

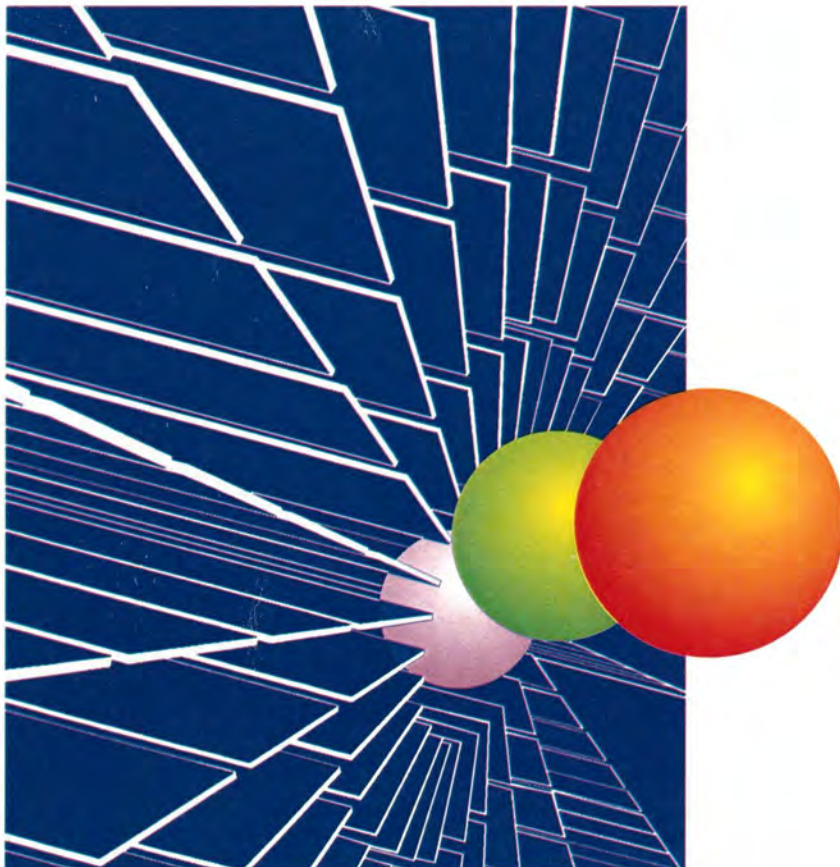
MoDOT

Research, Development and Technology Division

Product Development 96-004

Scrub Seal

Initial Report



September, 1998

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INITIAL REPORT

Product Development 96-004

SCRUB-SEAL

MISSOURI DEPARTMENT OF TRANSPORTATION
RESEARCH, DEVELOPMENT AND TECHNOLOGY DIVISION

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JEFFERSON CITY, MISSOURI
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The opinions, findings, and conclusions expressed in this publication are those of the principal investigators and the Research, Development and Technology Division of the Missouri Department of Transportation.

They are not necessarily those of the U.S. Department of Transportation, Federal Highway Administration. This report does not constitute a standard or regulation.

EXECUTIVE SUMMARY

Highway agencies in the United States spend billions of dollars annually on pavement maintenance. But soaring traffic volumes and truck loads make it more and more difficult to keep up with maintenance needs. As a result, highway agencies face a backlog of maintenance tasks, which means more pavements are in need of repair. Poor pavement conditions can impair highway safety, damage vehicle tires and suspensions, and annoy motorists.

Presently, our maintenance division uses preventative maintenance treatments such as chip seals, microsurfacing, and 1" hot mix overlays to restore damaged asphalt pavements. These treatments cost from \$0.53/s.y. to \$1.40/s.y. and can cost districts a considerable amount of money when they need to restore several miles of asphalt pavement each year as a part of their annual program.

The scrub seal is a process that can be used as pavement preventive maintenance. It is not a cure-all for any type of asphalt pavement, but can be used on specific asphalt pavements as described within. The scrub seal is a program strategy intended to arrest light deterioration, retard progressive failures, and reduce the need for routine maintenance and service activities. This treatment activates the old asphalt and preserves rather than improve the structural capacity of the pavement structure. Thus scrub seal treatments are limited to pavements in sound structural condition (i.e. base routes which have a constructed base).

The objective of this study is to determine if the scrub seal is more cost effective than microsurfacing, chip seals and the 1" hot mix overlay. Scrub seals were placed at 10 different locations and reviews of each section were made to determine the usefulness of the seal. Most of the scrub seals are very promising although it has been determined they should be limited to areas of less than 7500 ADT. Most of these scrub seals are about 1 year old and we are hoping to get a life span of 3 to 4 years from them.

This study cannot be completed until the life of the scrub seal can be determined. However, by taking an average life span for the chip seal, microsurfacing, and hot mix overlays, and assuming a 4 year life for the scrub seal, the scrub seal clearly has a cost per square yard less than the other preventative maintenance treatments. At this point in the study, we believe the scrub seal should be used on dry, cracked and oxidized asphalt pavements. With these pavement conditions, the scrub seal is an excellent process to help the maintenance division with their preventive maintenance program. However, the pavement and subgrade must be stable. Pavements that are cracked or weak because of a poor subgrade are not candidates for the scrub seal.

This is an initial report with initial specifications. A final report with revisions to the specifications will be prepared after the life of the scrub seals has been determined. We estimate the final report can be prepared in 2001 or 2002.

For now, we believe the scrub seals are very effective and should be used on stable asphalt pavements that are dry, oxidized and cracked. This can be an effective treatment for 3 to 4 years at which time another scrub seal could be placed or a more substantial preventative treatment may have to be applied.

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INTRODUCTION

MoDOT spends millions of dollars annually in asphalt pavement maintenance. This can range from pothole patching to pavement rehabilitation. The maintenance division frequently uses chip seals, 1" hot mix overlays and microsurfacing to maintain asphalt pavements. Maintenance uses these three treatments on hundreds of miles each year, especially the 1" hot mix overlay. Although these treatments are successful, they are expensive and the maintenance division is looking for a cheaper treatment. If the scrub seal can extend the existing life of an asphalt pavement at a lower annual cost than the mentioned preventative maintenance treatments, high dollar savings can be realized.

Missouri first heard of the scrub seal being used in the State of Arizona. We have a great need for this type of maintenance work and contacted Koch Materials Inc. in hopes to obtain a scrub seal Missouri could use. Koch Materials did derive their own scrub seal and it is anionic emulsion. The scrub seal used in Arizona is cationic emulsion.

The scrub seal is a process by which a unique polymer modified asphalt agent is applied to a pavement surface. The asphalt is scrubbed into the cracks and voids with a broom before a layer of aggregate is applied over the asphalt. The aggregate and asphalt is again broomed forcing the mix into the cracks and voids to form a seal. The seal is then rolled with a pneumatic tire roller and is usually ready for traffic 1 hour or less.

The scrub seal process is intended to rejuvenate dry, oxidized, and cracked asphalt pavements in lieu of a microsurface, chip seal or asphalt overlay. In October of 1996, a 2.2 mile test section was placed on Route 24, east of Lexington, in Lafayette County. This was the first scrub seal placed. We now monitor nine additional scrub seal projects that have been placed in districts 1 through 6.

LITERATURE SEARCH

There was a literature search performed at the beginning of the project but no information could be found concerning the process. Literature searches should continue as testing of the scrub seal continues.

OBJECTIVES

The main objective of this investigation is to determine if the scrub seal process is a cost effective alternative to chip sealing, microsurfacing and 1" hot mix overlays on asphalt pavements that are cracked and oxidized. To be suitable, the scrub seal must have a lower annual cost per square yard than the other treatments. Once again, only data from base routes will be used in the annual cost analysis.

Some minor crack sealing would be permissible but the scrub seal should be basically maintenance free during its lifetime. This would allow maintenance to perform other duties and allow them to spend their budget on other maintenance activities.

PRESENT CONDITIONS

The maintenance division overlays more than 1000 miles each year with a 1" hot mix overlay. In addition, they use microsurfacing and chip sealing to repair several miles of roadway each year. The 1" hot mix overlay is laid by a contractor and last from 4 to 10 years. It costs approximately \$1.36/s.y. The chip seal, performed by maintenance, has approximately the same life as a 1" hot mix overlay and costs approximately \$0.51 - \$0.55/s.y.. Microsurfacing also has approximately the same life span and costs approximately \$1.40/s.y.. Microsurfacing is done by contract; however, maintenance handles traffic control. Traffic control is included in all the costs stated above.

Hot mix treatments are used to "build up" roads on the supplementary system to give the roadway additional stability, whereas microsurfacing and chip sealing are used to fill cracks and seal the pavement. Each of these treatments are expensive and the life of the treatment varies with the condition of the existing pavement and subgrade as well as the construction of the seal.

If the scrub seal can extend pavement life at a cheaper annual cost than these treatments, it will be an additional tool for maintenance to use as pavement preventative maintenance. Used as a preventative maintenance tool, it may extend asphalt pavement life for an additional 3-4 years at which time a more aggressive preventative maintenance treatment can be used.

TECHNICAL APPROACH

The scrub seal is a polymer modified asphalt emulsion with an additive added to achieve the desired characteristics. Koch Materials Company is the supplier of this emulsion and have a patent on the emulsion so there is very little information available on it. The asphalt emulsion is sprayed onto the pavement with a distributor at a rate of 0.14 to 0.18 gallons per square yard depending on pavement condition. The emulsion is scrubbed into the cracks and voids of the pavement with a series of brooms (see Appendix B) that are attached to the distributor. Fine aggregate is then placed with a self-propelled aggregate spreader at a minimum rate of 12 lbs per square yard. The fine aggregate is also broomed with the same broom configuration as used on the polymer modified asphalt emulsion. The seal is then rolled with a 5-7 ton pneumatic roller making a minimum of two complete passes. Traffic is allowed on the seal after approximately 1 hour; however, full cure takes a few days.

Ten scrub seals have been placed. Data gathered during the scrub seal placements has been reviewed to arrive at an initial specification. Each of these locations were inspected by the author between March 10 and March 30, 1998. They will continue to be monitored for their lifetime to come to a final benefit/cost ratio when compared to other alternative seals. When the life of the scrub seals is determined, a final specification will be developed in a final report. This document is an interim report for the behavior realized using the scrub seal process in rehabilitating numerous asphalt pavements throughout the state.

The synopsis of the 10 locations can be found in Appendix A. The ten locations are:

District 1: Buchanan County, Route JJ; from Route V to Route HH
Andrew County, Business Route 71; in northbound lane beginning 0.5 miles north of I-29 intersection north to near Savannah

District 2: Chariton County, route 24; from end of PCCP east of Keytesville to west of Keytesville, 5.8 miles total
Randolph County, Route JJ; from Route 24 to Route C, 4.2 miles total

District 3: Audrain County, Route 22; from 5.0 miles east of the Boone county Line to 11.4 miles east of the Boone county Line, in Mexico

District 4: Lafayette County, Route 24; from beginning of two lane section east of Lexington east 2.2 miles
Henry County, Route 52, disjointed sections from Route 13 to Montrose.
Henry County, Route H; entire length of route in Henry County, 3.0 miles in length.

District 5: Cole County, Business Route 50, Missouri Boulevard; from South Ten Mile Road to Stadium Boulevard, eastbound lanes.

District 6: St. Louis, Route 67 NB, Lindbergh Boulevard; from Route 100 north to Route 40, 2.4 miles total

RESULTS AND EVALUATION

After one winter or more, some of these scrub seals are working exceptionally well. Other seals are not looking quite so good and are beginning to wear as far down as the old pavement.

The seal installations on Route 67 in St. Louis County and Business Route 71 in Andrew County were both installed in October, 1997. Both of these locations have experienced much more deterioration than should be expected for their age. In a March 31, 1998 phone conversation with Larry Reddick of Koch Materials, Mr. Reddick indicated that the weather conditions subsequent to these two installations was not conducive to proper curing of the polymer modified asphalt emulsion as the ambient temperature hovered around 60° F. The author mentioned the fact that the seal on Route 24 in Lafayette County, the first seal of this nature placed in the state, was installed in October, 1996 and it too was experiencing above average deterioration. The weather subsequent to this installation was unseasonably warm. Mr. Reddick responded that the deterioration here could be attributable to both Koch Materials and MoDOT being inexperienced in the process referred to as "scrub-seal". RDT is recommending that this sealing process not be placed before April 1 or after October 1, nor should it be placed when local weather forecasts predict rain or ambient temperatures below 60 ° F, within 72 hours after placement.

District 5 experienced severe dust problems after the installation of the seal on Business Route 50 in Cole County, due to the use of manufactured sand. RDT is recommending that manufactured sand not be used as aggregate for this seal and that aggregate meet the requirements set forth in Section 1005.2 of the Missouri Standard Specifications.

On a strip of the sealed portion of Business Route 71 in Andrew County, district 1 used 50 tons of wet bottom boiler slag obtained from St. Joseph Power and Light in lieu of fine aggregate. Due to the curing conditions, the majority of the seal has deteriorated in locations having washed sand, however, the section having the wet bottom boiler slag has done an exceptional job. RDT is recommending that in instances when wet bottom boiler slag or similar is available, that the engineer can at his/her discretion allow this material to be substituted for the aggregate specified in Section 1005.2 of the Missouri Standard Specifications.

Placement problems were encountered when the ambient temperatures were around 60° F and also when the ambient temperatures were in the upper 90's to 100° F. The seal appears to have less problems if you have a few days of warm curing weather after traffic has been placed. The seal does not work well under high traffic volumes.

The scrub seal is not intended to fill ruts but to fill and seal cracks. Field comments concerning the seal are very positive. It is inexpensive, seals the cracks quickly, can be opened to traffic quickly and basically maintenance free except for some possible crack sealing.

It should be noted that even when the scrub seal ravel away, the cracks in the old pavement appear to still be sealed with the scrub seal.

<u>Type of Preventive Maintenance</u>	<u>Estimated Useful Life (average)</u>	<u>Cost per s.y.</u>	<u>Annual Cost per s.y.</u>
1" hot mix overlay	4-10 (7)	1.36	0.19
chip seal	4-10 (7)	0.53	0.08
micro-surfacing	4-10 (7)	1.40	0.20
scrub seal	4	0.43	0.11

These annual costs only consider the initial cost of the treatments. Initial cost includes material, equipment, labor and traffic control. Annual maintenance costs were not factored in, but will be on the final report.

Using the annual cost figures above, the benefit of using the scrub seal over 1" hot mix is 1.73, over the chip seal is 0.72, and over microsurfacing is 1.82.

Although the benefit cost ratio for scrub seal versus chip seal is below 1, there are still some advantages in using scrub seal. The biggest advantage is that it is more pleasing to the public. The rock chips in the chip seal have a tendency to fly up and crack windshields. This is not a problem with the scrub seal. A highly skilled crew and well calibrated equipment is necessary to properly place chip seal. The scrub seal is easier to place; thus, more miles of the scrub seal can be placed in a day. Also, traffic can be opened sooner on a scrub seal project than a chip seal project.

Future monitoring of the scrub seal will be needed to see if the four year life can be attained and remain basically maintenance free. If the four year life can be attained and costs remain near \$0.43/s.y., the scrub seal should be a fine tool for maintenance to use with their preventive maintenance program. Also, at \$0.43/s.y., it will help maintenance with their restricted budgets.

When the life of the seal is determined, final conclusions, recommendations and modifications to specifications will be prepared at that time.

A complete copy of the initial specifications for this process can be found in Appendix B.

CONCLUSIONS

1. By making "life cycle" assumptions on 1" hot mix over lays, chip seals, microsurfacing and the scrub seal, the scrub seal is the most cost beneficial to use on asphalt pavements. Although the original asphalt pavement should meet certain criteria, the scrub seal works until a more aggressive maintenance procedure is needed. The benefit/cost ratio for the scrub seal is 1.82 when compared to microsurfacing, 1.73 when compared to 1" of hot mix asphalt and 0.72 when compared to the chip seal.
2. The condition of the asphalt pavement to become an ideal candidate for the scrub seal is a dry, oxidized and cracked pavement. However, it must be stable where no additional stability is needed from the thickness of the seal.
3. The scrub seal is a thin seal. It is not intended to fill ruts or to have sufficient thickness to add stability to a pavement. Its prime purpose is to fill the cracks and seal the pavement.
4. Even when the scrub seal becomes removed from the old pavement, it appears the old pavement cracks are still sealed with the scrub seal.
5. Although the prime purpose is not to improve friction of the pavement, friction values were good following the application. The only exception was the scrub seal in St. Louis where there was a high ADT and the scrub seal has worn extensively.
6. For the scrub seal to be affective, specifications in Appendix B must be adhered to.
7. At \$0.43/s.y., this is a good maintenance tool to be used as pavement preventive maintenance. This is a low cost seal and will allow the maintenance division to direct some of their budget toward other needs.

RECOMMENDATIONS

1. As a result of this study, it is recommended that the department use the scrub seal as a preventive maintenance tool to seal asphalt pavements. The scrub seal should be used on dry, oxidized and cracked asphalt pavements, yet stable and where the department is trying to get an additional 3 to 4 years of life before a more aggressive maintenance treatment or rehabilitation is needed. The scrub seal is not recommended for asphalt pavements that are yielding or unstable. This type of pavement will require a treatment that will provide additional thickness and stability.
2. Initial specifications are being prepared as soon as possible to allow the maintenance forces to construct the scrub seal this construction season or allow them to go out to contractors for bid. Scrub seals placed this year will be selected at random to be monitored for data. Scrub seals placed this year and the seals placed 1996-1997 will continue to be monitored for their life cycle cost and a final specification would be prepared after the life of the scrub seals is known. Scrub seals placed before the final specification is prepared can be placed with specifications being modified as new information becomes available from the new scrub seals.

3. Proper equipment is important for a quality job; therefore, we recommend each district's resource center be allowed to purchase a high performing self propelled chip spreader and pneumatic roller, if needed.

IMPLEMENTATION

1. This initial report will be immediately shared with the divisions of Materials and Maintenance. Materials is writing a specification which will allow the maintenance division to place the seal themselves or allow contractors to bid the work for the coming 1998 construction season.

2. Random selection of scrub seals placed in 1998 will be monitored for data such as weather conditions, pavement temperatures, oil and aggregate application rates, aggregate gradations and sources, oil samples, roller weights, etc. This data will be kept for future specifications and an annual follow up of these seals will continue until the seals are no longer useful which will probably be for 3 to 4 years from placement.

3. During 1998, each of the original 10 scrub seals placed will be evaluated for their condition. This will be a joint annual evaluation between RDT and district maintenance until the seals are no longer useful. When complete, this will allow RDT to determine the life span of the scrub seals placed in 1996 and 1997 and a final benefit/cost ratio to be calculated. This will be shown in the final report which we estimate to be completed in 2001 or 2002 but it will depend when the life of the seal is completed.

4. RDT will monitor the implementation of scrub seal usage in the districts beginning in 1998. This is to assure all districts are using the scrub seal and feel comfortable with its application.

5. In the final report, a final specification will be recommended to Materials for their review. This specification may not change from the initial specification, but it will be derived from data from seals placed from 1996-1998 or other seals placed after 1998 that would be beneficial.

APPENDIX A

LOCATIONAL SYNOPSIS

The ten locations that have been sealed were inspected between March 10 and March 30, 1998. Pictures and a detailed synopsis of the condition of each location can be found elsewhere in this report. A table showing traffic volumes in both 1996 and 1997 has been included.

Most of the locations having been sealed are in good to excellent condition. Each of these locations does have an occasional snowplow scrape and/or popout, and wear is minor. The locations that are experiencing significant wear, scrapes, and popouts are in District 1, 4, and 6. Reasons for this occurring can be found in the synopsis.

Andrew County Business Route 71, NB

This site was inspected on March 17, 1998, by Jim Preuss and the author.

This seal was placed in the passing lane on October 14, 1997. The driving lane was sealed a few days later. For several days after placement, the ambient air temperature hovered around 60 degrees Fahrenheit. In a March 31, 1998, phone conversation, Larry Reddick of Koch Materials, supplier of the emulsion, said that these conditions may not have been conducive for the optimum curing of the emulsion.

Mr. Reddick's explanation seems reasonable, as Mr. Preuss reported numerous instances of public complaint about oil splatter on vehicles that had been traveling northbound on Business Route 71 near Savannah. In the laboratory at the District office, several small samples of the seal that Mr. Preuss had taken from Business Route 71 were soaking in both water and salt brine identical to that used by MoDOT maintenance forces. It could be seen, especially in the samples soaking in the salt brine, that small oily clumps were floating on the surface of the liquid.

There was also a significant amount of wear in the wheelpaths on Route 71, so heavy in some area that little to no seal remained. This was especially highlighted in the areas next to the various turnarounds. Due to the rain that day, the amount of wear could not always be clearly defined, but it was still apparent.

The aggregate used in the majority of this project was washed river sand. A small portion of the project used wet bottom boiler slag, obtained from St. Joseph Power and Light. A total of 50 tons of the wet bottom boiler slag was used and its resistance to wear, as compared to the sand used, is phenomenal. Mr. Preuss was very impressed by the behavior of the slag so far, especially when considered with the extremely poor performance of the seal in this particular location.

During 1997, traffic averaged from 4900 vehicles per day to 9100 vehicles per day on certain segments of this location.

Photo #1: Samples of the seal soaking in salt brine. Oily clumps of the emulsion were floating on the surface and can be seen on the sides of the container. March 17, 1998; District 1, Andrew County Business Route 71



Photo #2: Wear and loss of seal on the surface. March 17, 1998; District 1, Andrew County Business Route 71



Photo #3: A close-up view of the surface showing wear and loss of seal. March 17, 1998; District 1, Andrew County Business Route 71



Photo #4: The driving lane (on the left) with washed sand aggregate and showing wear; the section having wet bottom boiler slag is on the right and is showing little to no wear. March 17, 1998; District 1, Andrew County Business Route 71



Photo #5: A second view of Photo #4 showing the difference in wear between the seal using sand as aggregate and wet bottom boiler slag as aggregate. March 17, 1998; District 1, Andrew County Business Route 71



Photo #6: A slightly closer view of Photo #5. March 17, 1998; District 1, Andrew County Business Route 71



Buchanan County

Route JJ

On March 17, 1998, the author met with Jim Preuss of District 1 Operations to inspect the two scrub-seal locations in the district.

The seal at this location was placed for the entire length of Route JJ in September, 1997. According to Mr. Preuss, the district rented equipment to distribute the aggregate. During placement, the machine had difficulty in placing the aggregate in the prescribed 12 to 15 pounds per square yard and a lot of the aggregate was placed somewhere in the range of 25 to 30 pounds per square yard. This necessitated that the surface be broomed several times to eliminate the excess aggregate.

This seal looks very good and is arguably the best looking one of the ten. There are two instances where minor damage has occurred. The first is in the outer wheelpath heading toward Route 116, where several sizable popouts have been noticed going up a hill. The other is in a slight dip in the apex of a horizontal curve, at the bottom of an uphill right hand curve. It appears that a raised snowplow may have bounced on the pavement, causing a sizable, lane wide scrape.

Traffic at this location was approximately 1350 vehicles per day during 1997.

Photo #1: A scrape in the surface most likely due to a snowplow. March 17, 1998;
District 1, Buchanan County Route JJ



Photo #2: A loss of seal in the wheelpath. March 17, 1998; District 1, Buchanan County
Route JJ



Photo #3: A driveby view of the surface. March 17, 1998; District 1, Buchanan County Route JJ



Photo #4: A view of the surface from around 6' above. March 17, 1998; District 1, Buchanan County Route JJ



Photo #5: A view of a crack and the texture of the surface. March 17, 1998; District 1, Buchanan County Route JJ



Photo #6: Another view of the surface from around 6' above. March 17, 1998; District 1, Buchanan County Route JJ



Chariton County

Route 24

This location was inspected on March 16, 1998. This section begins east of the Route 5 intersection at Keytesville and is 5.8 miles in length.

The persons at the maintenance building in Keytesville said that the seal was placed on June 20, 21, and 22, 1997. The maintenance personnel said that there have been no complaints as there have been in District 1, but rather that there have been many compliments for improving the ride quality on this section of pavement.

When driven at 55 miles per hour, the west bound lane on this section is much smoother than is the east bound lane. The first lane sealed could easily account for the differences experienced.

It was raining intermittently on the day of the inspection. From this, it could be seen that water is ponding in several areas, and several ruts are deep and narrow enough for water to flow at a considerable rate. This predicament cannot be attributed to the seal, but to the pavement.

Throughout the length of this project, it was discovered that there are two concrete patches in the old pavement that had been covered with seal. Both of these patches had retained the majority of the seal. Additionally, in an April 9, 1998, phone conversation with Paul Hague of District 2 Maintenance, the author was told that in finishing the eastbound lane, the amount of polymer modified asphalt emulsion needed ran short, and the project was finished with EA150 emulsion. The section having the EA150 emulsion has held up, but not nearly as well as has the rest of the project.

Mr. Hague said that this location was sealed within a day or two after Route JJ in Randolph County was sealed. In reading the synopsis for Randolph County, it can be seen that the oil was streaking and clumping when applied at a rate of 0.15 gallons per square yard. Mr. Hague said that a similar occurrence was taking place on Route 24, but it was suggested that a piece of carpet could be dragged behind the broom to smooth out the polymer modified emulsion. This seemed to help, but later on during the course of the sealing, the carpet was discarded and the application rate was reduced from 0.15 gallons per square yard.

Overall, this section looks very good. There are several popouts of the seal that were noticed, primarily in the outside wheelpath, but these were few in number.

In 1997, traffic at this location ranged from 1500 to 2550 vehicles per day.

Photo #1: Sheet flow on the driving surface. March 16, 1998; District 2, Chariton County Route 24



Photo #2: Ponding on the driving surface. March 16, 1998; District 2, Chariton County Route 24



Photo #3: Narrow channel flow on the driving surface. March 16, 1998; District 2, Chariton County Route 24



Photo #4: A concrete patch in the pavement beneath the sealant. March 16, 1998; District 2, Chariton County Route 24



Photo #5: Loss of sealant on the driving surface. The roll of masking tape can be seen for size reference. March 16, 1998; District 2, Chariton County Route 24



Randolph County

Route JJ

This location was inspected on March 12, 1998. It covers the entire length of Route JJ, approximately 4.2 miles, near Moberly, and was installed on June 17, 1997.

This section was driven at 55 miles per hour. The ride was rather smooth, and noise due to the seal was noticeable, but not to the point of being intrusive.

This particular section had a lot of reflective cracking in the seal. In a March 31, 1998, phone conversation with Larry Reddick of Koch Materials, supplier of the emulsion, it was said by Mr. Reddick that most of the cracking noticed should disappear when the seal expands due to warmer weather. It was approximately 25 degrees Fahrenheit the day of inspection.

The surface of Route JJ also had considerable areas of seal and/or material loss. This was evident in locations throughout, primarily in the outside wheelpaths, but also covering the entire lane in isolated spots. It was also noted that turning movements had caused the loss of seal in one location, an occurrence similar to what is being realized on Business Route 71 in Andrew County.

The author talked to Paul Hague of District 2 Maintenance on April 9, 1998. Mr. Hague said that Route JJ was the first location in which he had participated in placing this particular form of seal. The polymer modified emulsion was applied at around the prescribed rate of 0.15 gallons per square yard, but this was creating a sizable puddle in front of the first broom that was causing streaks and oil clumps in the surface. Mr. Hague said that it was his belief that these streaks and clumps would disappear upon application of the aggregate, but the streaks and clumps remained. Mr. Hague said that some of the clumps were hit with snowplows during the winter, and that in such instances, the seal was being pulled off down to the pavement below.

The 1997 traffic volumes for this route ranged from 4500 to 7000 vehicles per day.

Photo #1: Loss of seal between the wheelpaths. A glove is shown for size reference.
March 12, 1998; District 2, Randolph County Route JJ



Photo #2: Loss of seal throughout the width of the lane. March 12, 1998; District 2, Randolph County Route JJ



Photo #3: A series of small spalls in the seal. March 12, 1998; District 2, Randolph County Route JJ



Photo #4: Loss of seal due to turning movements on a side road. March 12, 1998,
District 2, Randolph County Route JJ



Photo #5: Loss of seal in wheelpath, near Route 24. March 12, 1998; District 2, Randolph County Route JJ



Audrain County

Route 22

This section was inspected on March 12, 1998. It begins at log mile 5.0 and runs to log mile 11.4 which is inside the Mexico city limits, near the Golden Corral restaurant. This seal was placed on October 15 and 16, 1997.

The seal at this location gave a reasonably smooth and quiet ride. Overall this section looked very good, but a few details do need to be addressed.

In several areas, there was a nonuniform texture from lane to lane, with the eastbound lane usually being the rougher one. One location on the west end of the project had very well defined grader tire imprints in the seal. Several areas of missing material and popouts were noted, most of which were between the wheelpaths. This can most likely be attributed to snowplows.

Mr. Paul Hague of District 2 Maintenance said in a phone conversation of April 9, 1998, that the heat index on the day of installation was around 104°F. Mr. Hague said that the seal remained soft for some time subsequent to placement, but did harden. Several days later, Mr. Hague stopped to inspect this installation, a day with a similar temperature and heat index as the day of installation, and Mr. Hague said that the seal was very soft, again, and could easily be compromised by twisting his foot on it.

Throughout the length of this seal location, the 1997 traffic volumes ranged from 4600 to 7000 vehicles per day.

Photo #1: View of the surface from the shoulder. March 12, 1998; District 3, Audrain County Route 22



Photo #2: Grader tire marks in the surface. March 12, 1998; District 3, Audrain County Route 22



Photo # 3: A few spots having loss of sealant. An ink pen is shown for size reference.
March 12, 1998; District 3, Audrain County Route 22



Photo #4: The inconsistent, sometimes coarse texture of the surface. March 12, 1998;
District 3, Audrain County Route 22



Photo #5: Snow plow damage. March 12, 1998; District 3, Audrain County Route 22



Photo #6: The sealant in a large pavement crack. March 12, 1998; District 3, Audrain County Route 22



Photo #7: Another view of the surface. This seal is easily identified in this location due to its very black color. March 12, 1998; District 3, Audrain County Route 22



Henry County

Route H

Route H was inspected on March 17, 1998. It begins at the Henry-Bates County Line and has a length of 3.0 miles. This seal was installed in September, 1997.

The aggregate used at this location is of an orange tint and its aggregate size is on a par with the small aggregate found in a lot of creek beds. This location, unlike Business Route 71 in Andrew County and Route JJ in Randolph County, appears to be fairly resistant to the turning movements of traffic.

Overall, this section looks very good, with a small number of the expected scrapes from snowplows found between the wheelpaths.

In 1997, the average daily traffic at on this route was less than 1000 vehicles per day.

Photo #1: A view of the driving surface. March 17, 1998; District 4, Henry County Route H



Photo #2: A close-up view of the surface, showing a mild snowplow scar. An inkpen is shown for size reference. March 17, 1998; District 4, Henry County Route H



Henry County

Route 52

Route 52 was inspected on March 17, 1998. It consists of disjointed sections between Route 13 and Montrose. This seal was installed in September, 1997.

This section was unique in that some sections had both lanes sealed, while other sections had only one lane sealed. In the areas where only one lane was sealed, the qualities of the seal are quite obvious, as can be seen in the pictures in the appendix. At several locations throughout the disjointed sections, emulsion could be seen clumped on the surface, similar to that of asphalt.

Riding and noise qualities are very good at this location. This project is of a desirable condition throughout.

This route had an average daily traffic range of 1250 to 1650 vehicles per day during 1997.

Photo #1: A view of the driving surface. March 17, 1998; District 4, Henry County Route 52



Photo #2: The lane on the left has been sealed; the one on the right has not. The seal appears to make a distinct difference in the quality of the driving surface. March 17, 1998; District 4, Henry County Route 52



Photo #3: Splotches of emulsion on the surface. A quarter is shown for size reference.
March 17, 1998; District 4, Henry County Route 52



Lafayette County

Route 24

Route 24 was inspected on March 16, 1998. It begins at the beginning of the two lane section just east of Lexington and runs east 2.2 miles.

The first "scrub-seal" in the state was placed here in October, 1996. RDT has performed several spot-checks at this location since that time. Noise and ride characteristics seem to have improved, but a seat of the pants evaluation (driving the length at 55 miles per hour, identical to the other locations) can be very subjective.

Very heavy wear has been noticed throughout, especially in the wheelpaths. Most of the wear seems to have occurred in the west bound lane, with a lesser degree of wear noticed in the east bound lane.

Several instances of rainbow colored splotches were observed on the east end of the project on the day of inspection. These were similar in appearance to the rainbow colored areas that can be found at a gas station when gasoline has been spilled on the ground, leading the author to believe that these were instances of the emulsion coagulating on the surface.

This section, after two relatively light winters, is experiencing a lot of pock-marks from pop-outs and loss of material. The seal at this location will be very fortunate to not be pock-marked throughout its entire length within another two years of similarly light winters.

In 1996 and 1997, the range of average daily traffic was less than 1200 vehicles per day.

Photo #1: Wear and loss of seal on the surface. The roll of masking tape can be seen for size reference. March 16, 1998; District 4, Lafayette County Route 24



Photo #2: More wear and loss of seal. The masking tape can be seen for size reference. In the vicinity of the car door, it can be seen where the seal was applied in such a fashion that the entire width of the lane was not covered. March 16, 1998; District 4, Lafayette County Route 24



Photo #3: A closer view of picture #2. March 16, 1998; District 4, Lafayette County Route 24



Photo #4: More wear and loss of seal. The masking tape can be seen for size reference. March 16, 1998; District 4, Lafayette County Route 24



Photo #5: Still more wear and loss of seal. March 16, 1998; District 4, Lafayette County
Route 24



Photo #6: A close-up view of Photo #5. March 16, 1998; District 4, Lafayette County
Route 24



Photo #7: The rainbow colored splotch reported on in the locational synopsis. A small area of sealant loss can also be seen. March 16, 1998; District 4, Lafayette County Route 24



Cole County Business Route 50, EB (Missouri Boulevard)

The seal on Missouri Boulevard was inspected on March 30, 1998, and it lies in the east bound lanes between South Ten Mile Road and Stadium Boulevard in Jefferson City.

This section looks very good, with no noticeable loss of material or sealant. The aggregate used on this project was manufactured sand, which created a lot of dust during placement. RDT will be recommending elsewhere in this report that manufactured sand not be used as an aggregate when using this type of seal for pavement rehabilitation.

The seal at this location is in very good condition, especially when the amount of traffic experienced here is considered.

The average daily traffic during 1997 was just under 20,000 vehicles per day.

Photo #1: A view of the surface at the turnoff to Wal-Mart. March 30, 1998; District 5, Cole County Business Route 50 (Missouri Boulevard)



Photo #2: A view of the seal lane (closest) and the unsealed lane. March 30, 1998; District 5, Cole County Business Route 50 (Missouri Boulevard)



Photo #3: A view of the surface from the west end of the project. March 30, 1998; District 5, Cole County Business Route 50 (Missouri Boulevard)



Photo #4: Another view of the surface. March 30, 1998; District 5, Cole County Business Route 50 (Missouri Boulevard)



St. Louis County Route 67 NB (Lindbergh Boulevard)

The seal on Route 67 lies in the northbound lanes, beginning at Route 100 and is 2.4 miles in length, ending just north of Route 40.

For the most part, the seal still looks reasonably well, although it is wearing somewhat quickly for having been placed in October 1997. On the uphill length heading toward the Frontenac city limits, the seal is worn to the point of being nearly nonexistent. However, the seal is still intact for the majority of the length of the project.

This section realizes the highest traffic volumes of any of the ten seal locations. Due to the rate of wear being realized, it appears that scrub-seal is a process that might be better suited for lower volume roadways.

Traffic at this location ranged from 10,500 vehicles per day to 13,200 vehicles per day during 1997.

Photo #1: View up the hill leading to the Frontenac city limits. The seal is almost gone in the wheelpaths. March 10, 1998; District 6, St. Louis County Route 67 (Lindbergh Boulevard)



Photo #2: A close-up of the wheelpaths in this location. March 10, 1998; District 6, St. Louis County Route 67 (Lindbergh Boulevard)



Photo #3: A closer view of the wheelpath from Photo #2. The seal is very worn. March 10, 1998; District 6, St. Louis County Route 67 (Lindbergh Boulevard)



Photo #4: Two squares approximately 2' x 1.5' that has no seal. Several such areas were noticed on the south end of the project. March 10, 1998; District 6, St. Louis County Route 67 (Lindbergh Boulevard)



Photo #5: Coldmilling that has been performed at Litzsinger Road. March 10, 1998;
District 6, St. Louis County Route 67 (Lindbergh Boulevard)



APPENDIX B

SCRUB SEAL MSP-98-07A

1.0 Description of MSP-98-07A. This specification covers the materials and construction requirements for producing and placing a polymer modified asphalt (scrub seal) emulsion intended for use as a surface rejuvenation treatment to fill and seal cracks.

1.1 Unless otherwise stated, specification section references are from the version, in effect at the time of this contract, of the Missouri Standard Specifications for Highway Construction and its supplements.

2.0 Materials.

2.1 Scrub Seal Emulsion. Scrub seal emulsion shall meet applicable requirements of Sec 1015 except as modified herein. It shall be smooth and homogeneous, be polymer modified, contain an asphalt rejuvenator and shall comply with the following requirements:

Tests on Scrub Seal Emulsion	Min.	Max.	Test Method
Saybolt Furol Viscosity, SFS @ 77 °F	30	100	ASTM D244
Storage Stability Test ^(a) , 24 hr., %	—	1	ASTM D244
Demulsibility, 35 ml of 0.02N, CaCl ₂ , %	—	60	ASTM D244
Sieve Test ^(b) , %	—	0.1	ASTM D244
Residue by Distillation ^(c) @ 400 °F, %	60	—	ASTM D244
Oil Distillate by Volume, %	—	3	

- Note: (a) Upon examination of the test cylinder after standing undisturbed for 24 hours, the surface shall show no white, milky colored substance but shall be a homogeneous brown color throughout.
- (b) A percentage of 0.30 is acceptable for samples taken at the point of use or shipped to the Central Laboratory for testing.
- (c) ASTM D244 with modifications to include a 400 ± 10 °F maximum temperature to be held for 15 minutes.

Tests on Residue from Distillation:	Min.	Max.	Test Method
Penetration @ 77 °F, 5 sec, 100 g, dmm	150	300	ASTM D5
Float Test @ 140 °F, sec	1200	—	ASTM D139
Solubility in Trichloroethane, %	97.5	—	ASTM D5546
Elastic Recovery, 50 °F, 200 mm elongation, 60 min. recovery, %	30	—	ASTM D5976
Saturates ^(d) , %	—	20	ASTM D4124

- Note: (d) ASTM D4124 with modification to use Alumina, CG - 20 Grade, available from Aluminum Company of America, Pittsburgh, PA.

2.2 Mineral Aggregate. The mineral aggregate shall conform to Sec 1005.2, except that manufactured sand shall not be used. Aggregate substitutions, such as wet bottom boiler slag, may be allowed as approved by the engineer.

2.3 Special Additives. These additives are any other materials that are added to the mixture or to any of the component materials to provide the required properties. All additives shall be supplied by the emulsion manufacturer.

2.4 Material Acceptance. Any scrub seal emulsion system, including materials and procedures, and any contractor proposing to place the system, and any entity proposing to supply the emulsion shall be prequalified prior to being offered for use. To become prequalified the contractor and/or scrub seal emulsion manufacturer shall contact the Division Engineer, Materials. Prequalification requirements may include, but are not restricted to, laboratory samples, company test results, use history, and field demonstrations. The engineer will notify the manufacturer or contractor when prequalification has been completed. After being prequalified, subsequent prequalifications will not be required so long as the material is not changed and so long as satisfactory results are obtained in the field.

2.4.1 Prior to beginning any work, the scrub seal emulsion manufacturer shall supply a set of certified test results for the material being supplied, indicating compliance with all specified material properties. Furthermore, for each load of scrub seal emulsion the manufacturer shall furnish a certification stating that the emulsion and any special additives are the same as those which were prequalified and that all materials meet the specifications. At least one sample of emulsion shall be taken by the inspector during the project and submitted to the Central Laboratory for confirmation purposes.

2.4.2 All aggregates shall be sampled, tested and approved by the engineer, prior to use.

2.4.3 Water shall be potable and approved by the Missouri Department of Natural Resources.

3.0 Equipment.

3.1 Aggregate Spreader. The self-propelled aggregate spreader shall be capable of evenly spreading aggregate in a width of 8 to 14 feet at a minimum rate of 12 pounds per square yard. Motor graders and trucks are not acceptable.

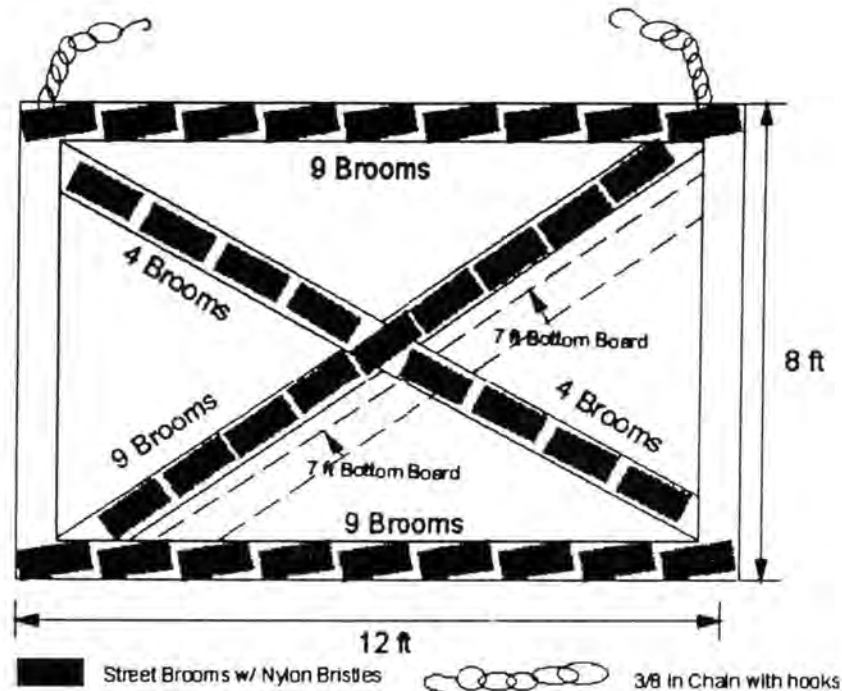
3.2 The pneumatic tire roller shall meet the requirements of Sec 403.12 with a 5 ton weight.

3.3 The brooms used in the scrub seal process shall be constructed to meet the nominal dimensions in Figure 1, using the following bill of materials.

<u>Qty.</u>	<u>Nominal Dimension</u>	<u>Qty.</u>	<u>Dimension</u>
2	2x6x7 ft wood member	112	3/16 in nuts
4	2x6x8 ft wood member	112	3/16 in flat washers
2	2x6x12 ft wood member	112	3/16 in lock washers
2	2x6x14 ft wood member	112	3/16 x 5 in carriage bolts
35	Street brooms with nylon bristles (3-1/2 in W x 6 in H x 16 in L)	2	3/8 in x 2 ft chain with hooks (minimum)
Weights as determined by the engineer		2	3/8 x 6 in bolts with nuts, locks and washers

The final assembly shall be constructed with the nominal dimensions and the arrangement shown in the figure 1.

Figure 1



4.0 Construction Requirements.

4.1 Surface Preparation. Immediately prior to applying the scrub seal emulsion, the surface shall be thoroughly cleaned of all vegetation, loose materials, dirt, mud, and other objectionable materials.

4.2 Application. Scrub seal emulsion shall be applied uniformly with a pressure distributor at the rate specified in the contract, or as revised by the engineer. The mixture shall be spread to fill cracks and minor surface irregularities and leave a uniform surface.

4.3 Physical Characteristics for Scrub Seal.

<u>Properties:</u>	<u>Minimum</u>	<u>Maximum</u>
Application rate of emulsion, gallons/sq. yard ^(e)	0.14	0.18
Emulsion Temperature, °F	110	160
Application rate of aggregate, pounds/sq. yard ^(e)	12	15
Pavement Temperature, °F	70	90
Time of set prior to opening, hours ^(f)	2	--
Number of roller passes	2	--

Note: (e) Application rate may change, final decision will be made by the engineer.

(f) The final decision for opening will be made by the engineer.

4.4 Method of Placement.

4.4.1 After proper surface preparation, a distributor truck shall place the scrub seal emulsion at the prescribed rate. The distributor truck shall pull the broom assembly to sweep and spread the emulsion uniformly on the surface and into the cracks of the pavement.

4.4.2 Fine aggregate shall be placed immediately after the application of the emulsion by a self-propelled aggregate spreader. Immediately following the aggregate spreader shall be a truck pulling a second broom assembly to combine the aggregate with the emulsion.

4.4.3 The pneumatic tire roller shall immediately follow the second broom and make a minimum of 2 passes.

4.5 Weather Limitations. The scrub seal emulsion shall not be placed when any of the following conditions exist: (1) the temperature of the surface on which the mixture is to be placed is below 70 °F or above 90 °F, (2) on any wet surface, (3) local weather forecasts predict rain or air temperatures below 60 °F within the next 72 hours, or (4) weather conditions prevent the proper handling or finishing of the mixture. (Temperatures are to be obtained in accordance with MoDOT Test Method T 20.)

4.6 Any traffic damaged or marred areas shall be repaired by the contractor at no additional charge.

5.0 Method of Measurement.

5.1 Measurement of scrub seal emulsion and mineral aggregate complete in place, including any multiple passes or courses, will be made to the nearest square yard. Measurement of individual passes or courses will not be made. Final measurement of the completed surface will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

6.0 Basis of Payment.

6.1 The accepted quantity of scrub seal in place will be paid for at the contract unit price, per square yard.

APPENDIX C

Proposed Work Plan

RI 96-19

EVALUATION OF SCRUB-SEAL AS A PAVEMENT REVITALIZER

November 1996

Introduction:

The goal of this investigation is to determine the suitability of the scrub seal as a crack sealer, regenerative agent, and wearing surface for older, worn asphalt pavements.

The scope of this project is to evaluate and report on the attributes, both positive and negative, of this sealer, through the Scrub-Seal process, in several locations throughout the state.

Background & Significance of Work:

Several western states, among them Arizona and Utah, have used the Scrub-Seal process on worn asphalt pavements as far back as 1989. They have met with considerable success. The temperatures realized in these locations are more extreme each season than what is realized in Missouri; therefore, it is believed that such a process could be successfully utilized here.

Action Plan:

A test section of Scrub-Seal was placed on Route 24 east of Lexington in Lafayette County on October 15, 1996. Another test section is being planned for placement in an urban area of District 6. These test sections will be evaluated within one month of placement, after the first snowfall (to determine vulnerability to deicing chemicals and plowing), and every three to four months thereafter. Friction numbers will be taken within roughly one month of placement, and upon every inspection thereafter.

Method of Implementation:

The success realized at these test sections will determine the extent and locations in which the RDT Division will recommend usage of the Scrub-Seal method.

Expected Benefits:

To significantly extend the life of highly worn asphalt pavements, without major rehabilitation, by sealing cracks and adding a wearing course, at an approximate cost of \$2000 per lane mile.

Staffing:

The anticipated staffing for this project will be a Senior Research and Development Engineer from this division and one Materials Research Assistant. The assistance of two or more Field Technicians will be required for the periodic inspections of the wearing surface.

Funding:

All funding will be from MoDOT funds.

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APPENDIX D

Cost Estimate Sources

The cost data came from several different sources. All costs include traffic control.

<u>Treatment</u>	<u>Source</u>
1" hot mix	1998 Average Unit Bid Prices
Chip seal	MoDOT's Maintenance Management System
Micro-surfacing	Division Maintenance's estimates
Scrub seal	Ivan Corp's estimate (district 4)

