Crack Sealing
Bituminous Pavements in Minnesota

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### Title and Subtitle
Crack Sealing Bituminous Pavements in Minnesota

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### Abstract (Limit: 200 words)
One of the most common maintenance activities performed on bituminous pavements by local governmental agencies relates to crack treatment. Crack treatments include crack sealing, crack filling, and crack repair. Crack sealing is the method of placing material in a crack to create a water tight barrier, while crack filling involves coating the sides or edges of a crack in an attempt to reduce the rate of deterioration. Crack repair is more extensive than both sealing or filling and can involve fine mix patching, tight blading, mill and repair, and overlays. Generally, rubberized materials, due to their ductile properties are considered to be crack sealants while asphalt based materials are considered fillers.

This report discusses the most commonly used materials and practices used by local engineers in Minnesota to seal and fill cracks on bituminous pavements. The report is based on the results of a survey conducted by the authors in 1991. The report presents the results in several ways and summarizes the findings.
CRACK SEALING
BITUMINOUS PAVEMENTS
IN MINNESOTA

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Prepared for the

MINNESOTA LOCAL ROAD RESEARCH BOARD
MATERIALS AND RESEARCH LABORATORY
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The opinions, findings and conclusions in this publication are those of the author and not necessarily those of the Minnesota Local Road Research Board or the Minnesota Department of Transportation
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FOREWORD

The purpose of this report is to give an overview of the practices of Minnesota city and county agencies with respect to sealing cracks on bituminous pavements. The report summarizes the results of a survey conducted on this subject by the authors during 1991. Guidelines are also given based on information available from other sources around the country.

The authors wish to acknowledge the contributions of the Minnesota city and county engineers and street/highway superintendents for their cooperation in completing the survey which comprises a large portion of this report. Individuals who also helped greatly in the preparation of this report are Roger Olson and Curt Turgeon of the Mn/DOT Physical Research Section, Office of Materials and Research, and Anne Mackereth and Sheila Hatchell of the Mn/DOT Information Services Center.

The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the information presented. The contents do not necessarily reflect the official views of the Minnesota Local Road Research Board (LRRB) or the Minnesota Department of Transportation (Mn/DOT).
ABSTRACT

One of the most common maintenance activities performed on bituminous pavements by local governmental agencies is crack treatment. Crack treatments include crack sealing, crack filling and crack repair. Crack sealing is defined as placing material in a crack to create a water tight barrier (1). Crack filling involves coating the sides or edges of a crack in an attempt to reduce the rate of deterioration. Crack repair is more extensive than sealing or filling and can involve fine mix patching, tight blading, mill and repair, and overlays (1). It is apparent from a recent survey that these terms are often used interchangeably. Generally, rubberized materials, due to their ductile properties are considered to be crack sealants while asphalt based materials are considered fillers. Procedures that involve sand or fine aggregate are considered to be crack repairs.

The goal of crack sealing is to prevent water and incompressible material from entering the pavement system. Water intrusion through cracks leads to softening of the underlying subgrade soil. This situation may result in a weak pavement which can be damaged by heavy loads. For many pavements with extensive cracking, water enters the pavement system from the surface at a much higher rate than from below or laterally.

Crack filling is done to reduce the effects oxidation has on the asphalt. When asphalt pavements begin to oxidize, they become brittle and cannot withstand the bending imposed by passing vehicles as well as when they were flexible. The application of fresh asphaltic material along the sides of an existing crack slows the rate of oxidation and thus the rate of deterioration.

In Minnesota, most cities and counties seal cracks on a periodic basis in an attempt to combat the deterioration of city streets and county highways within their jurisdiction. However, there are many different reasons, materials, equipment and techniques for crack sealing.

It is for this reason that this report was written. It is the goal of the authors to assist local engineers and street/highway superintendents, in determining what their peers are doing in the area of crack sealing/filling. A secondary goal is to present guidelines used by other agencies outside Minnesota which may be applicable.
BACKGROUND

Frequently, the first types of distress visible on a new bituminous pavement are transverse cracks. A transverse crack, as the name implies, typically extends across a road perpendicular, or transverse, to the centerline (2). They are sometimes referred to as temperature cracks. These cracks are caused by the expansion and contraction of the asphalt material as the temperature changes. A bituminous pavement can undergo extreme amounts of expansion in hot weather and contraction in cold weather. Generally, the colder the temperature, the wider the crack opening will be. Also, the more freeze-thaw cycles a pavement is subjected to, the more likely it is to experience transverse cracking. As a result, for nearly all bituminous pavements built in Minnesota, transverse cracking will develop within a relatively short time after construction.

The frequency and time until transverse cracks occur is largely dependent on the mix design. A softer asphalt (one with a higher penetration) is usually more ductile and can stretch more without cracking. One way to reduce the frequency of transverse cracking as well as delay the time it takes for them to appear is by building a road with a softer asphalt in the mix. A softer asphalt, in addition to being more flexible, is also more prone to rutting however. As a result, roadways with heavily loaded trucks or high volumes of traffic are not good candidates for paving with a softer mix. Another strategy in mix design used to lessen the effects of oxidation on the asphalt mix is to increase the asphalt content. By doing so, the air void content of the mix will be less, and thus the mix will be less affected by oxidation. Compaction, or more precisely, lack of it, can also have an impact on the rate a pavement oxidizes. Poor compaction will result in higher air voids in the mix and result in a mix much more prone to the effects of oxidation.

Another common type of cracking that develops on bituminous pavements is known as block cracking. Block cracking, as the name implies, consists of cracks that divide the pavement into blocks. This type of cracking, caused by highly temperature sensitive mixes, is accelerated by the aging of the asphalt material. When asphalt material ages, it oxidizes and becomes more brittle. In time, if the pavement becomes too brittle, it will begin to deteriorate.

Longitudinal cracks, cracks which extend parallel to the centerline of the pavement, are also very common in Minnesota. This type of cracking can have several causes. The main causes, however, are related to cold joints, lack of subgrade support (settlement) and load. When the longitudinal cracks are found in the wheel path, they are generally load related and indicate the early stages of alligator cracking.

Reflective cracks are cracks and joints in an underlying pavement which reflect through the surface layer. The more deteriorated or brittle the underlying pavement, the more severe the reflection cracking will be (7). These cracks are formed when the surface layer attempts to conform to the profile of the stiffer base layer (7). This type of cracking can be found on bituminous overlays of bituminous pavements as well as bituminous overlays of concrete pavements. The latter case is a special case caused either by the upward movement of the slab (faulting/pumping) encouraged by moisture penetrating the subbase, or the expansion and contraction of the underlying concrete slab due to temperature change.

Since cracking of the nature described above is difficult if not impossible to prevent, the most common way to deal with it is to seal or fill the cracks after they have developed. Not all types of cracks lend themselves to be sealed or filled. Alligator cracking, for example, is a load related distress caused by fatigue failure in the pavement materials. Sealing this type of cracking may slow down the water intrusion temporarily, but if the problem of overloading is not dealt with, the
expected life of the sealant is very low.

Normally, the best types of cracks to seal as part of a bituminous crack sealing program are transverse, longitudinal and reflective cracks. Block cracking, due to its extensive coverage of a pavement surface, may require so much material that it is not cost effective to crack seal. A seal coat or thin overlay may be more appropriate as a temporary measure. When sealing longitudinal cracks, it is important to determine if the cracks are in the wheel path, and thus load related, or not. Load related longitudinal cracks indicate the pavement is failing structurally and that another rehabilitation may be more cost effective and address the cause of the distress more directly (7).

Alligator cracking should never be treated by crack sealing or filling (7). When longitudinal cracking in the wheel path has progressed to the point that an alligator skin type pattern has developed, crack sealing provides little benefit.

COMMON CRACK SEALING/FILLING MATERIALS

The materials for which information was gathered are those materials identified by Mn/DOT as the most common or which have Mn/DOT specifications (1). The materials identified in the survey are as follows:

- Crumb Rubber Crack Sealer
- Hot-Pour, Elastic Type Crack Sealer
- Hot-Pour, Low Modulus Elastic Type Crack Sealer
- Hot-Pour, Extra Low Modulus Elastic Type Sealant
- AC-3, Heated Air Blown Asphalt
- MC Oil & Sand
- Asphalt Emulsion
- Cold Pour Silicone
- Other Miscellaneous Materials

Generally, the elastic sealers are defined as crack sealants, AC-3 and Asphalt Emulsion as fillers and MC Oil and Sand as crack repair materials. Sealers are generally used on newer pavement or on those where the cracks have not deteriorated significantly. Fillers are generally used on pavement where the cracks have deteriorated to the point that sealer is no longer a viable material (1). Mn/DOT reports that agencies seem to be using more crack sealants and less crack fillers than in past years.

Table 1 shows the various material types, applicable specifications they meet and any brand names commonly used which fall under the same category.
Table 1. List of Commonly Used Crack Sealing Materials

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Applicable Specifications</th>
<th>Brand Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crumb Rubber (crack sealant)</td>
<td>Mn/DOT 3719</td>
<td>Crafo AR-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Koch 9000</td>
</tr>
<tr>
<td>Hot-Pour</td>
<td>Mn/DOT 3723</td>
<td></td>
</tr>
<tr>
<td>Elastic Type Sealer (crack sealant)</td>
<td>ASTM D 3405</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crafo Road Sealer 221</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Koch 9005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>W.R. Meadows Hi-Spec</td>
</tr>
<tr>
<td>Hot-Pour, Low Modulus</td>
<td>Mn/DOT 3720</td>
<td></td>
</tr>
<tr>
<td>Elastic Type Sealer (crack sealant)</td>
<td>ASTM D 3405 Mod.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crafo Road Sealer 231</td>
</tr>
<tr>
<td></td>
<td></td>
<td>W.R. Meadows Sof-Seal</td>
</tr>
<tr>
<td>Hot-Pour, Extra Low Modulus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elastic Type Sealer (crack sealant)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>W.R. Meadows XLM</td>
</tr>
<tr>
<td>AC-3, Hot Air Blown Asphalt (crack filler)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC Oil &amp; Sand (crack filler)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asphalt Emulsion (crack filler)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cold Pour Silicone (crack sealant)</td>
<td>Dow Corning 890 SL</td>
<td></td>
</tr>
<tr>
<td>Other Materials (sealants &amp; fillers)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crafo Mn Blend 34506</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Koch Flex-A-Fill</td>
</tr>
</tbody>
</table>

The materials listed above are similar to those in LRRB report 89-19, "Evaluation of Materials and Methods for Bituminous Pavement Crack Sealing and Filling" (1). This report, written by Mr. Curt Turgeon with the Mn/DOT Office of Materials and Research, is an excellent resource for local agencies interested in crack sealing and filling. The report discusses procedures and materials and includes recommendations and sample provisions that could be incorporated into a specification.

LOCAL ROAD RESEARCH BOARD SURVEY

A survey was sent to over 200 Minnesota cities and counties in 1991 inquiring about their current bituminous pavement crack sealing practices. The survey asked each agency to identify up to two different crack sealing materials they typically use. For each material identified, the following 12 questions were asked:

- What time of year is the work done?
- What percent of the work is done in-house versus contracted out?
- Do you saw or route the cracks prior to sealing?
- How long does the crack sealing/filling technique keep the cracks sealed/filled?
- Have you ever had any failures?
- If this is a hot pour sealant, how is the material kept hot?
- What equipment do you use to place the sealant material?
- How many people are normally used on crack sealing crew?
- What is the approximate cost, including labor, to seal cracks with this material?
- Do you seal cracks prior to a seal coat?
- Do you seal cracks prior to an overlay?

A copy of the survey can be found in Appendix C.
OVERALL RESULTS OF LRRB CRACK SEALING SURVEY

CRACK SEALING PROGRAMS

The results of the survey indicate that 81% of the survey respondents have a crack sealing program. For the county agencies, 84% (56 agencies) of the responding agencies indicate they have a crack sealing/filling program. For cities, 78% (47 agencies) of the responding agencies have a crack sealing/filling program.

![Diagram of crack sealing program participation by agencies]

*BASED ON RESPONSES FROM 157 AGENCIES

Figure 1
PERCENT OF AGENCIES THAT HAVE A CRACK SEALING PROGRAM

The survey indicates that the counties crack seal more often than do cities. On average, the counties seal cracks every three years while the cities seal cracks every four years. The survey also asked if the agency sealed cracks on an as-needed basis or on a set schedule. The results indicate that over 77% of the counties crack seal on an as-needed basis versus 23% that seal cracks on a set schedule. For the cities, 57% seal cracks on an as-needed basis, 43% on a set schedule.

MATERIAL USAGE

Two materials stand out as being the most commonly used; Mn/DOT Spec 3723, an elastic type sealer, was the most common followed by AC-3 which is a hot, air refined asphalt crack filler. With the exception of AC-3, there was little or no difference between county and city agencies when it came to using a particular material. A large difference occurred however, when using AC-3. Of the 36 agencies reporting usage of AC-3, 92% were county agencies. The reason for this large difference is unclear. Surprisingly, all three cities that use AC-3 are located in northern Minnesota.
The number and percent of agencies indicating they use a particular material type is shown below:

![Material Usage Diagram](image)

Figure 2. PERCENT SEALANT IS USED

The figure below shows the number of agencies reporting use of the various materials. The figure also shows the distribution of use by agency type.

![Material Usage Diagram](image)

Figure 3. NUMBER OF AGENCIES USING EACH SEALANT
WHEN MATERIAL IS PLACED

The most common time of year to seal cracks, by a wide margin, was in the spring. The winter was the time of year least given by the survey respondents. Many of the agencies indicate that they seal cracks in more than one time of year, many seal them year round.

![Pie chart showing the distribution of when cracks are sealed.](image)

**Figure 4. TIME OF YEAR CRACKS ARE SEALED**

IN-HOUSE VERSUS CONTRACTED WORK

The survey shows that most crack sealing is done with the agency's own labor force and equipment. Nearly 80% of the crack sealing is done in-house as opposed to contracting out. The vast majority of agencies do all crack sealing in-house. Only 21% of the agencies ever contract out for crack sealing services. It appears that most agencies either do all of the work in-house or all of it by contract.
WHAT PERCENT OF THE WORK IS DONE IN-HOUSE?

<table>
<thead>
<tr>
<th>IN-HOUSE</th>
<th>79%</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTRACTED OUT</td>
<td>21%</td>
</tr>
</tbody>
</table>

Figure 5. IN-HOUSE VERSUS CONTRACTED WORK

There were definite differences depending on what type of material was being used. All of the AC-3, MC Oil & Sand and Cold Pour Silicone users did crack sealing in-house. Mn/DOT Spec 3720 was the only material which resulted in the majority of the work being done on a contract basis. Over 55% of the agencies contract out for crack sealing when using this material.

SAWING OR ROUTING CRACKS PRIOR TO SEALING

Whether or not the cracks are sawed or routed prior to sealing depends primarily on the type of material being used. The survey indicates that sawing or routing is done 45% of the time. Of those agencies that responded to the survey, 36% always saw or route prior to crack sealing, 9% sometimes saw or route and 55% never saw or route prior to crack sealing. The statistics change depending on what material is being used. For example, none of the users of MC Oil & Sand, Asphalt Emulsion or Cold Pour Silicone and only 3% of AC-3 users ever saw or route prior to crack sealing. On the other hand, over 50% of the Mn/DOT Spec 3719, 3723 and 3720 users always saw or route prior to sealing and approximately 75% of these users saw or route at least some of the time.

Only seven agencies that saw or rout cracks have ever used a bond breaker to prevent the crack sealing material from bonding to the bottom of the reservoir. If the crack seal material bonds to the bottom of the reservoir, it may pull away from the sides of the crack as the crack begins to open. In some cases, the bonding of the material with the bottom of the reservoir may cause the sealant to fail. Types of bond breakers include grease and other liquids, masking tape and foam backer rod. Mn/DOT does not recommend either liquids or masking tape when sealing random cracks (1). Backer rod is effective in preventing a bond from forming to the bottom of the reservoir in wide, deep cracks. Mn/DOT does not have enough experience in the use of bond breakers to make a recommendation on their use (1). The state of South Dakota is an advocate of using a backer rod (paper rope) in routed cracks prior to sealing (7).
Of those agencies that saw or route the cracks at least sometimes, the average size of the cut is approximately 3/4 inch wide by 7/8 inch deep. There was little variation in the dimensions of the reservoir between agencies. The most common size of reservoir reported was 3/4 inch wide by 3/4 inch deep.

**MATERIAL FAILURES**

The agencies were asked if they have ever experienced any failures using the material they were providing information on. Not surprisingly, at least 50% of the agencies said yes. The survey did not attempt to qualify what each agency considered a failure. Previous attempts to do so have resulted in a myriad of definitions. The materials in the "Other" category (see page 73 for a description of these materials) had the highest level of reported failures at 70%. The materials having the lowest level of failures experienced are the Extra Low Modulus Sealer and Asphalt Emulsion. Keep in mind that there were only two users of the Extra Low Modulus material responding to the survey. One indicated they had failures, the other indicated they did not.

Perhaps of more interest was the number of agencies indicating they have never had any failures with a certain material. Mn/DOT 3719, Crumb Rubber, had the most agencies indicating they have never had a failure with the material.
EQUIPMENT

The most common types of equipment used to keep the hot-pour materials hot are tar kettles and double wall, oil jacket kettles. The responses varied in degree of detail provided, making it difficult to summarize.

The type of material used tends to dictate what type of equipment is used to place the material into the crack. For example, for Mn/DOT Specs 3719, 3723, 3720 and the "Other" materials, a wand is the most commonly used tool. For the other types of material, a pour pot is the most common tool. Several agencies indicate that they use both types of equipment for the same material.
AVERAGE CREW SIZE

The size of crew did not vary much from material to material. Most of the variation is due to differences from agency to agency. The average size crew used on a crack sealing program for all materials was just under four persons per crew. The responses ranged from a low of two to a high of ten persons per crew. For the most frequently used materials, the crew size was typically four to five persons. The size of crew reported may or may not include traffic control. The survey did not specifically ask for the user to indicate whether or not it was.
COST INFORMATION

Cost information was provided for the various materials in both cost per lineal foot and cost per pound. Table 2 shows the average costs for the various materials which includes labor.

Table 2. Average Cost of Crack Sealing Materials (including labor)

<table>
<thead>
<tr>
<th>MATERIAL TYPE AND SPEC NUMBER</th>
<th>AVERAGE COST PER LINEAL FOOT ($)</th>
<th>AVERAGE COST PER POUND ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn/DOT SPEC 3719 - CRUMB RUBBER</td>
<td>0.39</td>
<td>0.93</td>
</tr>
<tr>
<td>Mn/DOT SPEC 3723 - ELASTIC TYPE SEALER</td>
<td>0.65</td>
<td>1.15</td>
</tr>
<tr>
<td>Mn/DOT SPEC 3720 - LOW MODULUS, ELASTIC TYPE SEALER</td>
<td>0.78</td>
<td>1.00</td>
</tr>
<tr>
<td>EXTRA LOW MODULUS, ELASTIC TYPE SEALER</td>
<td>0.41</td>
<td>1.00</td>
</tr>
<tr>
<td>AC-3, HOT AIR BLOWN ASPHALT</td>
<td>0.19</td>
<td>0.71</td>
</tr>
<tr>
<td>MC OIL &amp; SAND</td>
<td>0.32</td>
<td>*</td>
</tr>
<tr>
<td>ASPHALT EMULSION</td>
<td>0.28</td>
<td>0.69</td>
</tr>
<tr>
<td>COLD POUR SILICONE</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>OTHER MATERIALS</td>
<td>0.43</td>
<td>0.96</td>
</tr>
</tbody>
</table>

* No cost data given.

Figure 10. AVERAGE COST PER LINEAL FOOT (including labor)
The results of the cost information indicate the least expensive material on a lineal foot basis is AC-3. At only $0.19 per lineal foot, it is nearly half the cost of any other material. When measured per pound of material, Asphalt Emulsion was the least expensive material followed by AC-3. The most expensive material when measured by lineal feet is Mn/DOT Spec 3720. The most expensive material when measured by pound of material is Mn/DOT Spec 3723 followed by Mn/DOT Spec 3720 and Extra Low Modulus Sealer.

There were large differences in the reported costs of the various materials. Differences as much as 16 fold were reported for Mn/DOT Spec 3719. The reason for this may be related to how agencies included labor into the total costs as well as the quantities of materials used by the agency.

**LIFE EXPECTANCY**

According to the survey respondents, the material that lasts the longest is the Extra Low Modulus Elastic Sealer. However, there was only one agency that gave an estimate of the performance of that material. Likewise, the material felt to last the least amount of time, Cold Pour Silicone, also had only one agency responding to the survey. The results of survey are shown below indicating the life expectancy of the various materials. Of the more frequently used materials, Mn/DOT Spec 3720 had the longest life expectancy at 4.5 years.
The survey asked the respondents to choose the expected life from one of the following ranges:

- Less than 1 year
- 1-2 years
- 2-3 years
- 3-5 years
- 5-10 years
- Other

For determining the average life expectancy, the midpoint of each range was considered to be the answer given by the responding agency.

**COST EFFECTIVENESS**

Cost effectiveness is generally regarded as the maximum benefit for the least cost. As a result, the least expensive material is not always the best to use. Similarly, the material that lasts the longest may not be the best choice either. The agencies were asked if they considered the materials they use to be cost effective. The vast majority of the agencies (87%) indicate they feel the material they use to seal cracks with is cost effective. The materials considered to be most cost effective were the Extra Low Modulus sealers and Cold Pour Silicone. Of the materials used by a number of agencies, Mn/DOT Spec 3723 elastic type sealer is considered to be the most cost effective. Over 86% of the agencies that use this material consider it to be cost effective.
Very few agencies indicated a material as not being cost effective. Most agencies either responded that it was cost effective or did not respond to the question. There were two materials, however, that had a large percent of users indicating the material was not cost effective. Over 22% of AC-3 users felt the material was not cost effective, while 25% of the Asphalt Emulsion users felt it was not a cost effective material to use.

Based on the expected life and the average cost of the various materials, Table 3 shows the Cost Effectiveness Rating of the various materials. The Cost Effectiveness Rating was determined as follows:

\[
\text{Cost Effectiveness Rating} = \frac{\text{Expected life of material (years)}}{\text{Average cost of material (dollars/lineal foot)}}
\]

Thus the material that provides the longest life per dollar spent is considered to be the most cost effective. The results of this calculation for all of the materials except Cold Pour Silicone, for which no cost data was provided, is shown below:
Table 3. Cost Effectiveness Rating of Crack Sealing Materials

<table>
<thead>
<tr>
<th>MATERIAL TYPE</th>
<th>EXPECTED LIFE (YEARS)</th>
<th>AVERAGE COST ($/L.F.)</th>
<th>COST EFFECTIVENESS RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn/DOT SPEC 3719 - CRUMB RUBBER</td>
<td>3.6</td>
<td>0.39</td>
<td>9.2</td>
</tr>
<tr>
<td>Mn/DOT SPEC 3723 - ELASTIC TYPE SEALER</td>
<td>4.5</td>
<td>0.65</td>
<td>6.9</td>
</tr>
<tr>
<td>Mn/DOT SPEC 3720 - LOW MODULUS ELASTIC SEALER</td>
<td>4.0</td>
<td>0.78</td>
<td>5.1</td>
</tr>
<tr>
<td>EXTRA LOW MODULUS, ELASTIC TYPE SEALER</td>
<td>7.5</td>
<td>0.41</td>
<td>18.3</td>
</tr>
<tr>
<td>AC-3, HOT AIR BLOWN ASPHALT</td>
<td>1.7</td>
<td>0.19</td>
<td>9.0</td>
</tr>
<tr>
<td>MC OIL &amp; SAND</td>
<td>2.6</td>
<td>0.32</td>
<td>8.1</td>
</tr>
<tr>
<td>ASPHALT EMULSION</td>
<td>2.0</td>
<td>0.28</td>
<td>7.1</td>
</tr>
<tr>
<td>COLD POUR SILICONE</td>
<td>1.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>OTHER MATERIALS</td>
<td>4.3</td>
<td>0.43</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Figure 14. COST EFFECTIVENESS RATING

As can be seen, the material with the highest cost effectiveness rating is the Extra Low Modulus material. As mentioned before, there were only two agencies indicating they use this material. Of the materials that are most often used, the materials in the "Other" category had the highest rating, followed by Mn/DOT Spec 3719. Surprisingly, the material with the lowest rating was Mn/DOT Spec
3720. The expected life of the material was not high enough to offset its higher cost.

While Table 3 gives a general guide as to the cost effectiveness of various materials, it must be kept in mind that in some instances the expected life is more important, while the cost may be more important at other times. For example, if budget constraints limit the available resources for crack sealing, it may be more appropriate to use a material with a small unit cost so that more pavement can be sealed. However, it may not be feasible, especially in a large agency to be re-sealing cracks every one to two years. This may be the case if a material with a low life expectancy is used, such as AC-3 or Asphalt Emulsion. The decision as to what material to use in a given agency must be determined after considering all of the parameters involved.

A crack treatment material should also be evaluated on whether or not it prolongs the life of the pavement. Regardless of how long the material lasts or its cost, if it does not result in the pavement lasting longer or rehabilitation being delayed, it is probably not cost effective. The goal of any type of pavement maintenance should be to extend the life of the pavement. Obviously if the pavement that is crack sealed with a certain type of material deteriorates at the same rate it would if nothing was done, it would be difficult to justify the material as being cost effective.

CRACK SEALING PRIOR TO OTHER MAINTENANCE

The survey asked the respondents whether they seal cracks prior to overlaying and seal coating. The vast majority (82%) indicated that they seal cracks prior to a seal coat, at least some of the time; only 18% never do. The number of agencies that seal cracks prior to an overlay is considerably less. Almost half (48%) of the agencies said they never seal cracks prior to an overlay.

The material with the highest percentage of users sealing cracks prior to a seal coat is MC Oil & Sand (83%). The material with the highest percentage of users sealing cracks prior to an overlay is AC-3 (56%).

If cracks are to be sealed prior to overlays and seal coats, the material used to seal the cracks must be compatible with the overlay or seal coat. Incompatible materials may cause blistering or swelling in an overlay. One agency indicates that they do not use AC-3 prior to a seal coat due to bleeding of the material through the seal coat.
The agencies were also asked to include any comments that they felt were important concerning crack sealing. These comments are very informative and provide interesting reading. Appendix A contains a compilation of these comments.

Appendix B contains the information presented above in a slightly different light. Nine graphs are contained on each page, one graph for each material. These graphs show a comparison of the parameters used to evaluate the crack sealing materials such as cost, performance, etc.
SURVEY RESULTS FOR THE VARIOUS MATERIAL TYPES

The results of the survey varied depending on several factors. The factor that influenced the survey results the most, was the type of material used. The following information is given to assist the reader in reviewing the information received on the various materials. The information contained in following pages is grouped by material in the following order:

♦ Crumb Rubber (Mn/DOT Spec 3719)
♦ Elastic Type Sealer (Mn/DOT Spec 3723)
♦ Low Modulus Elastic Type Sealer (Mn/DOT Spec 3720)
♦ Extra Low Modulus Elastic Type Sealer
♦ AC-3, Hot Air Blown Asphalt
♦ MC Oil & Sand
♦ Asphalt Emulsion
♦ Cold Pour Silicone
♦ Other Materials

The agencies were also asked to include any comments that they felt were important concerning crack sealing.
CRUMB RUBBER
(Mn/DOT SPEC 3719)

This material is used by 15% of the respondents and was the third most commonly used material. This material consists mainly of crumb rubber. Crow Wing County indicated they have used a combination of AC-3 and crumb rubber on a limited basis with good results. Brand names for materials of this type include Crafo's AR-1, AR-2 and 516 and Koch 9000. Some of these materials actually exceed the requirements of Mn/DOT Spec 3729 by adding polymer modifiers. However, they do not meet all of the requirements of Mn/DOT 3723.

TIME OF YEAR CRACKS ARE SEALED
The most common time of year for placing Mn/DOT Spec 3719 is in the spring. 43% of the agencies that seal cracks with this material seal them in the spring. The next most common response was summer followed by fall. As is the case with several other materials, several agencies indicate that they seal cracks throughout the year, not just during a single time of year.

IN-HOUSE VERSUS CONTRACTED WORK
Most agencies that use Mn/DOT Spec 3719 use their own labor force to seal the cracks. On average, 83.9% of the work is done in-house versus contracted out. Most agencies either did 100% of the work in-house or 100% contracted out.
SAWING OR ROUTING PRIOR TO SEALING
Most of the agencies that use Mn/DOT Spec 3719 saw or route the cracks prior to sealing. 57.1% of the agencies always saw or route, 19% of the agencies sometimes saw or route and 23.8% never saw or route.

For those agencies that do saw or route, the average size of the cut is 0.76 inches wide by 0.73 inches deep. The width ranges between 1/2 and 1-1/8 inch. The depth ranges between 1/4 and 1-1/8 inches.

Figure 19
SAWING OR ROUTING PRIOR TO SEALING

EQUIPMENT USED TO PLACE MATERIAL
The most common tool used to place the material into the cracks is a wand. This was the case with all of the elastic type sealers.

Since this is a hot-pour material, information was provided concerning the most common way to keep the material hot. The most common response given was a double wall kettle or oil jacket kettle. Some brands of equipment given were Bearcat and Crafco.

Figure 20
EQUIPMENT USED TO PLACE THE SEALANT

AVERAGE CREW SIZE
The average crew size used when placing Mn/DOT Spec 3719 is five persons. One agency uses as few as two persons while another as many as eight.

Figure 21
AVERAGE CRACK SEALING CREW SIZE
COST PER LINEAL FOOT
The users of Mn/DOT Spec 3719 report an average cost per lineal foot (including labor) of $0.39. There was a large variation in the reported costs for this material. Costs ranging from $0.05 to $0.82 were reported. The large discrepancy is likely related to how the labor costs are included.

Figure 22
COST PER LINEAL FOOT ($)

COST PER POUND
The Mn/DOT 3719 users also report an average cost per pound (including labor) of $0.93. Similar to the lineal foot costs, there is a large variation in the per pound costs. Costs ranging from $0.20 to $3.06 were reported. Again, the large discrepancy is likely related to how the actual labor costs are included.

Figure 23
COST PER POUND OF MATERIAL ($)

EXPECTED LIFE OF MATERIAL
Most agencies that seal cracks with Mn/DOT Spec 3719 feel that the cracks stay sealed for 3-5 years. The average life expectancy reported is 3.6 years. A number of users (16%) feel this material will last between 5 and 10 years.

Figure 24
EXPECTED LIFE OF SEALANT
COST EFFECTIVENESS
As can be seen from the graph, the vast majority, 81%, of the Mn/DOT Spec 3719 users consider it to be a cost effective material.

With an average cost per lineal foot of $0.93 and an expected life of 3.6 years, the cost effectiveness rating of this material is 9.2, making it the third most cost effective of the nine materials in the survey.

Figure 25
IS THIS MATERIAL COST EFFECTIVE?

OCCURRENCE OF MATERIAL FAILURE
As was the case with most of the materials, over half of the users reported having some sort of failure occur when sealing with Mn/DOT Spec 3719. However, this material had the second highest percent of agencies and the highest number of agencies reporting never to have had a failure. One third (33%) of the users said they have never had a failure when using this material.

Figure 26
HAVE YOU EXPERIENCED FAILURES WITH THIS MATERIAL?

CRACK SEALING PRIOR TO A SEAL COAT
The vast majority of Mn/DOT Spec 3719 users seal cracks, at least sometimes, prior to seal coating. One third of them always do so. Less than 10% never crack seal prior to seal coating with this material.

Figure 27
ARE CRACKS SEALED PRIOR TO SEAL COATS?
CRACK SEALING PRIOR TO AN OVERLAY
The majority of agencies do not seal cracks with Mn/DOT Spec 3719 sealer prior to an overlay. Nearly half of them never do and only 14% always do.

Figure 28
ARE CRACKS SEALED PRIOR TO OVERLAYS?
HOT-POUR ELASTIC TYPE SEALER  
(Mn/DOT 3723, ASTM D 3405)  

This was the most frequently used material based on the survey. It is a hot-poured polymer modified asphalt material which performs much better than Spec. 3719 in cold weather (1). Nearly 27% of the agencies with a crack sealing program use this type of material. Some brand names that meet this specification are Koch 9005, Crafco 221 and W.R. Meadows Hi-Spec. The results did not vary much by agency type.

TIME OF YEAR CRACKS ARE SEALED  
The most common time of year for placing this material is in the spring. Almost half (49%) of the agencies that seal cracks with Spec 3723 seal them in the spring. The fall was the next most common response followed by summer. Over 11% of the agencies also seal cracks in winter with this material. Several agencies indicate that they seal cracks at more than one time of the year.

IN-HOUSE VERSUS CONTRACTED WORK  
Most agencies that use Spec 3723 use their own labor force to seal the cracks. On average, 65.3% of the work is done in-house versus contracted out.
SAWING OR ROUTING PRIOR TO SEALING
Most of the agencies using this material saw or route the cracks prior to sealing. 59% of the agencies always saw or route, 14% saw or route sometimes and 27% never saw or route.

For those agencies that do saw or route, the average size of the cut is 0.79 inches wide by 0.89 inches deep. The width ranges between 1/2 and 1-1/4 inch. The depth ranges between 1/4 and 4 inches.

EQUIPMENT USED TO PLACE MATERIAL
The most common tool used to place material meeting Mn/DOT Spec 3723 is a wand. A large number of agencies also use a pour pot or a combination of the two. One agency uses a banded crack seal method with a band applicator.

Since this is a hot-pour material, information was also provided concerning what equipment is used to keep the material hot. The most common responses were double jacket kettles, and oil jacket melters. Some brand names mentioned were Crafco, Cimline and E-Z Pour.

AVERAGE CREW SIZE
The average crew size used when sealing cracks with Mn/Dot Spec 3723 material is six persons. The reported crew sizes varied from a minimum of two people to a maximum of ten.
COST PER LINEAL FOOT
The users of material meeting Mn/DOT Spec 3723 report an average cost per lineal foot (including labor) of $0.65. Costs ranging from $0.27 to $1.43 were reported. The large difference is likely related to how each agency included labor into the cost. The cost per lineal foot was the second highest in the survey.

COST PER POUND
The Mn/DOT Spec 3723 users also reported an average cost per pound (including labor) of $1.15. As with the lineal foot costs, there were large differences between agencies. One agency reported costs as low as $0.65 per pound while another reported $2.54 per pound. It is likely that the difference is related to how labor costs were taken into account. The average cost per pound of this material was the highest of any material in our survey.

EXPECTED LIFE OF MATERIAL
According to the majority of the agencies, this material lasts between 2 to 3 years. However, 36% feel that it lasts between 3 to 5 years. As a result, the average life expectancy for this material is 4.5 years.
COST EFFECTIVENESS
As was the case with most materials, a large majority of users consider Mn/DOT Spec 3723 to be a cost effective material. Over 86% replied yes when asked the question. Only 5.4% felt sealing cracks with this material was not cost effective.

With an expected life of 4.5 years and an average cost of $0.65 per lineal foot, the Cost Effectiveness Rating of this material is 6.9. This is the second lowest rating of the 9 materials in our survey.

Figure 37
IS THIS MATERIAL COST EFFECTIVE?

OCCURRENCE OF MATERIAL FAILURE
As was the case with most other materials, over half of the users of Mn/DOT Spec 3723 report having experienced some sort of failure with the material. Nearly 70% of the users report having some sort of material failure. However, 22% of the users report never having had a failure with this material.

Figure 38
HAVE YOU EXPERIENCED FAILURES WITH THIS MATERIAL?

CRACK SEALING PRIOR TO A SEAL COAT
The majority of Mn/DOT Spec 3723 users seal cracks before seal coating at least some of the time. Over 35% always seal the cracks prior to seal coats while over 35% sometimes do.

Figure 39
ARE CRACKS SEALED PRIOR TO SEAL COATS?
CRACK SEALING PRIOR TO AN OVERLAY

As was the case with other materials, while most agencies seal cracks prior to seal coats, the percent that seal them prior to overlays is much less. Over 40% of the agencies reported that they never seal cracks prior to overlays. Only 51% reported they seal cracks prior to overlays compared to 70% for seal coats.

Figure 40
ARE CRACKS SEALED PRIOR TO OVERLAYS?
HOT-POUR, LOW MODULUS, ELASTIC TYPE SEALER  
(Mn/DOT 3720, ASTM D 3405 Modified)

This material is used by 11.5% of the agencies with a crack sealing program. Just as Mn/DOT Spec 3723 material, it is a hot-poured polymer modified asphalt. According to one report, it presently is the best Mn/DOT low temperature performing material (1). Some brand names that meet this specification are Crafco 231 and W.R. Meadows Sof-Seal. This material was used by an equal number of cities and counties.

TIME OF YEAR CRACKS ARE SEALED
There is no clear-cut choice as to the most common time of year for placing this material. The most common response was springtime. However, summer and fall sealing seems to be about as common. Only one agency indicated that they seal cracks with it in the winter.

IN-HOUSE VERSUS CONTRACTED WORK
Most agencies that use Spec 3720 contract out for the service. 55.3% of the agencies contract out when sealing cracks with this material versus 44.7% that use their own forces.
SAWING OR ROUTING PRIOR TO SEALING
Most of the agencies using this material saw or route the cracks prior to sealing. Of the agencies that saw or route the cracks prior to sealing them, 57% of the agencies always saw or route, 19% saw or route sometimes and 24% never saw or route.

The average size of cut for the agencies that do saw or route the cracks prior to sealing them with this material is 0.71 inches wide by 0.83 inches deep. The width ranges from 1/4 to 1-1/4 inches, the depth ranges from 1/2 to 1-1/2 inches. The most commonly reported size of cut was 3/4 inch wide by 3/4 inch deep.

EQUIPMENT USED TO PLACE MATERIAL
The most common tool used to place the material into crack when using Mn/DOT Spec 3720 is a wand. Over 70% of the users of this material use a wand, compared to 21% who use a pour pot. Some also use both tools when placing this material.

This material is also a hot-pour sealant. The most common equipment used to keep the material hot is double wall or oil jacket melter or kettle.

AVERAGE CREW SIZE
The average crew size used when sealing cracks with Mn/DOT Spec 3720 is five people. Crew sizes range from a minimum of three people to a maximum of ten.
COST PER LINEAL FOOT
The users of Mn/DOT Spec 3720 material report an average cost per lineal foot (including labor) of $0.78. This was the most expensive material in our survey on a lineal foot basis. Costs as low as $0.30 and as high as $1.90 were reported. Again, the likely cause for the large difference in costs is how labor was included.

COST PER POUND
The average cost per pound for this material is $1.00. While this was the most expensive material on a lineal foot basis, it comes in second when costs are on a per pound basis, behind Mn/DOT Spec 3723. Reported cost ranged from $0.35 to $1.35 per pound. There was much less variation in the per pound cost of this material than with the previously described elastic sealants.

EXPECTED LIFE OF MATERIAL
This material is expected to last 4 years according to the survey. All of the agencies felt it lasts at least 2 to 3 years. It was the third longest lasting material in the survey.
**COST EFFECTIVENESS**
Similar to other materials, the users of material meeting Mn/DOT Spec 3720 consider it to be cost effective. Over 81% of the agencies that use this material replied they felt it was cost effective.

With an average life of 4.0 years and an average cost per lineal foot of $0.78, the Cost Effectiveness Rating of this material is 5.1. This was the lowest value of any of the nine materials in our survey.

**OCCURRENCE OF MATERIAL FAILURE**
Again, like most other materials, most of the agencies that use this material have had some type of failure when sealing cracks with it. While 69% said they have experienced failures, only 19% responded that they have not. The percent of users responding that they have had failures is the second highest in our survey.

**CRACK SEALING PRIOR TO A SEAL COAT**
The majority of agencies seal cracks prior to a seal coat when sealing them with Mn/DOT Spec 3720. Nearly 69% seal cracks at least sometimes prior to seal coats when using this material, 37% always do while 31% sometimes do.
CRACK SEALING PRIOR TO AN OVERLAY
Over half of the users, 55.3%, seal cracks prior to an overlay when using this material. Nearly 19% always seal them while over 37% seal them at least sometimes before overlaying.

Figure 52
CRACK SEALING PRIOR TO AN OVERLAY
HOT-POUR, EXTRA LOW MODULUS
ELASTIC TYPE SEALER

There currently is not a Mn/DOT specification covering this type of material. However, Mn/DOT is considering this material under a new specification 372* (1). This specification will attempt to cover manufacturers’ products which exceed some or all of the requirements of Spec 3720. According to the survey, two agencies (1.4%) currently use this material, one city and one county. One product of this type is W.R. Meadows XLM.

TIME OF YEAR CRACKS ARE SEALED
There was no common time of year for placing this material. The only pertinent fact from the survey about placing it is that neither agency seals cracks in the winter with this material.

IN-HOUSE VERSUS CONTRACTED WORK
One of the agencies that uses this material contract out for the service, the other uses in-house forces.
SAWING OR ROUTING PRIOR TO SEALING
One of the agencies that uses this material always saws or routes the cracks prior to sealing, the other never does.

The size of cut is 3/4 inch wide by 3/4 inch deep.

EQUIPMENT USED TO PLACE MATERIAL
One of the agencies uses a wand to place this material while the other uses a pour pot.

AVERAGE CREW SIZE
One of the two agencies that uses this material uses a three person crew while the other uses a four person crew.
**COST PER LINEAL FOOT**
The average cost per lineal foot (including labor) reported by the two agencies using this material is $0.41. The lineal foot cost ranks in the middle of the nine materials in our survey. One agency reports a cost of $0.32 while the other reports $0.50 per lineal foot.

With an average life of 7.5 years and an average cost of $0.41 per lineal foot, the Cost Effectiveness Rating of this material is 18.3. This was the highest rating of any of the nine materials in our survey. However, only two agencies provided information concerning this material.

**COST PER POUND**
The average cost per pound (including labor) for this material is $1.00. Only one agency reported cost information on a per pound basis. Similar to the lineal foot costs, the per pound cost of this material ranks near the middle of the materials in our survey.

**EXPECTED LIFE OF MATERIAL**
Both agencies that use this material feel that it will last between 5 and 10 years, making it the longest lasting material in our survey with an average life of 7.5 years.
COST EFFECTIVENESS
Both of the users consider the Extra Low Modulus material to be cost effective.

With an average life of 7.5 years and an average cost of $0.41 per lineal foot, this material has a Cost Effective Rating of 18.3. This is the highest Cost Effectiveness Rating of any of the nine materials in our survey.

OCCURRENCE OF MATERIAL FAILURE
One of the agencies using this material has experienced some type of material failure while the other has not.

CRACK SEALING PRIOR TO A SEAL COAT
One of the agencies seals cracks with this material prior to a seal coat while the other does not.
CRACK SEALING PRIOR TO AN OVERLAY
As was the case with crack sealing prior to seal coats, one of the agencies always seals cracks prior to an overlay when using this material while the other agency never does.

Figure 64
ARE CRACKS SEALED PRIOR TO OVERLAYS?
AC-3
HEATED AIR BLOWN ASPHALT

This material was the second most frequently used material and the most frequently used material by county agencies. Of the 36 of the agencies that use this material, 92% are counties. It provided the largest difference in use by agency type of any of the materials in our survey. Two agencies indicate they use a mixture of AC-3 and other material. A number of agencies indicated that their goal when using AC-3 is not to seal the cracks but rather to coat the edges of the cracks to reduce the rate of deterioration.

TIME OF YEAR CRACKS ARE SEALED
The most common time of year for placing this material, by a wide margin, is in the spring. Over 72% of the agencies that seal cracks with AC-3 seal them in the spring. The next most common response was winter followed by summer.

Figure 65
TIME OF YEAR CRACKS ARE SEALED

IN-HOUSE VERSUS CONTRACTED WORK
Every agency (100%) that seals cracks with AC-3 uses its own forces to do the work. No agencies contract out for sealing cracks according to the survey.

Figure 66
IN-HOUSE VERSUS CONTRACTED WORK
SAWING OR ROUTING PRIOR TO SEALING
Only one agency (3%) indicated that they ever saw or route prior to sealing cracks with AC-3. That agency indicates that they only do it sometimes and the size of cut is 3/8 inch wide by 3/4 inch deep. The other 97% indicate that they never saw or route the cracks when sealing with AC-3.

EQUIPMENT USED TO PLACE MATERIAL
The most common tool used to place the material into the cracks when using AC-3 is a pour pot. 65% of the users of AC-3 reported using a pour pot compared to 31% who use a wand. Another 4% of AC-3 users indicate they use both tools.

The most common equipment used to keep this material hot is a tar kettle, typically heated with a propane fueled flame.

AVERAGE CREW SIZE
The average crew size used when placing AC-3 is five persons. One agency indicates it uses as few as three persons while another indicates it uses ten persons.
COST PER LINEAL FOOT
AC-3 is the lowest cost material on a per foot basis according to the survey respondents. The average cost per lineal foot (including labor) is $0.19. The costs reported were very consistent among the various agencies and ranged from a minimum of $0.05 to a maximum of $0.30.

COST PER POUND
While AC-3 was the least expensive material on a lineal foot basis, it was second to Asphalt Emulsion on a per pound basis. The average cost per pound (including labor) is $0.71. There was much more variation between agencies in the per pound cost as compared to the lineal foot cost. The reported minimum cost was $0.38 while the maximum was $1.92 per pound.

EXPECTED LIFE OF MATERIAL
Even though it is one of the most commonly used materials, 37% of the users felt that it lasted less than one year. The number of agencies that felt it was effective less than one year was higher for this material than with any other. The average expected life for AC-3 is 1.7 years.
COST EFFECTIVENESS
Just over 58% of AC-3 users think it is a cost effective material. This is the second lowest percentage in our survey. Only Asphalt Emulsion had a lower percent of users feeling it was cost effective.

With an expected life of 1.7 years and an average cost of $0.19 per lineal foot, the cost effectiveness rating for this material is 9.0, ranking it fourth out of the nine materials in the survey.

OCCURRENCE OF MATERIAL FAILURE
While the life expectancy of AC-3 is only 1.7 years, it was not considered to fail any more frequently than the other materials. Not surprisingly, nearly all of the agencies that felt AC-3 lasted less than one year indicated they had experienced failures with the material.

CRACK SEALING PRIOR TO A SEAL COAT
Like most of the other materials, users of AC-3 indicate that they normally seal cracks with it prior to a seal coat. Over 66% reported sealing cracks with AC-3 at least some of the time prior to a seal coat. One user indicated that their agency never does so due to problems with bleeding of the AC-3 material through the seal coat.
CRACKS SEALING PRIOR TO AN OVERLAY

More agencies seal cracks with AC-3 prior to an overlay than with any other material. Over 56% reported that they seal cracks at least sometimes prior to an overly when using AC-3. Over 27% always do so.

Figure 76
ARE CRACKS SEALED PRIOR TO OVERLAYS?
MC OIL & SAND

This type of sealer consists of a sand blotter over Medium Cure (MC) road oil. This type of material is used by 8.6% of the agencies that have a crack sealing program. Similar to AC-3, this material is a crack filler rather than a crack sealer. The material coats the edges of the crack in an attempt to slow down the rate of deterioration.

TIME OF YEAR CRACKS ARE SEALED
The most common time of year for sealing cracks with this material is during summer. Nearly 53% of the agencies that seal cracks with this material seal them in the summer. This was the highest percentage of users that seal cracks in the summer. No agency indicated that they sealed cracks during winter with this material.

IN-HOUSE VERSUS CONTRACTED WORK
Every agency (100%) that seals cracks with MC Oil & Sand uses its own crew to do the work. No agencies contract out for sealing cracks with this material according to the survey.
SAWING OR ROUTING PRIOR TO SEALING
None of the agencies saw or route the cracks prior to sealing them with this material.

EQUIPMENT USED TO PLACE MATERIAL
One half of the MC Oil & Sand users use a pour pot to place the material into the cracks. The remaining 50% are split equally between using a wand, pour pot & wand and other (a shovel).

The most common equipment used to keep this material hot is a tar kettle or asphalt distributor.

AVERAGE CREW SIZE
The average crew size used when placing this material is five persons. One agency uses as few as two persons while another uses as many as eight.
COST PER LINEAL FOOT
The average cost per lineal foot (including labor) for this material is $0.32, making it the third lowest costing material on a lineal foot basis. The variation in cost was the smallest of any other material. The reported cost ranged from a minimum of $0.25 to a maximum of $0.38. Only three of the 12 agencies reporting they use MC Oil & Sand provided cost information.

COST PER POUND
None of the agencies that use MC Oil & Sand reported cost information on a per pound basis.

EXPECTED LIFE OF THE MATERIAL
This material provided the most diversity in response to material longevity. A fairly large percent of agencies felt the material was effective over a broad range of life spans. The average life expectancy for this material is 2.6 years.
COST EFFECTIVENESS
Similar to AC-3, just over 58% of the MC Oil & Sand users feel the material is cost effective. This was the second lowest percentage in the survey.

Base on a life expectancy of 2.6 years and an average cost per lineal foot of $0.32, the cost effectiveness rating for MC Oil & Sand is 7.1. This was the third lowest rating of the nine materials in the survey.

Figure 85
IS THIS MATERIAL COST EFFECTIVE?

OCCURRENCE OF MATERIAL FAILURE
This material was very typical when considering the occurrence of failures. 67% of the users reported having had some type of failure with this material while 25% reported never having a failure.

Figure 86
HAVE YOU EXPERIENCED FAILURES WITH THIS MATERIAL?

CRACK SEALING PRIOR TO A SEAL COAT
The vast majority of MC Oil and Sand users seal cracks with the material prior to seal coating. Over 83%, the highest percentage of any material, of the MC Oil & Sand users do so.

Figure 87
ARE CRACKS SEALED PRIOR TO SEAL COATS?
CRACK SEALING PRIOR TO AN OVERLAY
Not very many agencies who use MC Oil & Sand seal cracks with it prior to an overlay. Only 33% reported they at least sometimes do. This was the second lowest percentage in the survey.

Figure 88
ARE CRACKS SEALED PRIOR TO OVERLAYS?
SAWING OR ROUTING PRIOR TO SEALING
None the agencies indicated that they ever saw or route cracks prior to sealing them with Asphalt Emulsion.

EQUIPMENT USED TO PLACE MATERIAL
All of the agencies using Asphalt Emulsion place the material into the crack with a pour pot.

AVERAGE CREW SIZE
The average crew size used when placing this material is four persons. The minimum crew size is two, the maximum crew size is six.
COST PER LINEAL FOOT
The average cost per lineal foot (including labor) to seal cracks using Asphalt Emulsion is $0.28 per foot. This was the second lowest lineal foot cost in our survey. Costs ranged from a minimum of $0.08 to a maximum of $0.50 per lineal foot.

COST PER POUND
The average cost per pound of material (including labor) for Asphalt Emulsion is $0.69. This was the lowest cost material on a per pound basis of any in our survey. Costs ranged from a minimum of $0.38 to a maximum of $1.00 per pound.

EXPECTED LIFE OF THE MATERIAL
The agencies that use this material were split equally when deciding on its longevity. One third feel if lasts less than 1 year, one third feel if lasts between 1 and 2 years and one third between 3 to 5 years. The average life expectancy of this material is 2.0 years.
COST EFFECTIVENESS
Two of the four agencies who use this material indicate that they feel it is cost effective, one agency did not and the other did not respond. The percentage that said it was not cost effective (25%) was the highest of any of the materials in the survey.

With an average life of 2.0 years and an average cost of $0.28 per lineal foot, the Cost Effectiveness Rating for this material is 7.1. This was the third lowest rating of the nine materials in the survey.

Figure 97
IS THIS MATERIAL COST EFFECTIVE?

OCCURRENCE OF MATERIAL FAILURE
Asphalt Emulsion users were typical of users of other materials in regard to material failures. One half of the agencies have experienced failures with the material while 25% have not. The other 25% did not respond.

Figure 98
HAVE YOU EXPERIENCED FAILURES WITH THIS MATERIAL?

CRACK SEALING PRIOR TO A SEAL COAT
Consistent with the other materials, most users of Asphalt Emulsion seal cracks with it prior to a seal coat.

Figure 99
ARE CRACKS SEALED PRIOR TO SEAL COATS?
CRACK SEALING PRIOR TO AN OVERLAY
The majority of Asphalt Emulsion users never seal cracks with it prior to an overlay. This material had the smallest percent of users reporting they seal cracks prior to an overlay.

Figure 100
ARE CRACKS SEALED PRIOR TO OVERLAYS?
COLD POUR SILICONE

Only one agency currently uses this type of material according to the survey. Cold pour silicones have primarily been used to seal concrete pavements. In fact, cold pour silicone is currently the only non-preformed material allowed by the Concrete Unit of the Mn/DOT Pavement Engineering Section (1) for sealing transverse joints in PCC. A self-leveling silicone is now available for sealing bituminous pavements; Dow Corning 890 SL.

TIME OF YEAR CRACKS ARE SEALED
The one agency that uses this material seals cracks in the spring.

IN-HOUSE VERSUS CONTRACTED OUT
The one agency that uses this material does the work 100% in-house when sealing cracks with it.
COST EFFECTIVENESS
The agency that uses this material considers it to be cost effective although no cost information was provided. As a result, a cost effective rating could not be calculated.

Figure 109
IS THIS MATERIAL COST EFFECTIVE?

Figure 110
HAVE YOU EXPERIENCED FAILURES WITH THIS MATERIAL?

Figure 111
ARE CRACKS SEALED PRIOR TO SEAL COATS?

OCCURRENCE OF MATERIAL FAILURE
No response was given concerning failures for Cold Pour Silicone.

CRACK SEALING PRIOR TO A SEAL COAT
The agency that uses Cold Pour Silicone seals cracks prior to a seal coat some of the time when sealing cracks with it.
CRACK SEALING PRIOR TO AN OVERLAY

Similar to seal coats, the agency that uses Cold Pour Silicone seals cracks prior to an overlay some of the time when sealing cracks with it.

Figure 112
ARE CRACKS SEALED PRIOR TO OVERLAYS?
OTHER MATERIALS

There are several materials that do not meet all of the Mn/DOT requirements for polymer modified asphalt sealants. These materials are classified under the "other" category. There were also materials not included in the survey selection that agencies indicated they use. Among these are RC 800 Oil, Koch Flex-A-Fill and Crafo ARMN 34056. Koch Flex-A-Fill® is a hot applied elastomeric compound consisting of asphalt, virgin rubber and fillers (Koch). Crafo ARMN 34056, also known as the Minnesota Blend is a crumb rubber sealant which makes use of recycled tires. These two materials account for 60% of the materials in this category.

TIME OF YEAR CRACKS ARE SEALED

The most common time of year to seal cracks with these materials is spring. 50% of the agencies using a material in this category seal the cracks in the spring. There were no trends for the various brands or materials in this category.

IN-HOUSE VERSUS CONTRACTED WORK

Most of the agencies that use a material in this category seal the cracks with their own work force. The work is done in-house 62.5% of the time.
SAWING OR ROUTING PRIOR TO SEALING
Most of the agencies using this material do not saw or route the cracks prior to sealing. 30% of the agencies always saw or route, 10% saw or route sometimes and 60% never saw or route.

Those agencies that do saw or route, use Crafo ARMN 34056 (Mn Blend). The average size of the cut is 0.84 inches wide by 0.84 inches deep. The width ranges between 1/2 and 1 inch. The depth also ranges between 1/2 and 1 inch.

EQUIPMENT USED TO PLACE MATERIAL
Most of the agencies that seal cracks with one of the materials in the "Other" category use a wand to place the material, although not by a wide margin.

Most of the materials in this category are also hot-pour materials. The equipment used to keep the material hot includes a double wall kettle, an oil distributor and a propane heater.

AVERAGE CREW SIZE
The average crew size used when sealing cracks with material in this category is five persons. The low was a three person crew, the high was a seven person crew.
COST PER LINEAL FOOT
The average cost per lineal foot (including labor) for the material in this category is $0.43. The reported costs ranged from a low of $0.25 to a high of $0.61. The lineal foot cost was the third highest in our survey.

COST PER POUND
The average cost per pound (including labor) for materials in this category is $0.96. Reported prices had very little variation. The costs ranged from $0.92 to $1.00. However, only two of the ten agencies that use this material provided cost information.

EXPECTED LIFE OF MATERIAL
The expected life of the materials in this category are split fairly evenly between several categories. The most common response is 2 to 3 years. The average life expectancy is 4.3 years, making it the third longest lasting material in our survey. There were no noticeable trends for the various brands of material in this category.

Figure 118
COST PER LINEAL FOOT ($)

Figure 119
COST PER POUND OF MATERIAL ($)

Figure 120
EXPECTED LIFE OF THE SEALANT
COST PER LINEAL FOOT
The average cost per lineal foot (including labor) for the material in this category is $0.43. The reported costs ranged from a low of $0.25 to a high of $0.61. The lineal foot cost was the third highest in our survey.

Figure 118
COST PER LINEAL FOOT ($)

COST PER POUND
The average cost per pound (including labor) for materials in this category is $0.96. Reported prices had very little variation. The costs ranged from $0.92 to $1.00. However, only two of the ten agencies that use this material provided cost information.

Figure 119
COST PER POUND OF MATERIAL ($)

EXPECTED LIFE OF MATERIAL
The expected life of the materials in this category are split fairly evenly between several categories. The most common response is 2 to 3 years. The average life expectancy is 4.3 years, making it the third longest lasting material in our survey. There were no noticeable trends for the various brands of material in this category.

Figure 120
EXPECTED LIFE OF THE SEALANT
COST EFFECTIVENESS
The materials in this category had 90% of their users respond that they felt it was cost effective, the highest percentage in our survey.

With an expected life of 4.3 years and an average cost of $0.43 per lineal foot, the cost effectiveness rating of this material is 10.0, the second most cost effective material in the survey.

OCCURRENCE OF MATERIAL FAILURE
While the highest percentage of users feel these materials are cost effective, the highest percentage also have experienced failures when using the material (70%). No agency replied that they have never had a failure with the material.

CRACK SEALING PRIOR TO A SEAL COAT
A large percent of the users of these materials did not respond to this question. As a result, only 30% of the users said they seal cracks with it prior to seal coating, the lowest, by a wide margin of any material in the survey.
CRACKS SEALING PRIOR TO AN OVERLAY
The percent of users that *never* seal cracks with these materials prior to an overlay was equal to the percent that *sometimes* do. None of the agencies indicated that they always do so.

Figure 124
ARE CRACKS SEALED PRIOR TO OVERLAYS?
SUMMARY

In summary, there are generally three types of crack treatments used by local agencies in Minnesota. They are crack sealing, crack filling and crack repair. Crack sealing attempts to provide a water tight barrier to prevent water and incompressible material from entering the pavement system. Crack filling attempts to coat the edges of the crack to reduce the rate of deterioration, particularly caused by oxidation of the asphalt. Crack repair consists of fine mix patching, tight blading, milling and repair or an overlay. In Minnesota, local engineers and street/highway superintendents use "crack filling" and "crack sealing" interchangeably to refer to placing material into cracks. The desired objective is dependent on the type and properties of the sealant/filler material.

Over 80% of the agencies responding to the survey have a crack sealing/filling program in-place. The most commonly used crack treatment materials are Mn/DOT Spec 3723 (hot-pour elastic sealer) and AC-3 (hot air blown asphalt). Mn/DOT Spec 3723 material is considered to be a crack sealer due to its stretching (ductility) properties while AC-3 is considered to be a crack filler. Most agencies feel the crack fillers last one to three years while crack sealants last four to eight years.

When choosing a crack treatment material, the objective (sealing versus filling) must be taken into account before other items such as cost and performance are considered. It is difficult to compare the benefits of different materials if the reason for using the material is different. If crack sealing is the objective, the elastic materials should be compared to each other rather than to fillers when deciding which material to use. Likewise, if crack filling is the goal, the crack filler material should be compared to other crack filling materials rather than to crack sealants.

The cost effectiveness of a crack treatment material depends on the cost as well as the expected life of the material. Also of importance is the number of years the pavement itself gains by having the cracks sealed, filled or repaired. If the pavement will fail in the same number of year regardless of whether the cracks are treated or not, the material and the entire treatment procedure is probably not cost effective. It is recommended that agencies monitor the condition of their pavements to determine if the deterioration rate is being reduced by the crack treatment being used. This information will ultimately determine which crack treatment technique and/or material is the most cost effective.
RECOMMENDATIONS

The recommendations given below are based on the results of the survey as well as those given by Mn/DOT in reference 1. They provide an overview of the methods and procedures found to work best when filling or sealing cracks on bituminous pavements.

CRACK SEALING

1. Crack sealing should be done on newer pavements or those where the pavement has not deteriorated appreciably.

2. Overbanding, extending the sealant material slightly beyond the actual width of the crack or reservoir, is recommended. Several agencies feel that this practice provides for longer sealant life. The overband limits cohesive failures and reinforces the edges of the reservoir or crack. However, plow blades may damage the sealant material when an overband is applied.

3. Sealing cracks less than 1/4 inch wide is not recommended unless the crack is routed or sawed to create a reservoir. The reservoir is required to ensure the material can be placed directly into the crack (1).

4. The reservoir should be as wide as it is deep (1). Stiff materials and pavement with long spacing between transverse cracks will require wider reservoirs to reduce the stress buildup which occurs along the crack edges.

5. At a minimum, the crack should be cleaned with compressed air prior to placing the sealant or filler into the cracks (1). The recommended procedure is sweep or blow the crack clean, dry the crack with a heat lance and then place the material into the crack as soon as possible afterward.

6. Crack sealing materials must be able to maintain their flexibility in extreme cold temperatures in order to keep the cracks sealed (1). If the material becomes stiff, it will not stretch as the crack opens and it will fail.

CRACK FILLING

1. Crack filling should be done when the pavement has deteriorated to the point that sealing is no longer viable (1). Typically, other repair alternatives need to be addressed as well.

2. The most widely used and resilient crack filler is AC-3 (1). Crumb rubber products have also been used as crack fillers.

3. Either a direct heat kettle or indirect (double) boiler kettle should be used to heat the material (1). The filler material should be squeegeed off to provide a slight overband of material.
REFERENCES


APPENDIX A
GENERAL COMMENTS FROM SURVEY RESPONDENTS

The questionnaire also asked agencies for any general comments about crack sealing they felt important. The comments provide good information as to what different agencies have tried and how they feel about certain materials and procedures. Listed below are their responses:

COMMENTS FROM CITIES

♦ "In 1991 we will be using a router and also sealing prior to overlays & seal coating. New superintendent, new program!"

♦ "Each year we crack fill the streets that are going to be seal coated."

♦ "Our crack sealing program is only going into it's second year. We are contracting until we get a feel for which crack sealing equipment will fit our needs best and because of lack of manpower."

♦ "Crack sealing is very important in years 3-5 of a pavements life."

♦ "Some control of AC-3 material may be in order. We have placed some product which will not set and tends to track when weather is hot."

♦ "In theory I believe that crack sealing is effective. I am uncertain as to what type of material and application techniques are correct. I would like to see this topic settled once and forever."

♦ "Crack filling depends on the whims of the street superintendent. It's value is questionable. Bituminous roads last 30-40 years with or without crack filling. Seal coating seems to prolong life more so than crack filling."

♦ "We do some every year and we are satisfied."

♦ "In the past very little crack sealing was done. When any sealing was done, an AC-3 was used with poor results. The product we are currently using seems to be working well at this point. We will continue to monitor."

♦ "What I hope to do is to try to crack fill new streets as they need it. Flex-a-fill works better than other products we tried several years ago. Crack filling costs a lot but so does any black top repair or replacement."

♦ "1990 was the first year of crack sealing program."

COMMENTS FROM CITIES (continued...)

♦ "Some streets hold the tar together in cracks better than others in cold weather months. What we plan on doing this summer is routing the cracks wider than usual, to get more tar in the
cracks. This may help when the road freezes and the cracks spread open."

♦ "Cracks are compressed air blown before we use a banded crack seal method. We seal cracks 1-2 months prior to seal coating. Excellent results."

♦ "It is a good material (crumb rubber) but is very messy for the people handling it."

♦ "Good program that should have a high priority. Lack of manpower dictates when and how long we can spend doing it.

♦ "We are just beginning our crack sealing program again after about a 4 year moratorium. We stopped using MC oil & sand to find a better, more effective method. Even the MC oil & sand gave us some benefit. It stopped the edges of the cracks from deteriorating quickly into potholes. This process didn't however keep water from penetrating through into the base except maybe the first few months...as soon as it got cold, the crack reappeared.

♦ "Some of our crack filling is done in the spring and fall but the majority in the winter.

♦ "We would like to do more but now have to give street reconstruction a priority.

♦ "On our last project by Bergman Companies we were given a 3 year, unconditional guarantee that any cracks which reopened would be resealed free of charge. The sealing looks excellent so far after 2 freeze-thaw cycles. We quit using CRS-1 in the early 1980's due to very poor performance.

♦ "Would like better qualification of materials to determine selection criteria.

♦ "We are beginning to bid out crack sealing as a part of our annual seal coating projects.

♦ "Crack sealing is done when time & funds availability permit. We have not sealed in the last 2 years."
COMMENTS FROM COUNTY AGENCIES

♦ "When crack becomes severe enough, we use hot mix fines to fill the void and bridge the area."

♦ "The extensive use of the crumb rubber product produced by Crafco & marketed by Spec Materials 2 years ago was precipitated by the fact that the crumb rubber was produced by the "Tire Cycle Plant" located in our county at Babbitt, Mn. The product performed remarkably well in comparison to AC-3 or other products occasionally used. The discontinuance of the program had nothing to do with dissatisfaction with the material, but was connected, in part, with the instability of the crumb rubber plant operation, and with the county's financial problems. Originally the plan was to order 80 tons of the crack filler this year."

♦ "Our crack sealing is evolving - we're using less AC-3. On older bituminous we're trying rubberized, with routing on newer surfaces. But we're still experimenting with it - this should be a good study to see what other people are doing - and what is effective for them."

♦ "We have used Mn/DOT 3723 only once on a test plot last year. We are planning on 3 more miles this year. The area that was done last year looks very good after first year."

♦ "We will be trying ASTM D-3407 this year on full depth new pavement cracks that open about 1-1½ inches."

♦ "We feel our crack sealing program is cost effective in conjunction with our cold in-place recycling (CIR) program (recycle with 2 inch overlay). The amount of transverse cracking on a CIR project is usually less than 1/3 that of a standard overlay, so less crack sealing is needed."

♦ "I am totally convinced that any level of effort in crack sealing is better than none. I have even taken cores out of the same pavement at cracks that were sealed and non-sealed and have visual proof of the effect."

♦ "We have been fairly aggressive in our crack sealing efforts in the past few years and hope to continue this in the future, if the budget allows. We are currently testing several different materials to try and find the best cost/benefit ratio for this type of work."

♦ "Up to now we have just been filling cracks to keep the joint "live" and to limit erosion & spalling. We plan to get into rubberized asphalt sealants on new full depth asphalt only, where initial contraction cracks open up to 1½ inches wide. Then I feel we need a sealant as soon as we know of something that works."

♦ "Our crack sealing program is intended to cover our entire bituminous road mileage about every three years with about 1/3 of the mileage done each year. New pavement (the previous year's construction season work) is done first or crack sealed the first year. We do not consider that we are filling and sealing the crack preventing moisture from entering but rather sealing the crack faces to minimize spalling or fracturing of the edges to slow down the creation of potholes. We also use an MC fine mix along with the AC-3 crack sealing to patch large cracks and level crack depressions."
"Overall, I think our program has been successful. We still have some failure but a majority of the cracks are shedding water."

"The material (Crafco 231 & Meadows Hi-Spec) seems to work as long as the reservoir is of proper dimension for the crack spacing, the cracks are properly prepared and the bond to the bottom of the reservoir is broken. It appears that the material may split from the bottom upward if the bottom of the crack is very narrow when the material is poured and if it adheres to the reservoir bottom it only has the narrow width of the crack to stretch instead of the width of the reservoir."

"Until about 3 years ago we did not feel that the sealants available were performing well enough to justify the expense of placing them. We are still testing the newer materials to see which one will work best for us."

"I have not seen a crack filler that doesn’t re-crack after a few years with the exception of routing and making a reservoir. I feel this is an extreme expense. All crack filling we have done in the past made the road last longer and we have very few potholes starting at the crack. I feel it comes back to the fact that the top and face is sealed even if the crack opens up. I also feel that the possibility of sawing blacktop (new jobs) like concrete and then using a reservoir methods would eliminate cracking."

"We are just getting started with crack fill program and therefore are very interested in your findings."

"We have been using rubberized asphalt crack sealant since about 1984 and low modulus the last couple of years. We are doing our newer highways about 5 years after they are paved with deep strength bituminous. The cracks on our deep strength bituminous highways usually open up 1½ inches wide in the winter and this is not the total answer but is far superior to using MC or RC. We have tried some 1 inch wide routing instead of 3/4 inch but felt the 3/4 inch looked better after 1-2 years. I am a firm believer in crack filling and would like to see a better method, product, or possibly sawing joints in bituminous paving to obtain a long term seal such as concrete highways enjoy."

"Our program is not intended to fill the cracks but simply to add additional oil; to the face of the crack to keep the asphalt pavement from oxidizing too rapidly. If we need to fill large crack we tack the crack with an emulsion and fill the crack with a fine mix bituminous mixture."

"Not satisfied with the results of crack sealing - always get some cracks back in the winter so it is often only effective for one season. Cracks do often close again as it warms. However, haven’t seen the effectiveness of routing and filling (we did have a test section done with the rubberized material). Have felt it important to try to keep joints from depressed due to material loss."

"In the future we may try Mn/DOT spec 2723 (ASTM D 3405) hot poured elastic type crack sealers."
"We do not use AC-3 crack filler prior to an overlay. In our experience, the fresh AC-3 bleeds through the new bituminous layer causing slight bumps at each crack."

"Would love to find something more elastic. We felt that at least we get some sealing and protection of the edge. We do blow out the dirty areas especially in municipalities. Usually in one year the AC-3 cracks open but the size is less than 1/3 of what we had before. Personally I have not encountered anything better for the price. "Rubberized" parking lot done a couple years ago looks good but was expensive and has not been checked lately. Interested in what the best would be for the price."

"We are planning to start using crumb rubber on new bituminous beginning this year."

"We have 360 miles of bituminous roads and limited maintenance personnel which limits our crack filling/sealing activities. We usually pour between 10-15 ton of AC-3 each spring."

"There may be better materials (than AC-3) at a higher cost. We plan on some experimentation with rubberized materials in the future."

"Our program is aimed at stabilizing the cracks, not at sealing them. We hope to prevent or slow pavement degradation and thus overall costs accordingly."

"Cracks don't stay sealed but edges seem to hold up better."

"We have had good results with the Crafco product (Crafco RS 221)."

"We fill only cracks 1/4 inch or wider. Those that are raised are milled & filled with a bituminous mix."

"Our crack filling program with rubberized material is in its second year. We were using as much of the research technology available with the equipment we have available."

"We started a crack sealing program in 1988. In 1990 we sawed 149,182 feet (28.25 miles) on newer bituminous roads, this was on 54 miles of road. We also filled 14.8 miles of older bituminous roads. The cracks on these roads were blown (heat lance) and filled then covered with pea-gravel or lime. Total crack sealant used in 1990 was 93,350 pounds (46.7 tons). Before we overlay roads we blow cracks and fill with cold mix bituminous. This material is heated with a Heat-O-Mix machine. This material is made from 1/4 inch taconite and 6.5% oil."
EQUIPMENT USED TO PLACE THE MATERIAL INTO THE CRACKS

Mn/DOT SPEC 3719
CRUMB RUBBER
BASED ON 21 RESPONSES

POUR POT 19%
WAND 81%

Mn/DOT SPEC 3723
ELASTIC TYPE SEALER
BASED ON 37 RESPONSES

OTHER 6%
WAND & POUR POT 17%
POUR POT 14%
WAND 63%

Mn/DOT SPEC 3720
LOW MODULUS ELASTIC SEALANT
BASED ON 18 RESPONSES

WAND & POUR POT 7%
POUR POT 21%
WAND 71%

EXTRA LOW MODULUS
ELASTIC TYPE SEALANT
BASED ON 2 RESPONSES

WAND 50%
POUR POT 50%

AC-3
HOT AIR BLOWN ASPHALT
BASED ON 96 RESPONSES

WAND 31%
WAND & POUR POT 4%
POUR POT 65%

MC OIL & SAND
BASED ON 12 RESPONSES

WAND 17%
OTHER 17%
POUR POT 50%
WAND & POUR POT 17%

ASPHALT EMULSION
BASED ON 4 RESPONSES

OTHER 25%
POUR POT 75%

COLD POUR SILICONE
BASED ON 1 RESPONSE

POUR POT 100%

OTHER MATERIAL
BASED ON 10 RESPONSES

WAND 56%
OTHER 11%
POUR POT 33%
CREW SIZE USED WHEN SEALING/FILLING CRACKS WITH VARIOUS MATERIALS

Mn/DOT SPEC 3719
CRUMB RUBBER
BASED ON 21 RESPONSES

Mn/DOT SPEC 3723
ELASTIC TYPE SEALER
BASED ON 37 RESPONSES

Mn/DOT SPEC 3720
LOW MODULUS ELASTIC SEALANT
BASED ON 16 RESPONSES

EXTRA LOW MODULUS
ELASTIC TYPE SEALANT
BASED ON 2 RESPONSES

AC-3
HOT AIR BLOWN ASPHALT
BASED ON 56 RESPONSES

MC OIL & SAND
BASED ON 12 RESPONSES

ASPHALT EMULSION
BASED ON 4 RESPONSES

COLD POUR SILICONE
BASED ON 1 RESPONSE

OTHER MATERIAL
BASED ON 10 RESPONSES
LINEAL FOOT COST OF SEALING/FILLING CRACKS WITH THE VARIOUS MATERIALS

Mn/DOT SPEC 3719
CRUMB RUBBER
COST PER LINEAL FOOT

$0.05
$0.39
$0.62
MINIMUM
AVERAGE
MAXIMUM

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.

Mn/DOT SPEC 3723
ELASTIC TYPE SEALER
COST PER LINEAL FOOT

$0.27
$0.65
$1.43
MINIMUM
AVERAGE
MAXIMUM

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.

Mn/DOT SPEC 3720
LOW MODULUS ELASTIC TYPE SEALER
COST PER LINEAL FOOT

$0.30
$0.78
$1.90
MINIMUM
AVERAGE
MAXIMUM

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.

EXTRA LOW MODULUS
ELASTIC TYPE SEALER
COST PER LINEAL FOOT

$0.32
$0.41
$0.50
MINIMUM
AVERAGE
MAXIMUM

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.

AC-3
HOT AIR BLOWN ASPHALT
COST PER LINEAL FOOT

$0.05
$0.19
$0.30
MINIMUM
AVERAGE
MAXIMUM

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.

MC OIL & SAND
COST PER LINEAL FOOT

$0.25
$0.32
$0.38
MINIMUM
AVERAGE
MAXIMUM

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.

ASPHALT EMULSION
COST PER LINEAL FOOT

$0.08
$0.28
$0.50
MINIMUM
AVERAGE
MAXIMUM

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.

COLD POUR SILICONE
COST PER LINEAL FOOT

NO DATA GIVEN

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.

OTHER MATERIALS
COST PER LINEAL FOOT

$0.25
$0.43
$0.61
MINIMUM
AVERAGE
MAXIMUM

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.
PER POUND COST OF SEALING/FILLING CRACKS WITH THE VARIOUS MATERIALS

Mn/DOT SPEC 3719
CRUMB RUBBER
COST PER POUND

$0.20 $0.93 $3.06
MINIMUM AVERAGE MAXIMUM

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.

Mn/DOT SPEC 3723
ELASTIC TYPE SEALER
COST PER POUND

$0.65 $1.16 $2.54
MINIMUM AVERAGE MAXIMUM

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.

Mn/DOT SPEC 3720
LOW MODULUS ELASTIC TYPE SEALER
COST PER POUND

$0.35 $1.00 $1.35
MINIMUM AVERAGE MAXIMUM

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.

EXTRA LOW MODULUS
ELASTIC TYPE SEALER
COST PER POUND

$1.00 $1.00 $1.00
MINIMUM AVERAGE MAXIMUM

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.

AC-3
HOT AIR BLOWN ASPHALT
COST PER POUND

$0.38 $0.71 $1.92
MINIMUM AVERAGE MAXIMUM

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.

MC OIL & SAND
COST PER POUND

NO DATA GIVEN

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.

ASPHALT EMULSION
COST PER POUND

$0.38 $0.69 $1.00
MINIMUM AVERAGE MAXIMUM

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.

COLD POUR SILICONE
COST PER POUND

NO DATA GIVEN

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.

OTHER MATERIALS
COST PER POUND

$0.92 $0.98 $1.00
MINIMUM AVERAGE MAXIMUM

*COST (INCLUDING LABOR) TO SEAL CRACKS WITH THIS MATERIAL.
Janisch, David W.
Crack sealing bituminous pavements in Minnesota