MICHIGAN DEPARTMENT OF TRANSPORTATION
M•DOT

Bituminous Crack Filling Test Section on US-10 near Evart

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SUMMARY

The purpose of this study was to have a side by side comparison of many different filler materials used for cracks in bituminous pavements. Twenty-one test sections involving nine materials were placed in May 1995. Different cover materials and addition of fibers and/or polymer additives to the fill material were also included in the study. Members of MDOT's Maintenance, Materials & Technology, and Construction Divisions, as well as a representative from a county road commission, visually rated the different test sections. Properties rated were: bridging, abrasion, adhesion/cohesion loss, bleeding and tracking. The ratings occurred one, three, seven, eleven, fifteen, and twenty-four months after the test sections were placed.

Two sections were performing excellent after twenty-four months. They were:

- A mixture of AC-10, 5% latex rubber, and 5% polyester fibers
- An AMZ machine using HFRS-2 with 3% latex rubber placed by a contractor

The AC-10 mixture was the best crack filler and is highly recommended. AMZ machines are only recommended when there is a lot of spalling, raveling, or potholes along the length of the crack such as with this test site.

Three other sections were performing satisfactorily after twenty-four months and are also recommended as bituminous crack filling materials:

- Prismoseal A-2
- Polyfil™ Crack Sealer as done by Terry Materials
- C-23 with 5% latex rubber

Where different cover materials were used, the 6 mm limestone was rated slightly better than either sand or sawdust. It is believed that the limestone gives the filler material more body to withstand traffic abrasion and tracking.

INTRODUCTION

It is a well known fact that bituminous pavements and overlays can crack. This allows the infiltration of water and incompressibles which can lead to rapid deterioration of the pavement structure. Therefore, sealing or filling the cracks is necessary to prevent the loss of pavement life and ride quality.

The Michigan Department of Transportation has been using several different crack filling materials with varying degrees of success. It was decided that a side by side comparison was necessary to determine which materials work the best at extending pavement life and maintaining good ride quality. It was desired to find materials that could last a minimum of three years before another application or other work is required.

In 1995, an 8.7 km section of composite pavement on eastbound US-10 just east of Evart was chosen as the test site. The site, as shown in Figure 1, begins at the east end of the bridge over the Muskegon River just outside the eastern city limit of Evart.

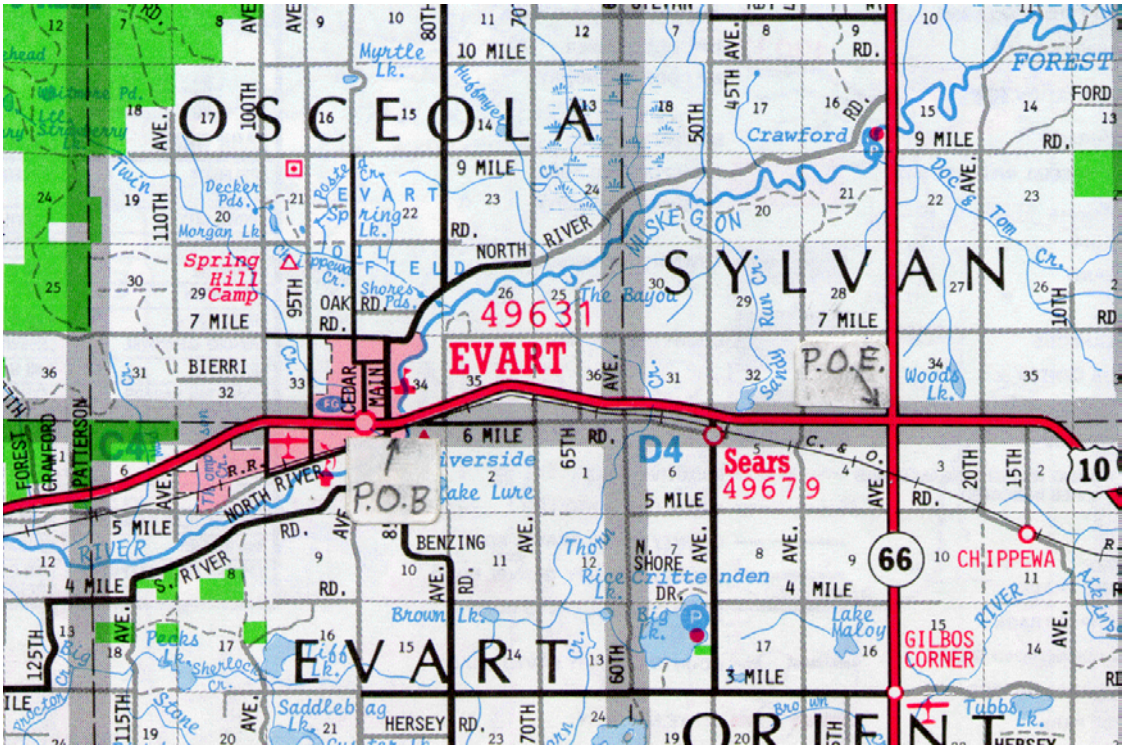

Figure 1 Location of test site.

Background

The test site is a 7.3 m wide composite pavement. The underlying concrete pavement was originally built in 1958 with the bituminous overlay placed in 1979. The ADT is 4200 vehicles with 9% of that being commercial traffic. Most of the transverse cracks have associated distress such as raveling, spalling, or potholes (See figure 2). Several transverse cracks experienced tenting from winter freeze-thaw cycles and had been bump-burned several months before crack filling (See figure 3).

Figure 2 Typical crack with associated distresses.

This pavement was older and in a worse condition than most pavements we use crack fillers on. We wanted a section of pavement that would severely test the ability of the filler materials to remain in place and keep the cracks sealed. If a material lasts during the evaluation period on this pavement, then a high confidence for successful usage would exist elsewhere in the state.

Figure 3 Typical bump burn area.

A variety of materials were chosen to be used on this test site. Most of the materials had been used at some point in Michigan. Two materials had been recently introduced to MDOT but had not yet been tried. Two of the materials could only be placed by a contractor since MDOT does not have the necessary equipment. The remainder could be done by either a contractor or MDOT maintenance crews. All the manufacturers, distributors, and contractors contacted were willing to donate their time and material to this test site.

After the materials and contractors had been chosen, a team was formed to evaluate the test sections over a period of two years. Representatives of MDOT's Maintenance, Materials & Technology, and Construction divisions were chosen. A county road commission representative was also chosen since many counties do contract crack filling on state roadways. The evaluations were by a visual rating of several properties of the crack treatment at 1, 3, 6, 9, 12, 18, and 24 months from completion.

CONSTRUCTION

Crack filling occurred between May 8 and May 18, 1995. The last material (AECF #60) was a late addition and was not placed until June 13. Each material was used to seal transverse and longitudinal cracks for three hours or 686 meters of roadway (eastbound lane only), whichever came first. The westbound lane was left alone as a control to provide a filled versus unfilled comparison. However, several months before the last evaluation, the westbound lane was crack filled adjacent to sections 8 through 11B. The 686 meters limit was used because that is the length of roadway sealed from a 208 liter barrel of the first material placed, Kold-Flo. The three-hour time limit was used so that we could get two materials placed per day.

The weather was generally good with temperatures ranging from about 7°C to 21°C. A few days were lost to rain, but no crack filling occurred on those days. Traffic control was provided throughout the operation by MDOT's Reed City maintenance garage and is not included when crew size is mentioned below. Unless specified otherwise, crack filling work was also done by the Reed City garage.

Sheets detailing the specifics (location, time, equipment, etc.) on each material, as well as pictures, can be found in the Appendix.

Test Sections 1, 1A, 1B, and 1C: Kold-Flo

Kold-Flo is manufactured by Unique Paving Materials and is described as a cold-pour, rubberized emulsion. It took two hours to fill 1172 meters of crack along 686 meters of roadway. The production rate was 586 meters of crack per hour. The operation consisted of blowing out the cracks with compressed air, pumping the material into the crack, and using a squeegee on the excess for an overband configuration. Section 1 had no cover material, 1A had silica sand, 1B had 6 mm limestone, and 1C was back to no cover material. A crew size of four was used. Filled cracks were opened to traffic in 12 to 15 minutes.

Test Sections 2 and 2A: Prismoseal A-2

Prismoseal A-2 is manufactured by Linear Dynamics and is composed of 65% asphalt cement, 19% crumb rubber, and 16% mineral filler. The contractor took three hours to fill 1292 meters of crack along 686 meters of roadway. The production rate was 431 meters of crack per hour. The operation consisted of cleaning the cracks with a hot-air lance, filling a drag bucket with material, and filling the crack with an overband configuration. The safe heating temperature for this material is 215°C. The contractor was heating it to 227°C which could affect the material's properties. Section 2A is the same as 2 but with polyester fibers mixed in. A crew size of three was used. Traffic was allowed on the roadway after 5 minutes.

Test Section 3: AMZ machine using HFRS-2

This section was done using an AMZ machine owned by MDOT's Saginaw district maintenance. An HFRS-2 emulsion manufactured by Koch was used along with Ohio #9 double washed stone. The operator took three hours to fill 520 meters of crack along 150 meters of roadway. The production rate was 173 meters of crack per hour. An AMZ machine is a specialized piece of equipment which has a hose for compressed air, emulsion, and stone all on a movable boom. Typically they are used for pothole patching. The operation consists of cleaning the crack with compressed air, filling the crack half way with emulsion, filling the remainder with a stone/emulsion mixture, and then blowing a final layer of stone on top. A crew size of two was used. Completed cracks were opened to traffic in 30 minutes.

Test Section 4: AC-10 with 5% R570 Rub-R-Road latex and 5% polyester fibers

This is a crack filling material used extensively across the state and is typically contracted out. The contractor took two hours to fill 3056 meters of crack along 430 meters of roadway. The production rate was 1528 meters of crack per hour. The contractor ran out of material, otherwise, they probably would have completed the 686 meter maximum within three hours. The operation consists of pumping the mixture from a large melting pot through a wand that has a round disk attached. The round disk acts as a squeegee that spreads the material to the desired width. A crew size of three was used. Traffic was allowed on the completed cracks after 15 minutes.

Test Section 5: AMZ machine using HFRS-2 with 3% R549 Rub-R-Road latex

This AMZ operation was done by a contractor. An HFRS-2 emulsion manufactured by Koch was used along with 6 mm limestone. 792 meters of crack was filled along 683 meters of roadway in two and a half hours. The production rate was 317 meters of crack per hour. Because an AMZ machine was developed for pothole patching, only the wider cracks with some spalling and potholes could be filled. This is why the length of cracks filled is lower than in other sections. The operation is the same as was stated in test section 3 above except a crew size of three was used.

Test Section 6: Polyfil™ CRS-2 modified(contractor)

Polyfil™ is a CRS-2 emulsion manufactured by Terry Industries. A crew from Terry Industries did the crack filling and they say that Polyfil™ is modified with a latex rubber. They filled 2679 meters of crack along 614 meters of roadway in two and a half hours. The production rate was 1071 meters of crack per hour. The material is heated to 49°C before it is pumped out through a wand and then spread with a squeegee. A 6 mm limestone was used as the cover material. A crew size of four was used. Traffic was allowed on completed cracks after 30 minutes.

Test Sections 7, 7A, and 7B: Polyfil™ CRS-2 modified (MDOT)

These sections were done by the Reed City maintenance garage. This time the Polyfil™ was not heated and was poured into the cracks using watering cans. This proved difficult because the slightest wind would blow the material away from the crack as it was being poured. This could be eliminated by bending over enough to ensure the material was entering the crack. However, a long day of bending over like this would be rough on the worker's backs and is not recommended. 964 meters of crack along 686 meters of roadway were filled in one and a half hours. The production rate was 643 meters of crack per hour. Section 7 had bank run sand as a

cover material, while 7A had sawdust, and 7B had 6 mm limestone. A crew size of six was used. The completed cracks were opened to traffic after 30 minutes.

Test Sections 8 and 8A: C-23 with 5% R563 Rub-R-Road latex

C-23 is an emulsion manufactured by R.L. & Sons Company. Crack filling was done by the Manistee County garage. They filled 1095 meters of crack along 743 meters of roadway in two and a quarter hours. The production rate was 488 meters of crack per hour. C-23 has a very slow cure time and must only be used when there will be no rain for at least twenty-four hours. Rain within twenty-four hours will wash the C-23 out of the cracks. The operation consists of pumping the C-23 through a wand, spreading with a squeegee, and applying the cover material. Section 8 had 6 mm limestone and section 8A had 2NS sand. A crew size of six was used. Completed cracks were open to traffic in 30 minutes.

Test Section 9: AMZ machine using HFRS-2

This section was done using an AMZ machine owned by MDOT's Charlotte maintenance garage. An HFRS-2 emulsion manufactured by Koch was used along with Ohio #9 double washed limestone. The operator took two and a half hours to fill 506 meters of crack along 384 meters of roadway. The production rate was 202 meters of crack per hour. The operation was the same as for test section 3. Completed cracks were opened to traffic in 30 minutes.

Test Sections 10 and 10A: HFRS-2P

This section was done by MDOT's Reed City and Marion maintenance garages using an HFRS-2P (now called HFRS-2M) manufactured by Koch. The HFRS-2 is modified with a polymer. 1145 meters of crack along 743 meters of roadway were completed in one hour and thirty minutes. The production rate was 763 meters of crack per hour. The operation uses a special truck that has a large tank mounted on the front to hold the crack filling material. The tank is pressurized so the material flows out through a wand when the valve is opened. The material is then spread with a squeegee and the cover material is applied. Section 10 had 2NS sand as the cover material and section 10A had 6 mm limestone. A crew size of six was used. Completed cracks were opened to traffic in thirty minutes.

Test Sections 11, 11A, and 11B: AECF #60

This section was a late addition to the test site. AECF #60, manufactured by Pavement Sealants Corporation, was applied on June 13 by MDOT's Reed City Maintenance Garage. 998 meters of crack along 695 meters of roadway were filled in one hour and fifteen minutes. The production rate was 798 meters of crack per hour. The operation consisted of pumping the material through a wand into the cracks, using a squeegee to spread the material, and then applying a cover material. Section 11 had sawdust as the cover material, section 11A had 2NS sand, and section 11B had 6 mm limestone. A crew size of six was used. The completed cracks were opened to traffic in thirty minutes.

Test Section 12: No treatment

This section was left untreated to serve as a control to show natural deterioration at the cracks.

EVALUATION

The evaluation team members are listed in Appendix B. This evaluation team first decided on evaluation criteria consisting of five visual characteristics properties.

- Bridging
- Abrasion
- Adhesion/Cohesion Loss
- Bleeding
- Tracking

The first three were determined to be the most important and would therefore be rated with a numerical scale. The scale is a modified Pennsylvania DOT joint sealant rating system where the characteristic is rated on a scale of 1 to 5 with 5 being the best (see Figure 4). The presence of bleeding and tracking were a yes or no answer. Each test site was to be evaluated at 1, 3, 6, 9, 12, 18, and 24 months. However, there were problems with scheduling six people to evaluate the test site at the same time, so the actual evaluations occurred at 1, 3, 7, 11, 14, and 24 months.

Each team member rated each test section on bridging, abrasion, adhesion/cohesion, and answered yes or no on bleeding and tracking. General comments were also made about special situations or the overall consensus of the team of the section. The numbers were averaged and tables of the results for each evaluation appear in the Appendix. Thirteen out of the twenty-one sections experienced some bleeding and tracking. In most cases, it had stopped by the second review, and was minor. For a few sections, the bleeding and tracking was still visible after the three and seven month evaluations. Pictures of typical filled cracks after two years of evaluation can be found in the appendix D. A discussion of each test section follows.

Test Sections 1, 1A, 1B, 1C: Kold-Flo

Kold-Flo was a poor performer throughout the evaluation. After only one month it was evident that Kold-Flo was almost nonexistent in the cracks. Despite it being a rapid setting material, this crack filler seemed to have flowed right through the pavement and provided no protection for the cracks. Type of cover material used made no difference in performance.

Test Sections 2 and 2A: Prismoseal A-2

Prismoseal A-2 performed fairly well. Ratings dropped after each winter because of an increasing amount of cohesion losses. The material is quite stiff and therefore cannot be expected to take very much movement in cold temperatures. It is expected that after one or two more winters, the cracks will be back to the same condition as before they were filled. Bleeding and tracking were not a problem with this material.

Because of its overband configuration, Prismoseal A-2 will delay the onset of raveling and spalling at the crack even when cohesion losses exist. After two years the crack filled lane is noticeably better than the untreated lane.

Test section 2A had fibers added to the material. These fibers did not help the performance of Prismoseal A-2.

Test Section 3: AMZ machine using HFRS-2

The ratings for this section were fairly good. However, it took three hours to complete 151 meters of one lane. With an AMZ process, the stone is an integral part of the repair rather than a cover material so there is more of a structural value than other filling materials. This along with the fact that it is all done with one dump truck and the AMZ machine, makes it good for pothole patching. The buildup of stone and emulsion creates an initial bump that is very noticeable as it is driven over. This bump will usually be flattened out by traffic over time to be less noticeable. Because of the ride quality concerns, AMZ machines are only recommended for crack filling on wide cracks (greater than 13 mm) and cracks with a lot of spalling and potholes.

Test Section 4: AC-10 with 5% R570 Rub-R-Road latex and 5% polyester fibers

This section performed very well. The combination of AC-10, polyester fibers, and latex rubber has been used extensively across the state with good results. After two years, the material is still in excellent condition with very little adhesion/cohesion loss. The treated lane is in much better shape than the untreated lane.

This material requires large heating kettles to be cost effective which MDOT does not have at this time. Therefore, this type of crack filler would have to be contracted out.

Test Section 5: AMZ machine using HFRS-2 with 3% R549 Rub-R-Road latex

This section also performed very well. There was some initial bleeding and tracking but it was evident that it ended between the one and three month evaluations. December 1995 ratings for this section decreased considerably but rebounded the next spring. This suggests that the filler material cannot take very much movement in colder temperatures and cracks. It then heals somewhat when it gets warmer. This could create a tenting problem if these cracks allow moisture from melting snow to penetrate and freeze.

After two years, there are a few signs of the cracks starting to come through (cohesion loss). MDOT does have AMZ machines, but the contractor in this section had a much higher production rate than the two MDOT garages from test sections 3 and 9.

The use of AMZ machines is only recommended on wide cracks with a lot of associated spalling and potholes and where little crack movement is expected.

Test Section 6: Polyfil™ CRS-2 modified(contractor)

This section performed well. Some initial bleeding and tracking were noted after one month. Ratings dropped during the first winter but improved the following spring suggesting that the material healed during warmer weather. After the first winter and through the second winter the

ratings were very consistent. There is some improvement over the unsealed lane. Based on its condition after two years, heated Polyfil™ is recommended as a crack fill material.

Test Sections 7, 7A, and 7B: Polyfil™ CRS-2 modified (MDOT)

The material in these sections was put down at ambient temperatures as opposed to 50°C in the previous section. The filling was also done by MDOT crews using watering cans, whereas section 6 was done by a contractor using a pump and wand. There was some bleeding and tracking in the first month. From the beginning, sections 7 and 7A performed poorly. There is little to no improvement over the unsealed lane. Section 7B, which had 6 mm limestone cover, performed very well at first but tailed off after two years. The difference between section 6 and sections 7, 7A, and 7B could be due to the temperature of the material, the cover material, or the system of delivering the material to the cracks. For now, Polyfil™ is recommended as a crack filler only when it is heated to the manufacturer's specifications and placed with a limestone cover.

Test Sections 8 and 8A: C-23 with 5% R563 Rub-R-Road latex

These sections performed fairly well. C-23 with latex additive has been used quite a bit in the northern portion of the lower peninsula. Some bleeding and tracking occurred in the first month. During the first winter, both section's ratings dropped due to some cohesion losses. However, the ratings improved once warmer weather arrived, in effect healing itself to some degree. Section 8 with limestone cover performed slightly better than section 8A with sand cover. The other lane had been sealed just before the last evaluation, so a comparison between sealed and unsealed could not be made. C-23 is recommended as a crack filler. Limestone cover should be used except in situations where dust is a concern.

Test Section 9: AMZ machine using HFRS-2

This section was not performing well after two years. The cracks have essentially come back through. The other lane that was sealed just before the last evaluation looks better. It is not known why this section did so poorly compared with sections 3 and 5.

Test Sections 10 and 10A: HFRS-2P

These sections did not perform very well. Some bleeding and tracking occurred within the first month. Initial ratings were good until they dropped off during the winter when a lot of the cracks reappeared through the material. Ratings improved slightly during the summer but dropped off significantly after the second winter. Section 10A with limestone cover looked slightly better than section 10, which had a sand cover. This is the same type of material used in the AMZ machines. It does not seem to work as well with the stone on top instead of intermixed like with the AMZ. These sections do not look as good as the recently sealed other lane. This material is not recommended when it is used as a stand alone crack filler (not mixed with stone).

Test Sections 11, 11A, and 11B: AECF #60

These sections performed very poorly. Some bleeding and tracking were present after the first month. It did not take long for the cracks to reappear through this material. Ratings dropped

significantly after the first winter and stayed constant for the remainder of the two years. The type of cover material made little difference. This material is not recommended as a crack filler.

Test Section 12: No treatment

This section was not rated but was looked at after each evaluation. It is believed that this section was actually in slightly better shape than the other sections, at the beginning of this study. This could be due to the section being at a higher elevation than the rest of the sections, leading to better drainage and lower deterioration rates. It did, however, show some pavement deterioration over the two years with cracks spalling and getting worse.

Crack Filler Rating Levels

Rating	Degree	Description
	Bridging	
5	None	Crack filling material is intact and in the condition as constructed.
4	Slight	Crack filling material is exhibiting cupping or lipping in less than 25% of the applied area.
3	Moderate	Crack filling materials is exhibiting cupping or lipping in less than 50% of the applied area.
2	Severe	Crack filling materials is exhibiting cupping or lipping in less than 75% of the applied area.
1	Deteriorated	Crack filling material is exhibiting cupping or lipping in more than 75% of the applied area.
	Abrasion	
5	None	Crack filling material is intact and in the condition as constructed.
4	Slight	Crack filling material is exhibiting distinct wearing and loss of surface in less than 25% of the applied area.
3	Moderate	Crack filling materials is exhibiting distinct wearing and loss of surface in less than 50% of the applied area.
2	Severe	Crack filling materials is exhibiting distinct wearing and loss of surface in less than 75% of the applied area.
1	Deteriorated	Crack filling material is exhibiting distinct wearing and loss of surface in more than 75% of the applied area.
	Adhesion/Cohesion	
5	None	Crack filling material is intact and in the condition as constructed.
4	Slight	Crack filling material is exhibiting a loss of adhesion and/or cohesion in less than 25% of the applied area.
3	Moderate	Crack filling materials is exhibiting a loss of adhesion and/or cohesion in less than 50% of the applied area.
2	Severe	Crack filling materials is exhibiting a loss of adhesion and/or cohesion in less than 75% of the applied area.
1	Deteriorated	Crack filling material is exhibiting a loss of adhesion and/or cohesion in more than 75% of the applied area.

Figure 4
Rating System for Crack Filler Materials

Conclusions and Recommendations

Based on the pavement condition in this test site after two years, we can conclude that we have found several materials that can slow the deterioration of the cracks and, thereby, extend the pavement life. This is based on the fact that the sections continuing these passing materials showed less crack deterioration than the untreated section. It is estimated that these materials can add three to five years to the life of the pavement.

Two sections were performing excellent after twenty-four months. They were:

- A mixture of AC-10, 5% latex rubber, and 5% polyester fibers
- An AMZ machine using HFRS-2 with 3% latex rubber placed by a contractor

The AC-10 mixture seemed to be the best crack filler and is highly recommended. AMZ machines are only recommended when there is a lot of spalling, raveling, or potholes along the length of the crack such as with this test site.

Three other sections were performing satisfactorily after twenty-four months and are also recommended as bituminous crack filling materials:

- Prismoseal A-2
- Polyfil™ Crack Sealer as done by Terry Materials
- C-23 with 5% latex rubber

Where different cover materials were used, the 6 mm limestone was rated slightly better than either sand or sawdust. The limestone appears to give the filler material more *body* to withstand traffic abrasion and tracking. However, this *body* only helps when you have cracks that are wide open or have a lot of raveling and spalling, which was the case with this test site. When the cracks are narrow and in good shape the *body* tends to be more of a bump in the pavement that reduces ride quality.

The following recommendations are also made:

- Where dust is a concern, such as in towns, use sand or sawdust as the cover material, not limestone.
- Polyfil™ should be heated to approximately 50°C before applying.
- Use a system that delivers the material directly to the crack. Do not use watering cans or the like to fill by hand.
- Keep the width of the band of material on top of the pavement, particularly the AC-10 mixture, narrow (50 mm to 75 mm).

APPENDIX A

TEST SECTION CONSTRUCTION INFORMATION

APPENDIX B

EVALUATION TEAM

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APPENDIX C

EVALUATIONS

APPENDIX D

PHOTOGRAPHS