TECHNICAL ASSISTANCE REPORT

EVALUATION OF SPRAY INJECTION PATCHING

G. W. Maupin, Jr.
Principal Research Scientist

Charles W. Payne
Engineer I

Virginia Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the
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DISCLAIMER

ABSTRACT

A preliminary telephone survey of users of spray injection patching equipment revealed general satisfaction. In addition, a demonstration and follow-up 2-month evaluation of a rented truck-mounted unit convinced Virginia Department of Transportation officials to purchase a unit for a more detailed evaluation.

The purchased unit was evaluated over a 2.5-year period with respect to cost-effectiveness of repairs, effectiveness during cold temperatures, and potential increased worker safety. The unit worked well and produced durable patches, even during cold temperatures. It was important to use clean aggregate and a different type of emulsion during extremely cold temperatures. A cost-benefit analysis indicated that patches installed by the spray injection unit were more cost-effective than repairs using the skin patching technique.

Fewer workers were exposed directly to traffic during the operation, which is a potential benefit, especially on highways with considerable traffic. The unit may be preferable and perhaps necessary where the number of available personnel is limited.

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INTRODUCTION

Potholes are an annoyance and a hazard for the traveling public, and their repair is costly. The conventional methods that are used can be effective if done properly and during the time of year when warmer temperatures are prevalent; however, potholes usually begin to develop during the winter months due to freeze-thaw cycles. Therefore, patching must be done on short notice or on an emergency basis during the winter months when cold temperatures are predominant. The cold temperatures and frequent wet conditions make the chances of achieving successful patches minimal. Frequently, potholes that are patched during the winter months have to be patched repeatedly.

As part of the research done by the Strategic Highway Research Program (SHRP) in the late 1980s and early 1990s, an effort was made to determine the most effective and economical patching methods. In 1993, SHRP published *Innovative Materials Development and Testing*.[1] Part of this study was devoted to pothole repair. A total of 1,250 pothole patches were placed at eight test sites in the United States and Canada using different proprietary, state-specified, and local cold-mix patching materials. Several installation techniques were used to determine an optimum combination of materials and procedures for improving the cost-effectiveness of patching operations.

Two conclusions of the SHRP study were that high-quality cold-mix materials and the spray injection method should be used for winter-time pothole repair. The cost of continually patching the same holes with poor-quality materials could be offset by paying more for high-quality material that offered a longer service life. The findings of the SHRP research project were that the spray injection patch method was the least expensive and the patch service life was much better than with the other patching methods tested in the study. The early performance results of this study are shown in Figure 1. The plot shows the percent failed at the last evaluation, which varied from 35 to 84 weeks depending on the location of the test section.

In 1996, an RA-300 truck-mounted spray injection patcher was demonstrated to Virginia Department of Transportation (VDOT) personnel at several residencies by a representative from the Rosco Manufacturing Co. After the demonstrations, a telephone survey was made by the author to several states that were using the spray injection patching method. The comments from the different agencies contacted are provided in Appendix A. It was the consensus of the states contacted that the spray injection patching method was superior to any other patching methods, with a life expectancy of 4 to 5 years. In addition, it was learned during the survey that pothole

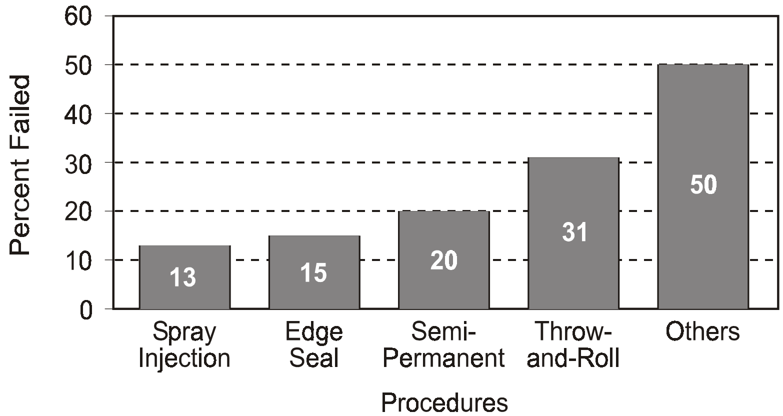

Figure 1. Patches Failed by Procedure (at last evaluation)

patching during the winter using the spray injection patching method was more successful than the cold-mix patching that is normally used in cold weather.

In 1997, VDOT leased an RA-300 ROSCO patcher for 2 months and used it in the Lynchburg and Salem districts. During that period, cold-mix patches were also placed for comparison purposes. The patches were monitored by a team of evaluators from each district for 1 year, and it was concluded that the spray injection patches lasted longer and were more economical.

The total cost of the materials, personnel, and equipment for placing 39.5 tons of material was $3,950 for the spray injection patches and $4,564 for the cold-mix patches. The spray injection patching technique cost slightly less than the cold-mix patching technique, appeared to last longer, and exposed workers to fewer traffic hazards. Exact measures of service life were unavailable because of the short evaluation period.

Virginia spends approximately $19 million each year on various types of patching operations, with an estimated 25 to 30 percent of that amount being spent for repairing potholes. Traditionally, these potholes are repaired with skin patches, cold-mix patches, or hot-mix patches. Based on the conclusions from the SHRP study, the information learned from the telephone survey, and the cost data that were collected during the 2-month equipment rental period, there was a potential for significant savings with the spray injection method. Based upon this information, VDOT decided to purchase a truck-mounted spray injection patcher that would be evaluated more rigorously.

PURPOSE AND SCOPE

The purpose of this study was to evaluate the effectiveness of the spray injection patching method. Potential benefits that were examined were:

1. longevity of repairs

2. cost-effectiveness of repairs

3. potential safety (less equipment and fewer personnel exposed to traffic)

4. effectiveness during winter conditions.

VDOT's Salem District agreed to work with the Virginia Transportation Research Council (VTRC) in furnishing test roads for evaluation of the spray injection patching method and control sections using conventional skin patching.

METHODOLOGY

In 1998, VDOT purchased an RA-300 spray injection patcher that was based in the Salem Residency and shared by all residencies in the Salem District. It was agreed that the spray injection patcher would be operated by trained VDOT operators and that the data collection and observation would be coordinated by VTRC. The visual evaluations of the patches were done by a team composed of personnel from the Salem Residency and VTRC.

Spray injection test patches were placed during all seasons to determine how cold weather patching compared to patching during warmer weather. Work was done on similar roads with different levels of traffic to determine how the spray injection patches would perform under high and low traffic levels. In addition to data collected using the RA-300 spray injection patcher, data were collected on some roads that were patched with the conventional skin patching method for comparison purposes. The skin patching method was used for a comparison because it is the patching method that is most frequently used at the area headquarters where the patcher was based. The supervisory personnel at the area headquarters were responsible for determining the locations where skin patching would be performed. The form shown in Appendix B was used to collect the field data that were also used on the Expenditure Form (Appendix C) to analyze the cost data. These forms were modeled after forms presented in an SHRP manual of practice.[2]

As previously stated, potholes generally occur during cold weather; however, depending on their severity, the patching sometimes is not done until warmer weather when the annual skin patching program begins. Skin patching is the application of an asphalt layer followed by a layer of aggregate and compacted with either a steel wheel or rubber tired roller. The skin patching method is normally used to seal surface cracks; however, it is used to patch potholes by applying multiple layers. Skin patching allows surface cracks and potholes to be repaired by the same repair operation, similar to the repair operation of the spray injection process.

TEST SECTIONS

The routes and counties where patching was performed are shown in Appendix D. More spray injection sites were included than sites repaired with skin patching. The maintenance supervisor determined that because of the lack of personnel and the apparent effectiveness of the spray injection patching method, it was more cost-effective to use a 3-person crew with the spray injection patching than to use a 6-to-8-person skin patching crew that also required more equipment. The skin patching sites that were used for comparison purposes exhibited basically the same type of roadway distresses.

It can be observed from Appendix D that the spray injection patching method was used on interstate, primary, and secondary roads and the skin patching was used on one primary route and three secondary routes. The table in Appendix C also shows the average daily traffic from 23 to 50,307 on the roads that were skin patched and 48 to 80,000 on the roads where spray injection patching was used.

MATERIALS

The materials that were used for the spray injection patches were CRS-2 asphalt emulsion and No. 9 dolemite aggregate; however, a small amount of No. 8P dolemite aggregate was used in the Hillsville Residency. The materials used for skin patching were also No. 8P dolemite aggregate and CRS-2L emulsion. The aggregate for both patching methods was furnished by W.W. Boxley at Blue Ridge (see Table 1), and the asphalt was supplied by Central Oil in Roanoke, Virginia. The spray injection test sections employed mainly CRS-2 emulsion, but one tank of CMS-2 was used during extremely cold weather. The asphalt materials conformed to the requirements of Section 210 of VDOT's *Road and Bridge Specifications*[3] with the additional requirements listed in the VDOT Asphalt Surface Treatment Special Provisions.

> **CRS-2** shall be a rapid setting cationic emulsified asphalt when tested in accordance with AASHTO T59 Testing Emulsified Asphalt and shall meet the requirements of Type ll coating ability.
>
> **CMS-2** shall meet the same requirements as the CRS-2 except it is a medium setting asphalt.

It was learned in 1997 during the 2 months that VDOT leased the spray injection patcher that it was necessary to use clean aggregate to prevent buildup in the aggregate supply line. Gradation data on the aggregate used were not obtained; however, visual inspection ensured that the aggregate that was used was reasonably clean. Table 1 shows the gradation specification for No. 8P and No. 9 aggregate.

Table 1. **Aggregate Gradation**

Sieve Size	% Passing	
	8P Aggregate	**9 Aggregate**
½	100	100
3/8	75-100	
No. 4	5-30	84-100
No. 8	Max 5	10-40
No. 16		Max 10
No. 50		Max 5

PATCHING METHODS

Spray Injection

The spray injection process is a unique one-person, one-truck patching operation. With the exception of the traffic control, the patching operation is controlled from the truck cab, thus reducing the traffic hazards, safety risk, and liability that are associated with other patching methods. From the preliminary telephone survey that was conducted, all states that were contacted emphasized that only experienced and well-trained operators should operate the spray injection patcher. This requirement ensured good-quality patches and ensured that the equipment was maintained in good working order.

The spray injection pothole patcher was originally designed for patching potholes; however, additional repairs are also possible on alligator cracking, edge erosion, depressions, bridge decks, concrete pavement, and utility cuts.

The spray injection test patches that were placed for this study used a Rosco RA-300 spray injection patcher, shown in Figure 2. The patcher had a 400-gallon asphalt tank that kept the asphalt emulsion heated using the heated antifreeze solution from the truck radiator that passed through a tube in the bottom of the tank. The 6 yd^3 aggregate hopper had an optional heating system that used the truck exhaust heat to heat the aggregate during cold periods. The emulsion tank and aggregate hopper stored enough materials for at least 1 full day of patching. It was equipped with a high-volume blower system capable of producing 350 CFM for cleaning the pavement or pothole prior to patching as well as forcing the asphalt-aggregate mixture into the patch. It blew the materials in at such a high velocity that the aggregate was seated in place, thus eliminating the need for rolling. A typical specification for truck-mounted spray injection patchers is provided in Appendix F.

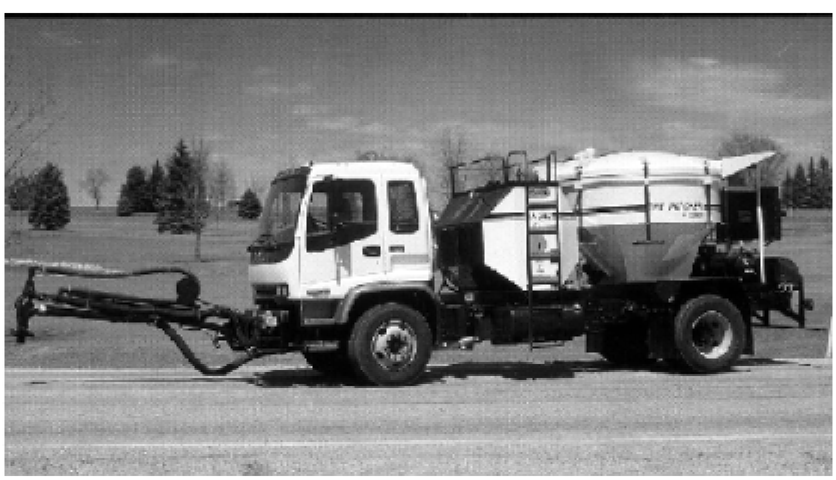

Figure 2. RA-300 Spray Injection Patcher

VDOT owns a Dura-Patch pull-type spray injection patcher that is located in the Suffolk District. VTRC personnel observed the operation of the patcher that uses the same procedure as the truck-mounted patcher, and it seemed to produce the same quality patch except during cold temperatures. The cost of the pull-type patcher is approximately one-third the cost of the truck-mounted type; however, there are limitations. The pull-type unit requires an extra person to work the wand, and this person is directly exposed to traffic. There are seasonal limitations as with the other patching methods because it does not have the capability of heating the stone during cold temperatures.

The uniqueness of the spray injection process is that it is done with minimal traffic control, and in some states, the arrow board on the truck is used to control traffic without the use of flaggers. In addition, once the patch is completed, it is ready for traffic immediately without the concern that the new patch might be distorted by the traveling vehicles.

The following four steps illustrate the simplicity of the spray injection process as described by Kliger.[4]

1. Clean the hole. The operator applies a blast of air to remove loose rock, debris, and possibly water from the area to be patched (Figure 3).

2. Use the same nozzle to apply a tack coat of emulsion.

3. Using the joystick, combine the aggregate and hot asphalt with air and force it into the hole (Figure 4).

4. Turn off the valve controlling the hot asphalt and apply a top coat of dry aggregate to the surface (Figure 5).

After application of the dry aggregate, the patch is ready for traffic without compaction.

Figure 3. Hole Being Cleaned for Repair

Figure 4. Aggregate and Asphalt Blend Being Applied

Figure 5. Coat of Dry Aggregate Being Applied

Skin Patching

The skin patching method employs the application of an asphalt emulsion layer followed by the application of a layer of clean, well-graded aggregate. Sometimes, depending on the severity of the roadway distress, multiple layers of asphalt emulsion and aggregate may be required. Conventional equipment was used for the skin patching operation. It consisted of three standard dump trucks, one smaller two-ton dump truck, a distributor, and a steel wheel roller.

Table 2 lists the personnel and equipment requirements for the two patching methods. The skin patching method was used only on secondary and primary routes, whereas the spray injection patching method was used for interstate, primary, and secondary routes. The skin patching method is not normally used on interstate roads because of the increased potential for broken windshields.

Table 2. Personnel and Equipment Required for the Two Patching Methods

Skin-Patching		Spray Injection Patching			
Primary and Secondary		Interstate		Primary and Secondary	
Personnel	Equipment	Personnel	Equipment	Personnel	Equipment
5 Operators	3 Dump trucks	4 Operators	Patcher	1 Operator	Patcher
1 Supervisor	1 Two-ton truck		3 Trucks	2 Flaggers	
2 Flaggers	1 Distributor		3 Cushions		
	1 Roller				

RESULTS

Patch Observations and Evaluations

The visual evaluations of the patches during the 2.5-year construction-evaluation period were performed by a team of at least three evaluators. The evaluating team consisted of staff from VTRC, the spray injection patcher operator, the area superintendent, and sometimes the residency maintenance manager. All of the evaluators had a vast knowledge of patching techniques and how to determine failures. Visual observations were done on all patches. Even though the team observed the patches on an individual basis, they came to a consensus as to whether the patches received a poor, fair, good, or excellent rating.

During the study period, visual observations were conducted every 3 to 4 months. The evaluating team looked at the performance of the individual patches; however, the overall evaluation concluded with an average performance for each type of patch. From the observations, the evaluating team concluded that the performance of the spray injection patches was excellent. The only failures or poor performance observed was where some spray injection patches were placed using a dirty aggregate and when the spray injection patching was done during extremely cold weather using regular CRS-2 emulsion. Patch failures were observed by the evaluating team at one location where patches were placed at below freezing temperatures. However, at the same location, the patches placed at above freezing temperatures were performing well at the first quarterly evaluation and continued to perform well. Patch failures were also observed at one site location that used dirty No. 9 aggregate. Some of the spray injection patches at locations on I-81 were performing well after 2 years, but the pavement surrounding the patches had continued to deteriorate. It was the consensus of the evaluating team that even though some failures had occurred at two locations, the life expectancy of the spray injection patches was between 3 and 5 years. This was the same experience expressed by other states during the preliminary telephone survey.

The performance of the skin patches was not nearly so good as the performance of the spray injection patches. For almost every patch, a certain amount of deterioration or failure had occurred when the first evaluation was performed, and the patches that were placed on Route 419, the primary route, were severely flushed within the first month. It was concluded by the evaluators that the average life expectancy of the skin patches was approximately 1 year.

Equipment Observations

It was necessary for only well-trained operators to operate the spray injection patcher. Even though the patcher is not a complex piece of equipment, a good operator is necessary to achieve good patches Because the RA-300 patcher was designed and built so well, mechanical failures were few. It is necessary to do regular and preventive maintenance to prevent problems from occurring. The machine works well if clean aggregate is used and the patcher is cleaned daily as suggested by the manufacturer.

If the asphalt tank is not empty at the end of the week and the asphalt is kept heated during the weekend, a means to circulate the asphalt should be installed to prevent asphalt coagulation. On one occasion, less than 100 gallons of asphalt was left heating over the weekend, which caused problems with asphalt coagulation. This problem was resolved by installing a connector at the front end of the boom where air could be connected and forced through the system. The asphalt should be circulated for 30 to 60 minutes prior to patching. If a circulation system is not used, the asphalt that coagulates in the supply tubes and the bottom portion of the tank will hinder operations until it is dispersed when patching operations begin the following week. The best solution to this problem is to plan in such a way that no asphalt is left in the tank for prolonged periods of time.

Cost Analysis

The SHRP manual of practice[2] was used to help develop the forms shown in Appendices A and B used to record data in the field during the evaluation. Appendix E summarizes the information, showing the area patched, total cost, and time required at each of the patching locations. Table 3 shows the unit cost per square yard over an assumed 4-year period at a 6 percent discount rate for the two types of patching. The observation time was only 2.5 years; however, considering the condition of the spray injection patches, it is projected that the service life will be at least 4 years. The condition of the skin patches and opinions of the experienced maintenance personnel that helped evaluate the patches indicated that a 1-year service life for skin patches was reasonable.

The total unit cost of the spray injection patching method was 36 cents more per square yard than the cost for the skin patching. These figures include the total costs for each patching operation, which included materials, equipment, and personnel. The present worth over the 4-year period of the spray injection patching is $4.86 ($7.17 to $2.31) per square yard less than the present worth of the skin patching. The large difference in present worth for the two methods is because the skin patching had to be repeated on an approximately annual basis.

Table 3. Cost Comparison of Patching Methods

Beginning of Year	Skin Patching		Spray Injection	
	Unit cost/yd^2	Present worth/yd^2	Unit cost/yd^2	Present worth/yd^2
1	$1.95	$1.95	$2.31	$2.31
2	$1.95	$1.84	0	0
3	$1.95	$1.74	0	0
4	$1.95	$1.64	0	0
Total	**$7.80**	**$7.17**	**$2.31**	**$2.31**

CONCLUSIONS

- *The performance of the spray injection patches was superior to the performance of the skin patches.* The life expectancy of the spray injection patches was 3 to 4 years, whereas the skin patches were often showing signs of failure when the first quarterly evaluation was done. The skin patches had an average life expectancy of 1 year.

- *The spray injection patches were more cost-effective than the skin patches.* Even though the initial coast of the spray injection patches was higher, the superior longevity of the spray injection patches overrode the higher initial cost.

- *Placing spray injection patches is much safer than placing other types of patches because the operation is performed from the truck cab with a minimal number of personnel exposed to traffic.*

- *Spray injection patches can be successfully placed throughout the year.*

RECOMMENDATIONS

1. VDOT should consider purchasing additional spray injection patchers where the number of personnel is limited, where traffic may present a serious threat to the safety of workers, and where cost savings similar to those in this study could be achieved.

2. At temperatures less than 32ºC, special formulated CRS-2 or CMS-2 should be used.

3. A good, clean, cubical No. 9 aggregate should be used. It is also allowable to use a clean No. 8 aggregate; however, it is recommended that it not be used on high-traffic roads so as to eliminate the possibility of broken windshields.

4. Only experienced and well-trained operators should be used. This will ensure quality patches and keep the equipment in good operating order.

ACKNOWLEDGMENTS

The author thanks Roger Maxey of the Southwest County Area Headquarters, the operator of the spray injection patcher, for his hard work during this project. Special thanks go to Larry Chaffin and John Green and the other members of the Hanging Rock and Airport Area Headquarters for coordinating the test sections for this project. Appreciation is also expressed to all Salem District and Salem Residency personnel involved in making this project a success. Acknowledgment is given to C.W. Payne for performing the telephone inquiry and field evaluation and synthesizing the results. Special thanks are expressed to Linda Evans, Randy Combs, and Eileen Aiken for their help in preparing this report.

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APPENDIX A

AGENCY COMMENTS ON SPRAY INJECTION PATCHER
(Telephone Canvassing Results)

ERES Consultants. They did the testing of the spray injection patchers for SHRP. Of the several patchers they tested, the Rosco performed the best, with no problems. The spray injection patching technique is a good method, but the key to a good job is a well-trained operator. They indicated that the patches lasted much longer than conventional types of patches.

SCDOT. They stated that they have used the truck-mounted and the tow-along patchers and the results are better than their standard ways of patching. The patches last longer and are less expensive than conventional patches. The spray injection patching has been used on concrete pavements, and the patches last longer than other types of temporary concrete patching. They indicated that a good operator is a must. They indicated that the life of the spray injection patches was somewhere between 3 and 5 years.

PennDOT. They have had excellent results with the spray injection patching method with an expected average patch life of 4 years. Winter time patching is as good as the warmer weather patching. It was indicated that they do all types of patching repairs on all types of asphalt and concrete roads. When patching on high-traffic volume roads, they use No. 9 aggregate to avoid broken windshields. A well trained operator is necessary for a quality job.

Baltimore County Public Works. It was indicated that they have had excellent results on patching all types of roadway discrepancies using a good operator. Their patches last 4 to 5 years, which is 2 to 3 times the life expectancy of their conventional patches.

Delaware Turnpike Authority. Success rate with the spray injection patching method was much better than with their conventional ways of patching and last as long. A well trained operator is a necessity.

City of San Diego. The spray injection patching method has yielded excellent performance, with an average life expectancy of 4 years. They, too, emphasize the need to have a well-trained operator.

City of Columbus. Excellent results with the spray injection patching method. Winter time patches have held up well also. They indicated that the spray injection patches last 3 to 5 years and emphasized the necessity for a good operator.

Alaska Department of Transportation. They are very pleased with the Rosco patching units. They prefer the truck-mounted rather than the tow-along unit due to versatility. They have a good success rate on winter time patching when using CMS-2 emulsion. Patches last on an average of 2 to 3 years. Good operator needed.

Kittitas County Washington. They especially like the Rosco truck-mounted units. Winter time patching has been very successful using CMS-2 emulsion and a good operator. The patches last an average of 4 years.

VMS, Inc. They like the results with the spray injection patching method using both the truck-mount and tow-along units. It was stated that they thought it was the most effective way to fix a hole because you did not have to dig a hole to fix a hole. The person from VMS was once with the North Carolina DOT and stated that the patches lasted 4 to 5 years with better performance than conventional types of patches.

VDOT Salem. By far the most effective way to patch any kind of roadway discrepancy. Savings realized with the spray injection method pays for the patcher in less than 2 years. It is very important that a well-trained operator be used to ensure good patches and minimal equipment problems. It was by the maintenance manager and the supervisors that the performance and longevity of the spray injection patches were determined to be better than those of any conventional type patches.

APPENDIX B

POTHOLE PATCHING CONSTRUCTION FORM

Date ____________

District_____________ County__________________ Route ___________ ADT
From: _________________________________To: ______________________________
Temperatures:
Air_______________ Surface________________Times___________________________

Type of Patch:
Test Patch___ Control Patch____

Patching Method:
Spray Injection _____Skin Patching _____
Machine Type ______________________
Equipment Used _____________________
Personnel __________________________
Asphalt Type________ SOURCE ____________________QUANTITY ____________
Aggregate Type______ SOURCE ____________________QUANTITY ____________

Ease of Construction: Poor____ Fair____ Good____ Excellent_____

Number of Patches __________________
Sizes _____________________________

TOTAL SQUARE YARDS __________________ TIME IN MINUTES____________
MINUTES PER SQUARE YARD____

Comments:
____
____
____
____
____
____
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____
____
____

APPENDIX C

PATCHING EXPENDITURES

Date ____________ District ______________Route ______County _______________
Patching Type _______________

MATERIALS COST

Asphalt cost/gallon $__________
Gallons of asphalt used __________ X the cost $_______ = $ ___________
Aggregate cost/ton $ ____________ Cold mix cost/ton = $ ______________
Tons of material used____________ X the cost $________ = $ ___________

EQUIPMENT COST

Distributor
Pull Type cost/hr. $____________
Hours used __________________ X hourly cost $______ = $____________
Truck mount cost/hr. $_________
Hours used __________________ X hourly cost $______ = $____________
Patcher cost/hr. $_____________ X hourly cost $_____ = $____________
Dump truck cost/hr. $__________
Hours used __________________ X hourly cost $______ = $____________
One ton dump cost/hr.__________
Hours used __________________ X hourly cost $______ = $____________
Pick-up truck cost/hr. __________
Hours used __________________ X hourly cost $______ = $____________
Roller cost/hour ______________
Hours used __________________ X hourly cost $______ = $____________

PERSONNEL COST

Flaggers cost/hr. $_____________
Hours worked________________ X hourly cost $______ = $____________
Laborers cost/hr. $ ____________
Hours worked________________ X hourly cost $______ = $____________
Operators cost/hr. $____________
Hours worked ________________ X hourly cost $______ = $____________
Foreman cost/hr. $_____________
Hours worked_________________ X hourly cost $______= $____________
Supervisor cost/hr. _____________
Hours worked_________________ X hourly cost $______= $____________

TOTAL COST $____________

SQUARE YARDS OF COMPLETED PATCHES____________________
COST PER SQUARE YARD $___________

APPENDIX D

PATCHING LOCATIONS

ROUTE	COUNTY	DAILY TRAFFIC		PATCHING TYPE	AIR TEMP.	
		Average	Range		Average	Range
638	Cumberland	575	331-818	Spray Injection	64	50-68
600	“	1314	218-1481	“	60	52-65
672	“	129	53-259	“	61	59-62
616	Appomattox	296	121-553	“	68	67-69
667	Roanoke	157	78-264	“	79	78-80
11	Botetourt	8,126	8,126	“	76	72-79
735	Roanoke	30,230	30,230	“	61	60-61
644	Floyd	122	57-204	“	72	69-76
796	“	235	235	“	71	67-75
647	“	300	100-500	“	64	63-65
221	“	2838	2,064-3,679	“	68	54-74
648	“	101	50-153	“	55	53-57
615	“	889	48-3133	“	64	52-76
600	Montgomery	1,107	151-2606	“	75	72-77
787	“	642	210-942	“	73	71-78
1541	Roanoke		1340-3184	“	79	67-91
I-81	“	46,331	45,448-47,211	“	76	65-86
I-581	“	66,000	52,000-81,000	“	81	70-92
688	“	1383	811-2316	“	64	52-76
220	Roanoke	27,439	25,672-33,663	“	29	26-43
1150	“	765	765	“	45	37-53
635	“	762	762	“	40	28-52
628	“	2,473	2025-3489	“	27	31-34
670	“	81	54-108	“	45	33-56
600	“	320	320	“	42	34-54
708	Montgomery	75	50-125	“	43	35-55
460	Roanoke	15,974	13,124-17,977	“	39	36-42
714	“	114	114	“	88	75-93
669	“	64	64	“	76	65-86
220	Botetourt	52,502	52,502	“	75	64-82
639	Cumberland	246	246	Skin Patching	63	53-69
419	Roanoke	42,522	29,653 50,307	“	62	52-72
735	Botetourt	240	240	“	65	52-72
690	“	24	24	“	53	42-64
691	“	23	23	“	55	44-63

APPENDIX E

PATCHING DATA BY LOCATION

Route	County	Patching Type	Square Yards	Total Cost (Materials, Equipment, & Personnel)	Time/Minutes
638	Cumberland	Spray Injection	50	$264.00	75
600	"	"	219	$793.00	303
672	"	"	38	$68.00	31
616	Appomattox	"	39	$112.00	24
667	Roanoke	"	328	$367.00	188
11	Botetourt	"	41	$260.00	75
735	Roanoke	"	69	$378.00	160
644	Floyd	"	169	$392.00	207
796	"	"	84	$197.00	84
647	"	"	103	$179.00	104
221	"	"	112	$338.00	187
648	"	"	80	$232.00	81
615	"	"	48	$86.00	33
600	Montgomery	"	32	$165.00	68
787	"	"	84	$313.00	111
1541	Roanoke	"	194	$372.00	153
I-81	"	"	183	$152.00	44
I-581	"	"	78	$209.00	56
688	"	"	168	$264.00	93
220	"	"	217	$361.00	140
1150	"	"	320	$320.00	161
635	"	"	529	$487.00	234
628	"	"	213	$135.00	69
670	"	"	236	$257.00	119
600	"	"	144	$233.00	87
708	Montgomery	"	17	$50.00	20
460	Roanoke	"	132	$386.00	188
714	"	"	99	$112.00	52
669	"	"	95	$209.00	98
220	Botetourt	"	85	$287.00	104
639	Cumberland	Skin Patching	18	$133.00	27
419	Roanoke	"	1104	$331.00	62
735	Botetourt	"	99	$202.00	56
690	690	"	311	$784.00	168
691	"	"	691	$944.00	121

APPENDIX F

SPECIFICATIONS

TRUCK MOUNTED POTHOLE PATCHER – SPRAY INJECTION TYPE

General: The truck mounted asphalt patching machine shall be designed for pavement repair operations including air cleaning of potholes and cracks, pressure mixing and placing of liquid asphalt and aggregate and surface coating with aggregate. The unit shall be new and of a model in current production or an update of an existing model

CHASSIS

General: The truck chassis-cab shall be furnished by the successful bidder. The successful bidder shall mount the asphalt patcher on the truck chassis-cab in accordance with the specifications. Chassis is to be class 7, 4x2, cab-forward type with a minimum 33,000 lb. GVW rating. All suspension and chassis components are to be no less than those specifications, or the pothole patcher manufacturer's recommendations, whichever is greater. Wheelbase and cab-to-axle dimensions are to be recommended by pothole patcher manufacturer for proper weight distribution.

Engine: To be turbocharged diesel developing not less than 185 horsepower gross at rated RPM. To be equipped with heavy duty air filter with restriction indicator, oil filter, muffler, minimum 90 amp alternator, and 12 volt batteries. Heated fuel filter/separator to be furnished.

Transmission: Transmission is to be Allison 6 speed automatic. To have a torque capacity equal to engine.

Front Axle: To be equipped with minimum 12,000 lb. Axle and suspension. Axle to be "I" beam. To be equipped with shock absorbers and power steering, and Stemco type seals.

Rear Axle: Gear ratio to provide a road speed of at least 60 mph at rated engine rpm. Axle and suspension rating is to be minimum of 21,000 lbs.

Tires: To be minimum 11R22.5 tubeless steel belt radial. Front and rear tires and wheels must conform to chassis GVWR.

Fuel Capacity: Total capacity to be not less than 50 gallons.

Brakes: Brakes are to be full air. An air drier is to be furnished and must be either Salem 918-101, or Chicago Rawhide Brakemaster #62 with heat element. All brakes to be furnished with automatic slack adjusters.

Cab: Cab is to be air conditioned. Cab is to include electric windshield wiper(s), windshield washer, dual West Coast type outside rearview mirrors, fresh air heater and defroster, seat belts, tinted windshield and glass, sun visors, tachometer and gauges for fuel level, engine water temperature, engine oil pressure, and ammeter and voltmeter.

Bostrom Air#914 or National Cush-N-Aire Model 95 driver's seat to be furnished. Passenger seat to be individual foam rubber type with seat belts.

POTHOLE PATCHER

Aggregate System: The aggregate tank should hold a minimum of 8 cubic yards of aggregate. The tank is to be equipped with a cover to prevent aggregate from bouncing out when transporting and to seal the tank so it can be pressurized to equalize the pressure developed in the feed hose. The tank should have the ability to feed the aggregate to the air feed system with no conveyors, augers, or hydraulic dump mechanisms. The aggregate should be metered into the air stream without the use of mechanical air lock or wear pad type positive feed systems. This system should have no moving wear parts, and should be capable of delivering up to 22,000 lbs. of aggregate per hour to the aggregate placement nozzle. The system should be designed to work with local aggregates up to ¾ inch in size and should not be adversely affected by fines or dirty material. The aggregate flow should be remotely adjustable, allowing the gates to open and close without resetting the rate.

Asphalt Delivery System: A minimum 400 gallon capacity, insulated asphalt storage tank, pressurized at 60 psi for asphalt delivery shall be provided. The fill opening shall be a minimum 6 inch diameter with a suitable cap or lid to provide sealing. The asphalt control valve shall be mounted in the truck cab.

Hydraulic System: The truck engine shall be a hydraulic system which in turn shall provide power for the air blower, aggregate conveyor, boom movement functions, and other hydraulic components as necessary. The hydraulic system shall consist of at least one(l) hydraulic pump rated at 15 GPM, reservoirs, motors, cylinders, control valves, hoses, pressure relief methods, filters, and other components to comprise a complete system.

Boom: The material hoses and nozzle shall be positioned by a hydraulic operated boom. The boom shall telescope and rotate through two planes utilizing a minimum of three(3) double acting hydraulic cylinders. The boom shall be attached to a removable bracket at the front of the truck. There shall be a positive means for securing the boom in a travel position. The boom and the mounting brackets shall not interfere, or shall be easily positioned so that the truck cab can be tilted through a normal range for maintenance.

Controls: The patching operation shall be controlled by one person working from the truck driver's position. These controls shall include PTO engage/disengage, all boom movement functions, aggregate feeder speed, asphalt delivery, aggregate delivery, and air delivery, as a minimum.

Equipment: The unit shall be complete with all standard equipment and accessories normally furnished. In addition, equipment shall be furnished as follows.:

1. The unit shall meet all OASHA requirements.
2. The unit shall meet all of the requirements of 49 CFR 172 and 173 related to transport and roll-over protection for heated asphalt.
3. Heater for asphalt tank, 220 volt.
4. Tank, pressurized, solvent, ASME approved, minimum 30 gallon.
5. All necessary hoses and nozzles.
6. All special tools needed for adjustment, maintenance, and disassembly of the machine.
7. All necessary hoses and nozzles.
8. Power-take-off (PTO), transmission.type.
9. Boom storage (travel) locking device.
10. Hand throttle.
11. Asphalt and aggregate mixing nozzle.
12. Mud flaps brackets, pre-drilled, installed behind rear wheels (mud flaps not required).
13. Aggregate hopper drain valve.
14. Asphalt tank drain valve.
15. Toolbox, one (1) each securely mounted, lockable hasp, and of minimum size 24"Lx16"Hx13"D.
16. Back-Up alarm.
17. One (1) fire extinguisher, 20 lb., ABC type, mounted on drivers side of platform.
18. Rear bumper, DOT type.
19. Truck rear license bracket with light.
20. Loading inlet, with cover, for asphalt tank.
21. Full width, safety tread deck, steel walkway over asphalt tank, not less than 24 inches wide.
22. Access ladder to asphalt tank walk area.
23. Air blower with filter, hydraulically operated.
24. Hydraulically operated metal cover for aggregate hopper.
25. Hydraulic filter, heavy duty with replacement element.
26. Water cooler bracket.
27. Traffic control sign, rear mounted, black, not to block operator vision, 30"x60" weatherproof. Sign shall comply with the specifications listed under the SIGN PANEL paragraph below.

Sign Panel: The sign panel shall be size 30" vertical and 60" horizontal. The sign shall be constructed of aluminum and shall be adequately framed and braced for transporting and when erected for operation. There shall be fifteen (15) sealed beam lamps arranged and wired to produce at least the following indications when flashing:

1. Double arrow thirteen (13) lamps) flashing.
2. Right arrow ten (10 lamps) flashing.
3. Left arrow ten(10 lamps) flashing.
4. Travel warning – four (4 lamps) in corners flashing.

The lamps shall be 12 volt, number 4412A, amber, and shall have visors that extend at least five (5) inches beyond the lamp face and encompass 180 degrees or more of light circumference. The lamps shall provide a minimum legibility distance of one (1) mile.

The sign shall be powered by the truck electrical system. The sign controller shall be and electronic unit mounted in the truck cab. The control panel of the controller shall have an on-off switch selector, selector for the various display modes, and a manual “bright/dim” lamp intensity adjustment.

Spare Filters: Each machine delivered is to include one spare filter for each system (air, fuel, engine oil, hydraulic, etc.) on the machine. *Filters are to be boxed and labeled for each receiving location. Shipping loose in the cab is not acceptable.*

Safety: Vehicle is to be furnished to conform to the (National Traffic and Motor Vehicle Safety Act of 1966) Federal Motor Vehicle Standards, with amendments as of date of delivery, and the Motor Vehicle Code of Virginia.

Delivery: Equipment is to be delivered to the District Headquarter locations listed in the invitation for bid. Unit is to be fully assembled and ready to operate before being accepted by the department.

Instruction: A manufacturer or dealer representative is to inspect the equipment after delivery and provide operators and technicians orientation on the operation and maintenance requirements for the units to each district receiving equipment. This must be scheduled with the VDOT District Equipment and Facilities Manager.

Advertisement: No stickers, decals, or plates displaying dealer or distributor name or logo shall be affixed to equipment. Manufacturer plate with model or serial number is to be on the equipment.

Current Model: Equipment is to be standard proven model of manufacturers latest current production and include all *standard equipment as advertised* with additional optional equipment outlined herein. All components, unless otherwise required by these specifications, shall be the standard or optional equipment specifically advertised and installed by the manufacturer.

Warranty: The unit is to be warranted for a minimum of 24 months from the date that it is placed in service by VDOT. Any forms requiring for updating warranty start dates are to be delivered to the VDOT District Equipment and Facilities Manager at the time the unit is delivered. Warranty is to include all items covered under the manufacturer’s standard warranty. Wear items such as blades , teeth and points, etc. are excluded. The manufacturer shall agree to replace any parts which fail during normal use. Replacement is to include at no cost to the Commonwealth of Virginia all parts, labor, and transportation cost to the location of the equipment. At the option of the District Equipment and Facilities Manager, the machine may be returned to the dealers facility for repairs.

Bid Literature: Descriptive literature will be required to substantiate the details specified in the bid.

Manuals and Parts Lists: Successful bidder shall furnish *one operator's service manual, and one parts list* in CD-ROM or microfiche for each unit delivered. If microfiche, parts lists is to be 4x6 inch cards, positive or negative, 24X or 42X magnification. All manuals and parts list under any circumstances must be congruent with the unit delivered and shall include information on all components and items furnished.

Two additional copies of operators manuals, shop manuals and parts list are to be delivered to each receiving district.

One additional copy of the parts lists is to be delivered to VDOT's Administrative Services Division, 1401 East Broad Street, Richmond, VA.23219, ATTENTION – Inventory Management Section.