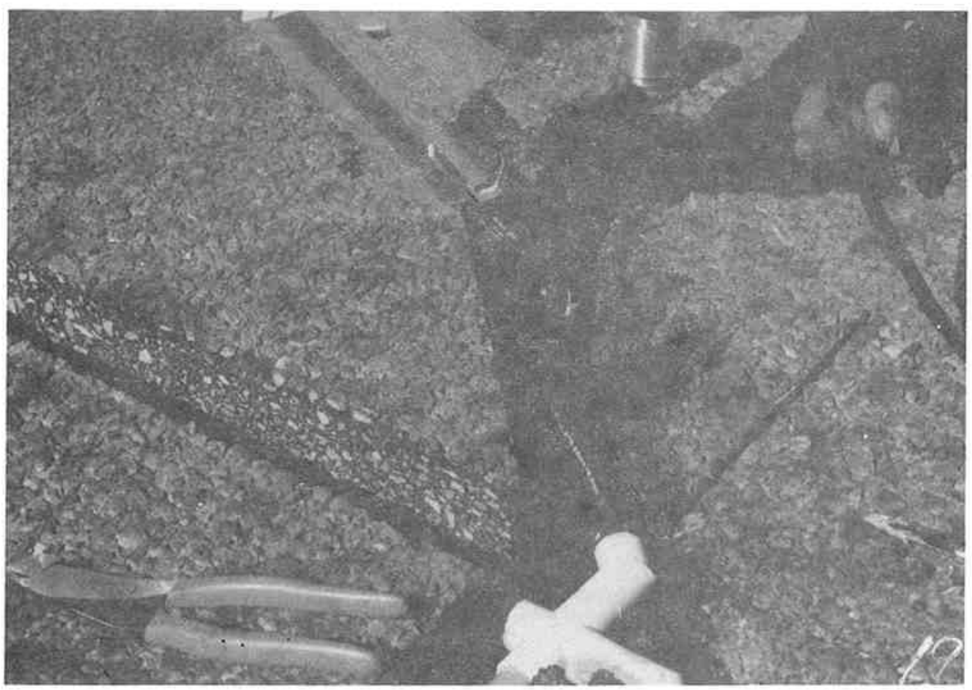
Picture 16: The splices are sealed with heat shrink tubing.



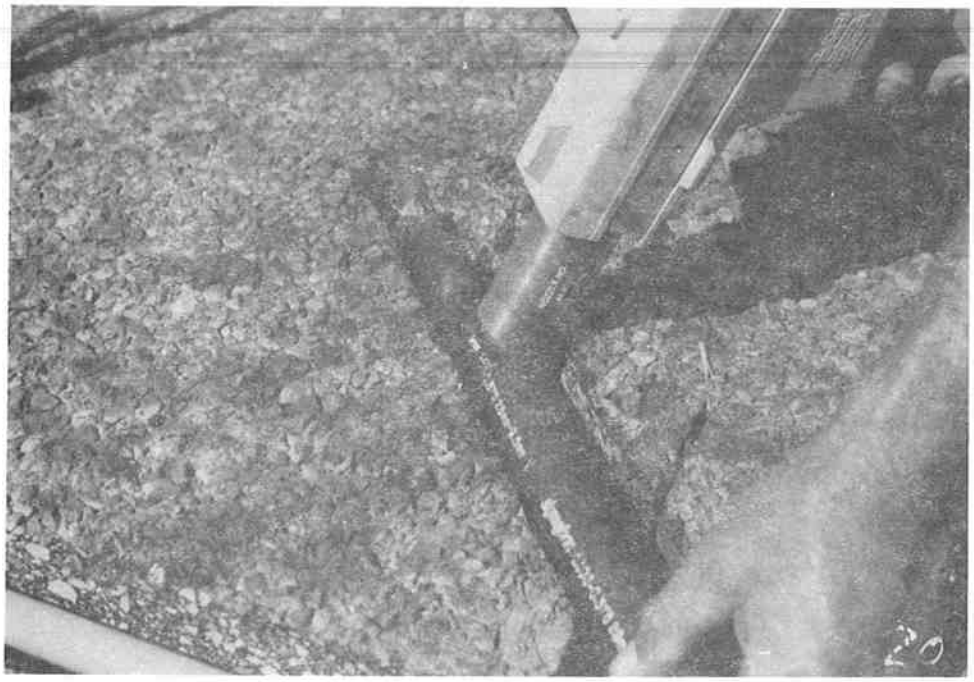
Picture 17: The larger sleeve is heated, working away from the conduit. This process had us a little worried.



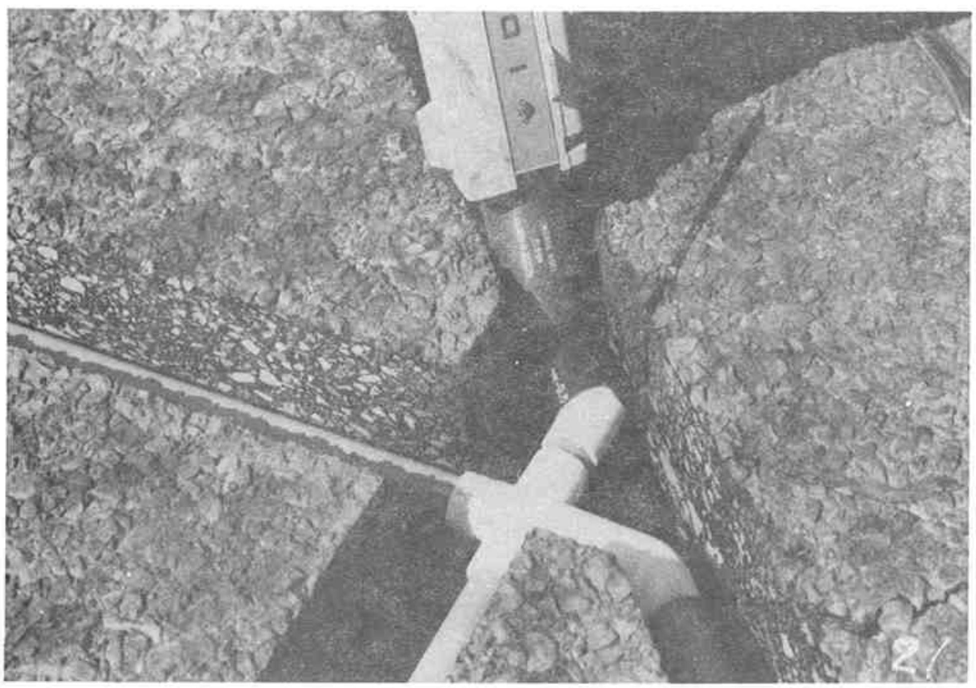
Picture 18: The large sleeve begins to shrink and slide off the end of the conduit.



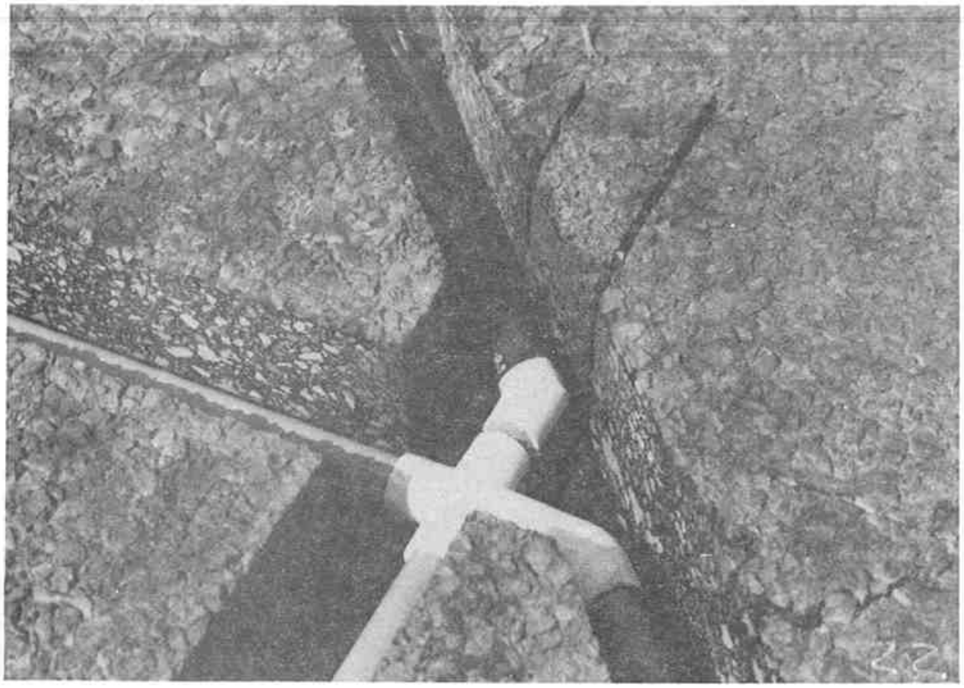
Picture 19: The entire splice is now encased in the heat shrink tubing.



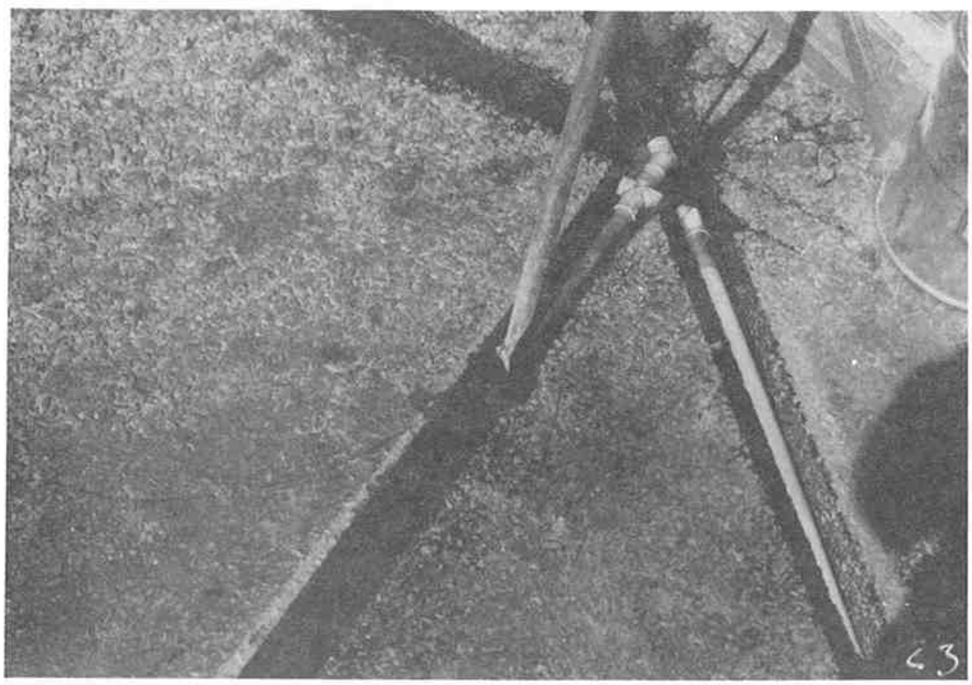
Picture 20: The second set of loops were sealed in a reverse process, starting at the far end of the heat shrink tubing and shrinking back to the conduit.



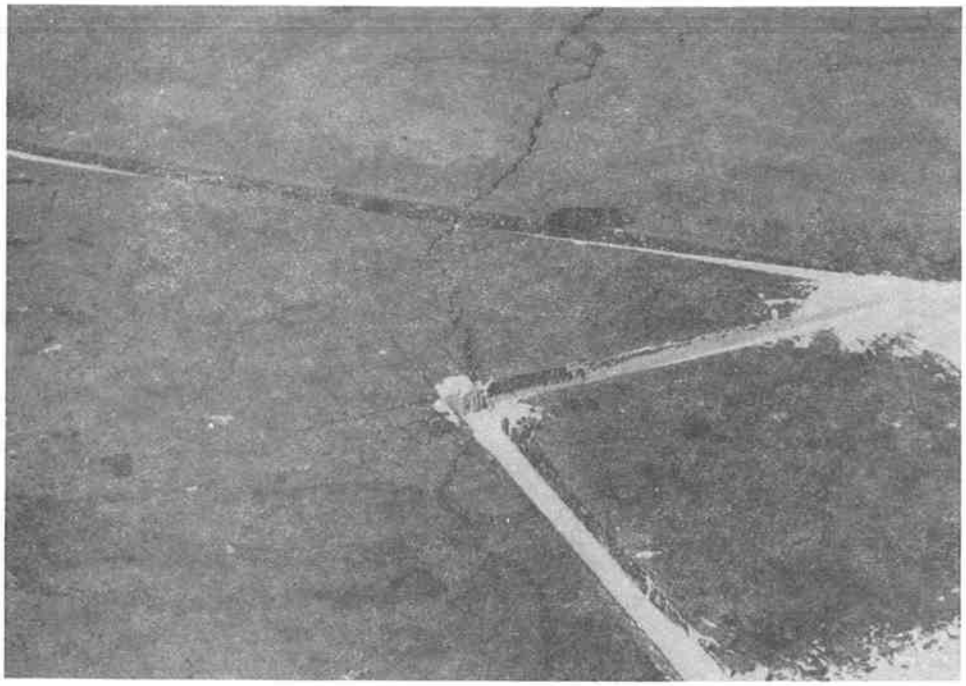
Pictures 21: The large sleeve has a better hold on the conduit, even though it did tend to slip a little.



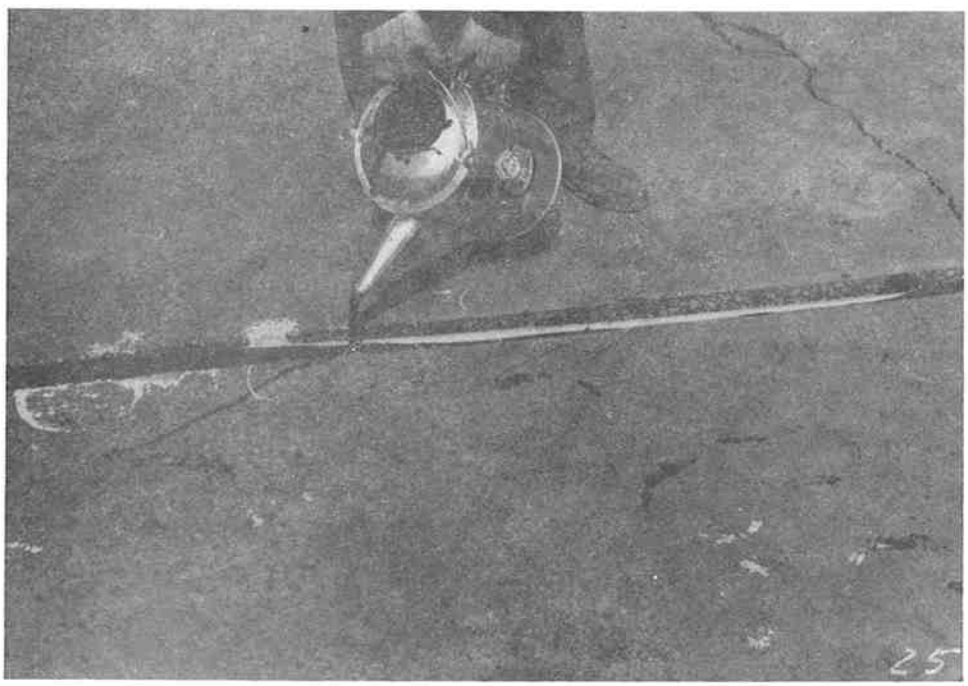
Picture 22: Completed loop connection.



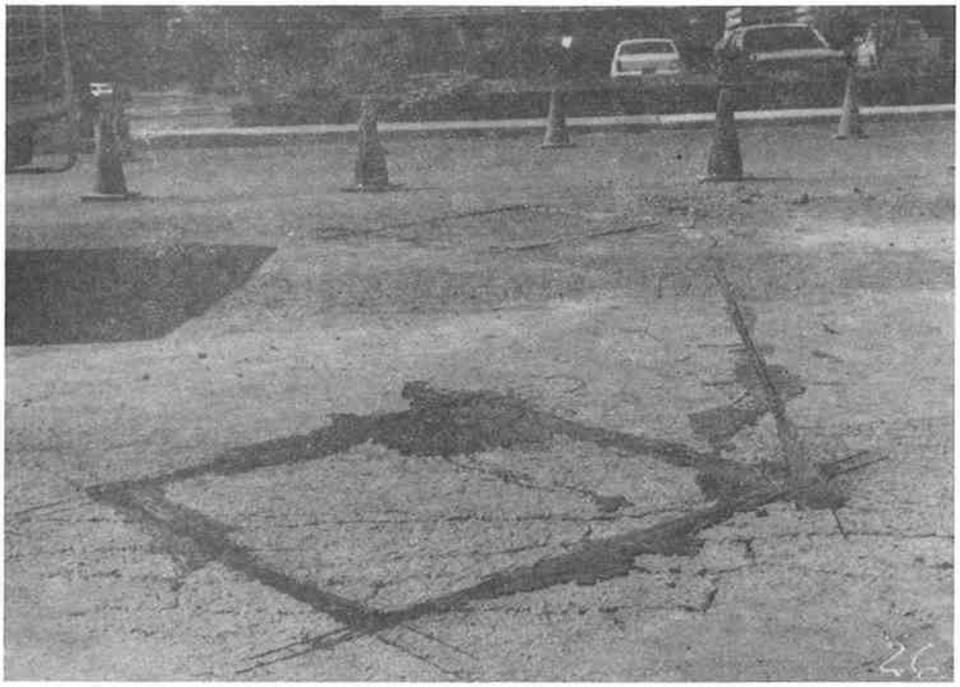
Picture 23: One unanticipated problem was encountered as the epoxy was placed in the saw cut. The conduit floated. This was countered by pouring just enough epoxy into the cut to catch the bottom of the conduit. After the epoxy set, it held the conduit in place in the bottom of the cut.



Picture 24: Epoxy poured almost to top.



Picture 25: We experienced a shortage of black epoxy. This was countered by pouring grey epoxy into the bottom of the cut and covering it with black.



Picture 26: The completed installation. Notice the broken pavement in the foreground. This is the section scheduled to be ground out next year.

As of April, 1986 the preformed loop is still performing with no problems. In September, 1985 the grinding operation over the loop was completed and recycled asphalt mix was placed. Because of the high cost of epoxy, a fine A.C. mix is recommended for filling the saw slot. Also, the splice between the loop wires and loop lead-in cable would now be made according to our more recent design standard. This standard specifies that the splice be made in a junction box and not in a splice cut-out area.

It is evident, both from our experience and from gathered data, that complete loop saw slot cleanout and drying is vital to long lasting, effective loop performance. In our search for the best method to achieve this goal, we became very interested in the saw slot cleaning nozzle developed by the State of New York. (See report FHWA/RR-84/119). This nozzle uses the "Venturi" principle to supply pressurized water for use in saw slot cleanout. The Oregon Traffic Signal Unit, fabricated a nozzle based on a sketch from the aforementioned report. In order to allow for the option of air only, water only or an air/water mixture, valves were added to control both the air and water feed lines. See Figure 'C' for a sketch of this modified New York developed nozzle.

This nozzle is presently being used by three out of five Oregon regions for some state installed loops. Electrical Supervisors of "user" regions have been very positive towards the attributes of the saw slot cleanout nozzle.

They note that a better bonding of sealant to saw slot is obtained because of the more efficient cleaning which the nozzle provides.

In July, 1985, Metro Region maintenance personnel installed 500 ft. of Conoga C20002 magnetometer home-run cable. The installation was made at four intersections on Clackamas Highway, Oregon Route No. 224. The cable was installed to modified State of Idaho specifications and has performed satisfactorily with no loop failure. Maintenance personnel formed 3 ft. by 3 ft. loops from 2 turns of this cable. Splices in the adjacent junction box were made as shown in Figure D. At present there does not appear to be any overwhelming advantage to the use of this cable. Cable installation in the saw slot is somewhat easier than loop wire installation although a wider saw slot is required.

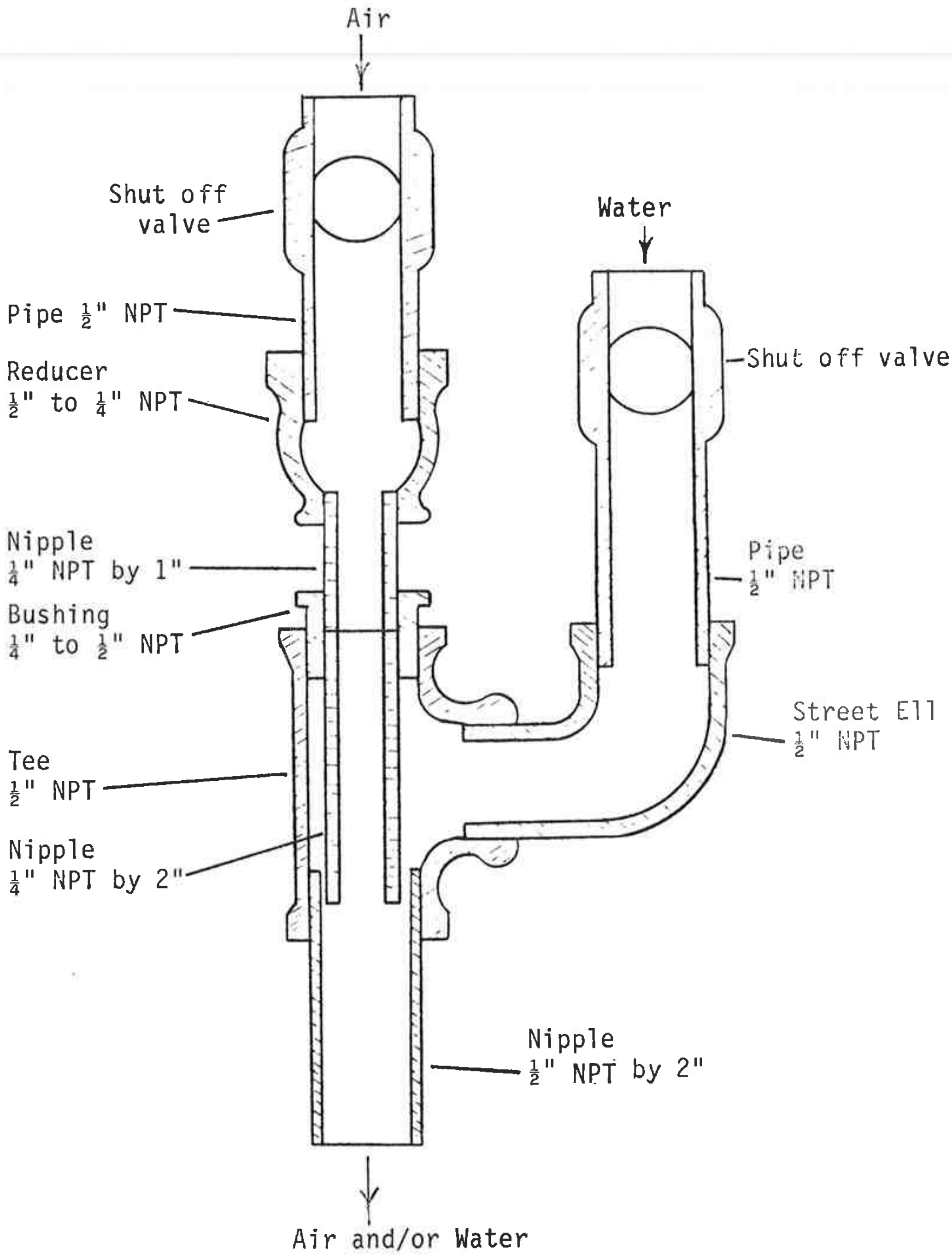


Figure C

Saw Slot Cleanout Nozzle

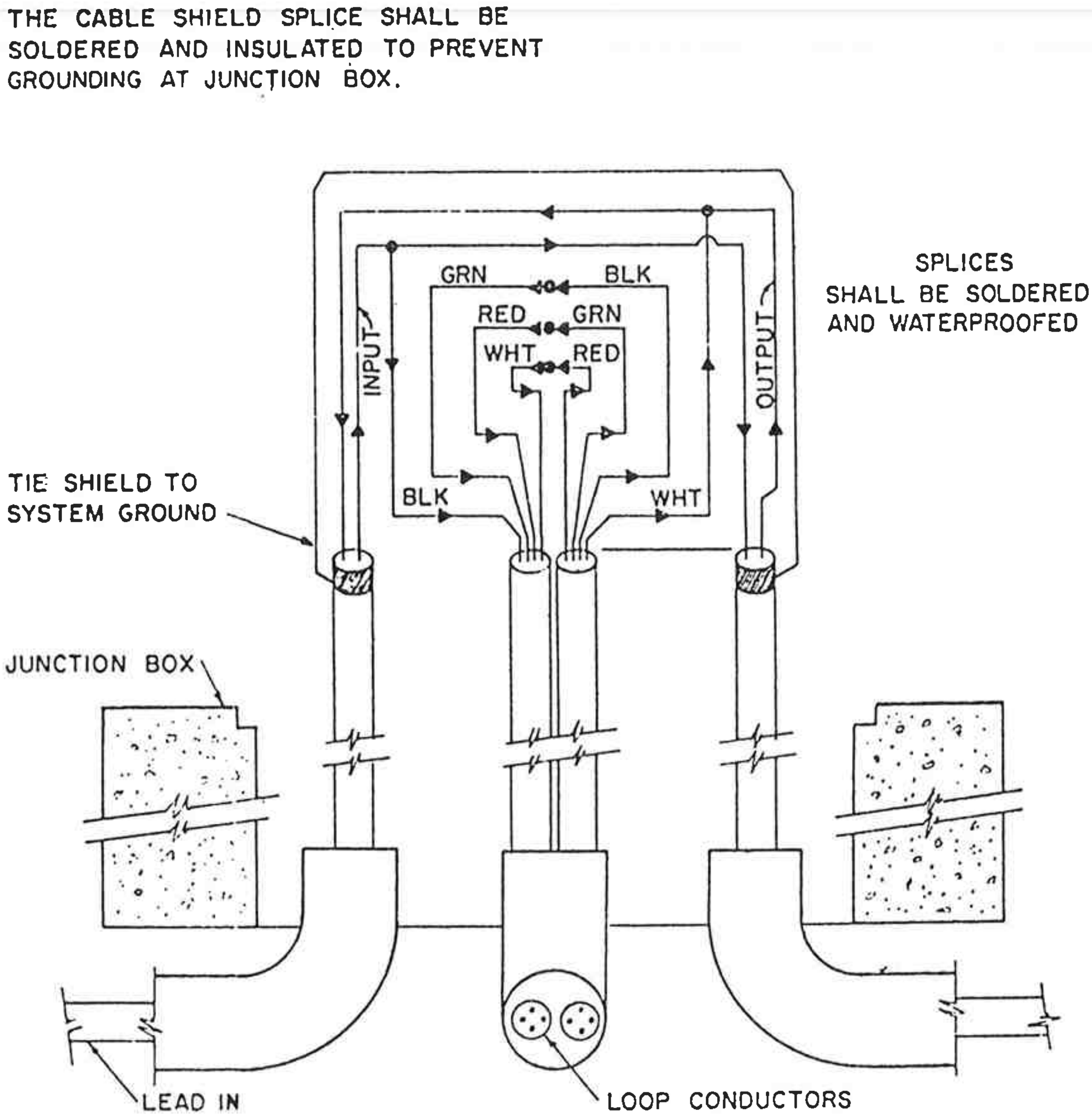


Figure D

Conoga C20002 Cable Splice to Loop Feeder Cable

The search for a loop sealant that provides long lasting and durable protection for loop wires is an ongoing project in Oregon. In July, 1983, we performed a study of 16 loop sealants. Following are excerpts from that study test report.

ODOT Highway Division

Traffic Engineering Section

LOOP SEALANT INSTALLATION

SEALANT INSTALLATION

Introduction and Background

Loop sealants for use on State of Oregon traffic signal installation projects are contained in the special provisions on an approved product list. Three products were included on this list until recently. All three encountered problems in the field either from cracking, loss of adhesion to the saw cut or from failure to set properly. These failures initiated a search for additional products to seal vehicle detector saw cuts.

In April, 1983 letters were sent to loop sealant suppliers and manufacturers requesting samples for testing. These letters were sent to as many companies as addresses could be found. Ten firms returned samples; some of these furnished more than one type of sealant.

The purpose of testing is to find durable, long lasting sealants for detector loops and loop feeder runs. These sealants must protect wiring not only from the environment, but also from vehicular traffic. With this end in mind, the mixing requirements, etc., of the individual sealants is of less consequence to the state than the final product obtained.

Test Site Location

A test site where sealants could be installed in both Portland Cement Concrete (PCC) and Asphaltic Concrete (AC) paving was desired. Most loop installations in the state are in AC, but occasionally installations in PCC are required. It was also desired that the PCC and AC sites be located relatively close together. This close proximity would ease installation and traffic traveling over testing areas would be comparable.

The Wilsonville-Hubbard Highway was chosen because of the close proximity of PCC and AC surfacings. The PCC site is near mile post 1.6. This is just south of Arndt Road. The AC site is near mile post 1.4 which is just north of Arndt Road. The northbound lane was used at both sites. (See the attached map.)

Saw Cuts

The saw cuts for testing sealants were made on July 7, 1983. The weather this date was cool and cloudy with occasional showers.

One quarter inch wide saw cuts were made from the highway painted center-line to the edge of paved surfacing. The saw cut depth was approximately two inches. Seventeen such saw cuts were made at each of the two test areas.

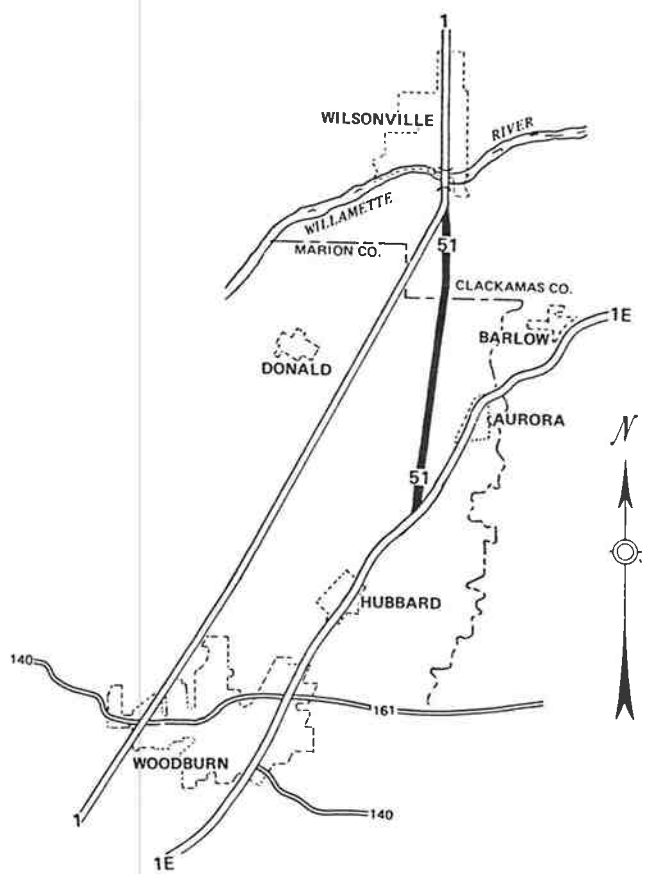
After cutting was completed, the saw cuts were washed out with water and then blown dry with compressed air.

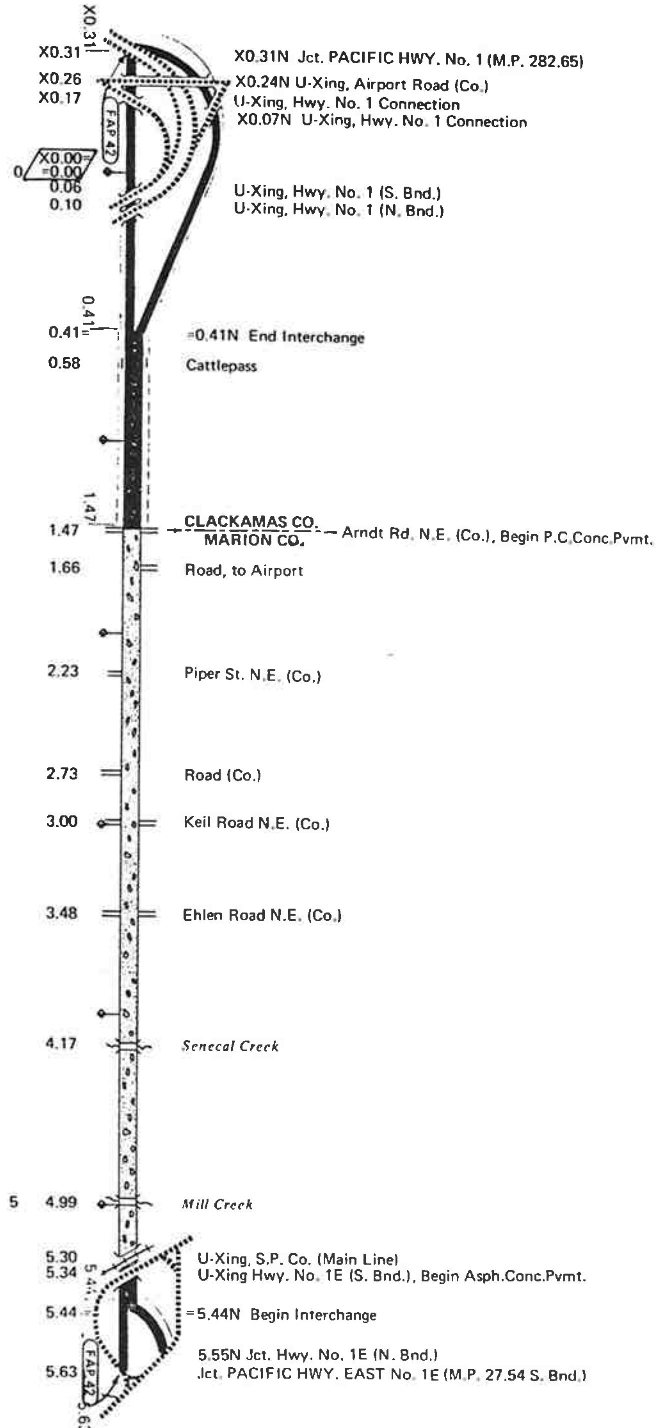
Sealant Installation

The sealants were installed July 11, 1983. The weather during installation was clear to partly cloudy, with a high of 87^{o} and relative humidity of about 50%. It should also be noted that the two days preceding the installation date were clear to partly cloudy with highs in the 70's. Saw cuts were first cleaned by washing with a pump fed water stream. Then they were thoroughly dried with a high-pressure air hose. This procedure is required by the state's specifications.

After cleaning and drying, a single No. 14 THWN wire was installed from the shoulder to highway centerline and back to the shoulder. Enough wire was left at the shoulder to enable a meter check of continuity.

Finally, the sealants were prepared one by one and installed in the saw slots. The sealants and saw cuts were as follows (see the attached map for numbering and location):





WILSONVILLE-HUBBARD HIGHWAY No. 51

(A) Asphaltic Concrete Sawslots

17A	ELS 293
16A	EDOCO 3011
15A	EDOCO 2094
14A	Concresive 1219
13A	Concresive 1064
12A	EAS - 14
11A	495 HP
10A	491 HP
9A	Dural Polyester
*8A	-----
7A	Dural 306M
6A	Niklepoxy
5A	Sealex
4A	3M Sealant
3A	Tar + poly rope
2A	Tar + sissal rope
1A	Tar + nylon rope

(C) Concrete Sawslots

17C	PG 3-52-1
*16C	-----
15C	EDOCO 2094
14C	Concresive 1219
13C	Concresive 1064
*12C	-----
11C	495 HP
*10C	-----
* 9C	-----
* 8C	-----
7C	Dural 306-M
6C	Niklepoxy
5C	Sealex
4C	3M Sealant
3C	Tar + poly rope
2C	Tar + sissal rope
1C	Tar + nylon rope

* No test sealant in sawslot

__1C and 1A:__ Hot roofing tar (Type III) over nylon rope. Rope was cut into sections, overlapped to allow for heat shrinkage and tamped into the saw slot. Hot tar was poured into the slot from a special bucket. Installation went well and the tar set quickly. To get neater results a different container for pouring would be desirable. Also, as the tar cooled in the bucket pouring became more difficult.

__2C and 2A:__ Hot roofing tar over sissal rope. Rope was placed in saw cut in one piece and was much easier to place than the nylon rope. The tar was installed as in 1C and 1A.

__3C and 3A:__ Hot roofing tar over poly rope. The rope was again cut into two to three foot lengths (as with the nylon rope) and overlapped to allow for heat shrinkage. The poly rope was a little easier to install than nylon, but took more time than the sissal. The tar again was installed as in 1C and 1A.

__4C and 4A:__ 3M loop sealant. 3M sealant is a one part material and contained in one quarter cylinders. The sample came in gray only. It was applied using a caulking gun. This material is available in five gallon pails and can be pumped. Installation using the caulking gun was slow and tedius, but material went into the slot well. The viscosity of 3M sealant is somewhat thicker than honey. The setting time for this material is extremely long, but traffic can drive over it immediately after installation.

__5C and 5A:__ Sealex Loop Sealant (by W. R. Meadows, Inc.). Sealex is a two component sealant. It was supplied in black only. The base material is contained in a one gallon can. A four ounce can of activator is added to the base material and thoroughly mixed. The consistency when pouring began was similar to thin honey. Within a few minutes the material began to thicken and pouring was a little more difficult. Overall installation was satisfactory.

__6C and 6A:__ Niklepoxy Loop Detector Cement (by Rocky Mountain Chemical Company). Niklepoxy is a two component epoxy mixed at a one to one ratio. It was supplied in both black and gray. The black sample was installed with no problems. Both components of the gray sample were a paste. These two pastes were mixed and installed with a putty knife.

__7C and 7A:__ Dural 306-M (by Dural International Corporation). Dural 306-M is a two component coal-tar epoxy and is mixed in a one to one ratio. It was furnished in both black and gray. Both samples mixed well and had viscosity similar to syrup. The epoxy poured well but ran badly, even on normal highway crown (0.02 ft./ft.).

8C and 8A: Dural 337 (by Dural International Corporation). Dural 337 is a two component epoxy mixed at a one to one ratio. It was furnished in gray only. Mixing went well, but the consistency of the material was very thin. Just prior to pouring the material begin reacting in the mixing container. It got very hot and set up before it could be poured.

9A only: Dural Polyester (by Dural International Corporation). Dural Polyester is a two component system. A quart of base material is mixed with a few ounces of activator. This material mixed well and had a viscosity similar to honey. Pouring was accomplished with no problems. Only two quarts were furnished so both were poured in the same AC saw slot.

10A only: 491 HP (by The Euclid Chemical Company). 491 HP is a three part system and was furnished in one color only. The liquid base material is first thoroughly mixed with the dry filler. The liquid converter is then added and mixed for about two minutes. 491 HP has the consistency of thick honey after mixing. Pouring in the AC saw slot went well, but the material set up in the mixing container before it could be installed at the PCC site.

11C and 11A: 495 HP (by The Euclid Company) 495 HP is a two part epoxy. It was supplied in only one color. The two components are mixed at a ratio of one to one. The consistency after mixing was similar to thick honey and pouring went well at both sites.

12A only: EAS-14 (by QCM Company). EAS-14 is a two part epoxy and is mixed at a one to one ratio. Mixing went well, but because of the small sample size, both black and gray samples were poured in the AC saw slot. Mixing and pouring went well.

13A and 13C: Concresive 1064 (by Adhesive Engineering Company). Concresive 1064 is a two part epoxy. It came in both black and gray. The components are mixed at a one to one ratio. The material has the viscosity of thin honey after mixing. Pouring went well except that the epoxy had a tendency to run down the saw slot.

14A and 14C: Concresive 1219 (by Adhesive Engineering Company). Concresive 1219 is a two part epoxy and was furnished in gray only. The two parts are mixed at a ratio of one to one. The consistency after mixing was similar to thick honey. It mixed and poured well at both sites.

15A and 15C: EDOCO 2094 (by EDOCO Technical Products). EDOCO 2094 is a two part epoxy sealant and was provided in both black and gray. The two parts are mixed one to one and the viscosity after mixing was similar to thick honey. Both mixing and pouring went well at both locations.

16A only: EDOCO 3011 (by EDOCO Technical Products). EDOCO 3011 is a two part, rubberized, black asphalt emulsion sealer. A one half gallon sample of base material was received. This was mixed with a small amount of setting agent (approximately two ounces). The viscosity after mixing was about like thin honey. Pouring went well except that the material had a tendency to run. The sample was only large enough to install in the AC saw slot.

17A only: ELS 293 (by Permagile-Salmon Ltd.). ELS 293 is a two part epoxy sealant that was supplied in gray only. Mixing ratio is one to one. Mixing and pouring went well, but the sample was only large enough to pour the AC saw slot.

17C only: PG 3-52-1 (by Permagile-Salmon Ltd.). PG 3-52-1 is a two part epoxy coating and grout that was supplied in gray only. The mixing ratio is one to one. After mixing the material has a viscosity similar to thin syrup. Because of the small sample size it was poured into the PCC saw slot only. Pouring went well except that the material ran too easily.

SEALANT PERFORMANCE

As related in the Sealant Installation Report, the State of Oregon tested 16 different types of loop sealants. Sealant installation was made July 11, 1983, and observed until the spring of 1984. The sealant was subjected to a good cross section of Oregon weather. July, August, and a portion of September were very warm. In December, snow and freezing conditions were present. Cold and wet conditions continued throughout the winter months.

Final observations were made February 22, 1984, as the weather was warming and sealants that appeared to have no signs of deterioration were added to the approved product list. These sealants are:

Adhesive Engineering Company - Concresive 1064
Adhesive Engineering Company - Concresive 1219
Dural International Corporation - 306-M
EDOCO Technical Products - 2094
Permagile-Salmon, LTD. - E.L.S. 293
Permagile-Salmon, LTD. - P.G. 3-52-1
QCM Company - EAS-14
Rocky Mountain Chemical Company - Niklepoxy
The Euclid Chemical Company - 491 HP
W. R. Meadows, Inc. - Sealex

As these sealants are used on signal projects, additional inspections will be made.

Most of the sealants that were not approved were rejected because of cracking and loss of adhesion to the saw slot. This occurred in varying degrees. The sealants involved were:

Tar
3-M Detector Loop Sealant
Dural International Corporation - Polyester
EDOCO Technical Products - 3011

One sealant, Dural International Corporation - 337M, set up in the container before it could be poured. The Euclid Chemical Company - 495 HP, did not appear to set properly and will be watched for a longer period of time. EDOCO Technical Products - 3011, remained very soft in addition to loss of adhesion.

Manufacturers or their representatives were notified as to whether their sealants were approved or not. Testing of additional sealants and some retesting of disapproved products will be done as required.

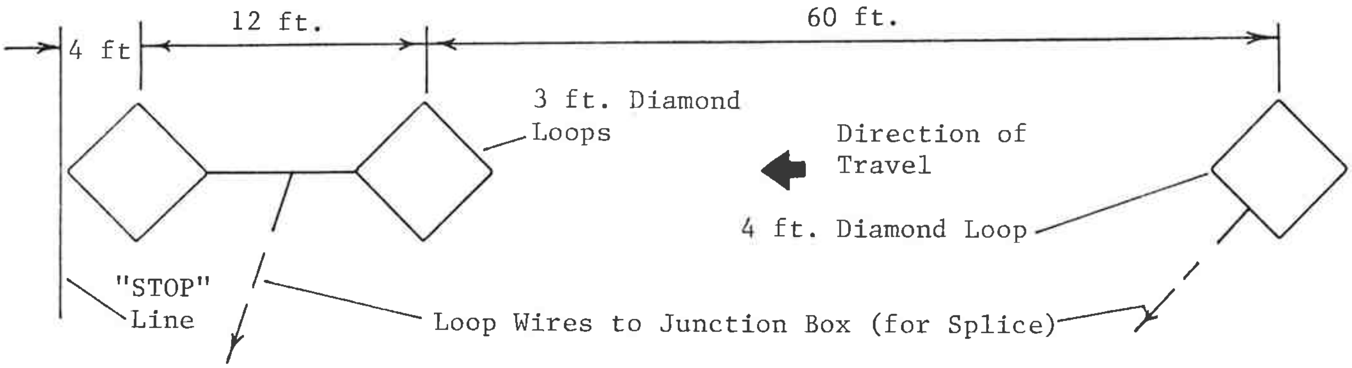
Oregon's vehicle detection system has been amended appreciably during the period of this research project. We have implemented many improvements into our specifications based on information gathered from this project. We continued to specify 3 ft. by 3 ft. diamond loops when the loops are in series in the field. However, any single loops are now required to be 4 ft. by 4 ft. diamonds. This change arose from a desire for increased inductance gained by the larger dimensions in a single loop. We now utilize either THWN or XHHW wire for loop wire, with four turns being used for both the 3-foot and 4-foot diamond loops. Backer rod loop wire hold down is now specified on all state contract projects. There are three backer rod materials that are on the preapproved list. They are: Epoxy Industries - Cera-Rod 1000; Hercules Mfg. - HBR-XL; and W. R. Meadows, Inc. - Cera-Rod. The splice between loop wires and loop feeder cable is now made exclusively in junction box locations. Maintenance personnel report much greater ease of maintenance in the latter method. Our specified loop feeder cable is now IMSA 50-2 or Belden 8720 or equivalent. Loop feeder cable is run in conduit from the splice junction box to the controller. There are ten loop sealants on the current preapproved sealant list. Eight are of the epoxy type, one of the polyester type, and one is of the polyurethane type.

Presence loop configuration evolved to its present specification in order to accommodate the occurrence of smaller vehicles in the traffic stream. Two 3 ft. by 3 ft. diamond loops are seriesed in the field. A single 4 ft. by 4 ft. diamond loop is placed upstream to provide a long loop affect. The 4 ft. loop is input into a separate detector channel so that the 170 controller "carryover" feature may be utilized. Presence type operation is used on left turn lanes and most side streets. Presence loop spacing from the 'STOP' line is now 4 ft.-12 ft.-60 ft. (See Figure 'E'.)

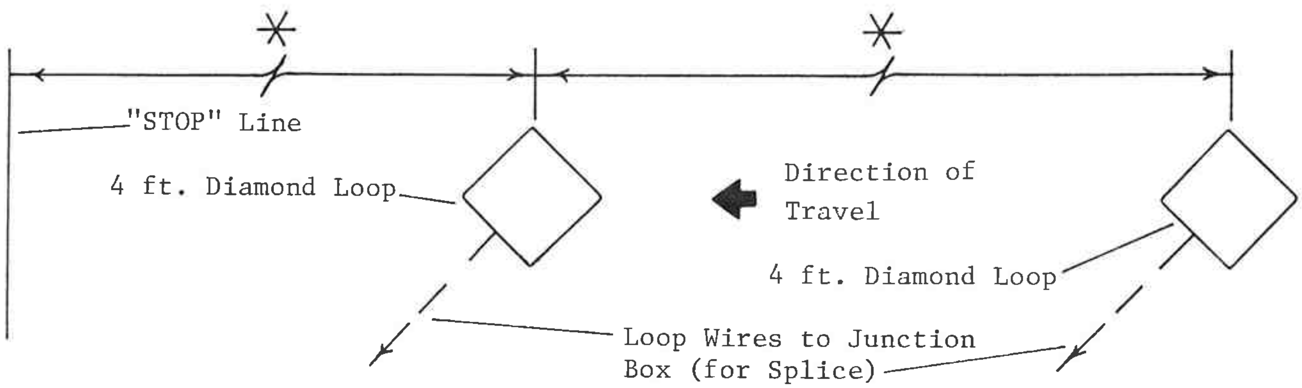
Improved inductive loop installation will come about both through improved technology of methods and materials related to traffic detection loops and strict adherence to specifications. We recommend ongoing field testing of all materials involved in an inductive detection system as well as openness to methods utilized by outside agencies. We will continue to test various epoxy sealants and modify our preapproved sealant list as necessary to obtain the best sealants available. We will also continue to monitor the performance of the New York developed saw slot cleanout nozzle. Maintenance personnel in Oregon have expressed interest in enclosing the loop wire in a 1/4-inch vinyl tube prior to placement of the wire in the loop saw slot. We feel that this item is worthy of consideration but we are concerned about the wider saw slot and extra sealant that would be necessary as a result of the specification requirement which mandates twisting the loop wires 4-6 turns per foot from the loop to the splice junction box.

There are many benefits to be derived from actively pursuing improvement in any field. The improvements that were implemented as a result of this research project have benefited the State of Oregon by providing a traffic detection system that requires less maintenance. This translates into more consistent, reliable traffic control, and has the ultimate benefit of greater safety for all users of city streets, county roads and state highways in Oregon.

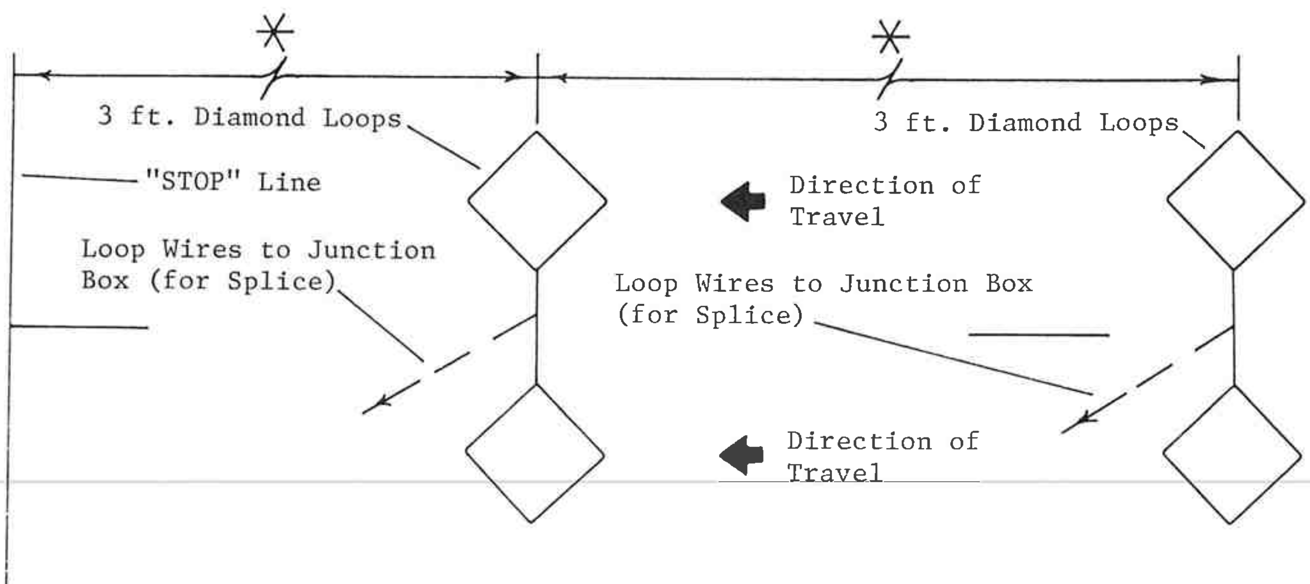
FIGURE E
Loop Size As Shown
✳ Distance Varies With Speed



Present Presence Loop Configuration



Present Density Type Detection (Single Lane)



Present Density Type Detection (2 Lane Section)