DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

CEMP-ET

ETL 1110-1-125

Technical Letter
No. 1110-1-125

4 May 1984

Engineering and Design
GUIDANCE FOR FUEL RESISTANT SEALERS FOR PAVEMENT

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GUIDANCE FOR FUEL RESISTANT SEALERS FOR PAVEMENTS

1. Purpose. This letter furnishes guidance on use of fuel resistant sealers for bituminous concrete pavements.

2. Applicability. This letter applies to all HQUSACE/OCE elements and all field operating activities having Military Construction design responsibility.

3. Discussion.

a. In addition to the rubberized-tar slurry seals recommended for fuel resistant surfacings in Para 9.6 of TM 5-825-2 other materials are now on the market. Some of these materials have been evaluated by WES and test results and conclusions are contained in the Draft Report "Fuel Resistant Sealers" (Incl 1).

b. Some of the numerous materials marketed as fuel resistant sealers are costly (approximately $20/gal) and others are relatively inexpensive (approximately $2/gal). Experience has shown that some perform satisfactorily and others do not. The initial least/first cost of sealers is not always a good measure of the cost since some of the less costly perform for a short time while the more expensive may perform for extended periods (several years).

c. The Waterways Experiment Station has developed a test procedure (Incl 2) for evaluating the quality of fuel resistant sealers in the laboratory. This procedure involves dripping fuel on the sealed asphaltic concrete surface, conducting an abrasion test and evaluating the damage. This test procedure evaluates the effects of fuel and traffic but it does not evaluate long term performance as affected by changes of sealer properties with time and temperature.

4. Action To Be Taken. Use of sealer materials now available should be based on conformance with laboratory test performance developed by WES, lowest life cycle costs, satisfactory application according to manufacturer's specification and satisfactory performance records. Materials not meeting these requirements should not be selected for use.

5. Implementation. This letter will have routine application for Military Construction as defined in Para 6c, ER 1110-345-100.

FOR THE COMMANDER:

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as

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Chief, Engineering Division
Directorate of Engineering & Construction

# FUEL RESISTANT SEALERS

## PART I: INTRODUCTION

### Background

1. A large number of asphalt concrete pavements are damaged each year due to the spillage of fuel onto these pavements. The fuel softens the asphalt binder and causes the asphalt concrete mixture to disintegrate and erode under traffic. Of prime concern is JP-4 fuel.

2. In order to prevent this damage due to fuel spillage, other pavement surfacings such as portland cement concrete (PCC) must be used or some technique to protect the asphalt concrete from fuel spillage must be provided. PCC pavements generally are more expensive; therefore, the use of bituminous pavements is desirable. In the past, tar and tar-rubber concrete pavements were used in fuel spillage areas; however, poor performance resulted in their use being discontinued. Also, the manufacture of tar-rubber has become increasingly difficult due to restrictions by the Occupational Safety and Health Administration (OSHA)

3. The use of fuel resistant sealers to protect the asphalt concrete from the adverse effects of fuel spillage is a desirable technique. These sealers are simple to apply and their use is more cost-effective than the previously mentioned options. Many sealers are on the market but few claim to be jet fuel resistant, and most lack documented information concerning their field performance.

### Objective

4. The objective of this study was to determine by laboratory tests the adequacy of a number of sealers to protect asphalt concrete mixtures from the adverse effects of fuel spillage (jet fuel) and to exterpolate this data to predict field performance.

### Scope

5. A number of companies were contacted and requested to furnish potential fuel resistant sealers for this study. These sealers were evaluated through a laboratory testing program to determine potential performance under fuel spillage conditions. The laboratory evaluation consisted of dripping fuel (Reference Fuel B, paragraph 13) on asphalt

concrete specimens that had been sealed, conducting an abrasion test to identify damaged specimens, and determining the weight loss after the abrasion test.

## PART II: PRODUCTS

6. The materials used for this project were selected from a previous study which evaluated the use of fuel resistant sealers or binders for porous friction courses (Shoenberger, 1983). The materials selected had generally shown good performance in this previous study. A description of each of the materials selected is provided in Table 1. The overall evaluation of the materials investigated included material cost, laboratory performance when subjected to fuel spillage, and ease of preparing laboratory specimens.

7. The cost of materials varied from approximately $1.00 to $19.00 per gallon (Table 2). For these costs to be meaningful, the application rate to protect an asphalt pavement from spillage and the expected life of the sealer would have to be determined. In other words, the material that cost $19.00 per gallon may be cheaper for a life cycle cost than the material that cost $1.00 per gallon.

8. There are many other materials available for use as jet fuel resistant sealers; however, it was felt that the ones selected are typical of most types of sealers.

## PART III: LABORATORY TESTING

9. A laboratory testing program was conducted to evaluate each of the seven products. Dense graded mixtures were prepared in the laboratory, sealed with each of the products being evaluated, and tested for effects of fuel spillage and abrasion. Table 1 contains a list and description of all products tested.

10. The asphalt concrete cores upon which the sealers were applied consisted of a bituminous wearing course mixture compacted in the

laboratory to approximately the expected field density. The cores were 6 $\pm$ 0.1 in. (50.8 $\pm$ 2.5 mm) in diameter and approximately 2 in. (5.1 mm) in height.

11. The asphalt cores were sealed on the side, top, and bottom. The materials were evenly applied to the test specimens with a 1.5-in, nylon brush. The specimens were initially sealed on all but the bottom and allowed to dry to a nontacky state. Then after inverting the specimen, the remaining side was sealed and this side became the test surface for all tests.

12. The curing time required was dependent upon the type of material used and was based on manufacturers' recommendations. An initial set (nontacky) was obtained within 24 hours at room temperature in all cases. The chem-crete, RT-14 and sulflex sealed specimens, although considered to be cured (nontacky) after 24 hours, were easily marked by fingerprints, etc. and hardened slowly for several days. Sulflex hardened at the slowest rate of all materials.

13. After the specimens were cured, they were subjected to a fuel drip test. In approximately 10 minutes, 1000 ml of reference Fuel B 70% Iso-octane + 30% toluene by volume), under a constant 5 psi pressure head, was dripped on each specimen tested. This fuel covered the entire specimen surface for the required time. The specimens were rotated 90 degrees every 2-1/2 minutes to help assure uniform coverage of fuel over the specimen surface. The specimens were placed on a wire mesh for the fuel tests to prevent the fuel from accumulating on the bottom of the specimen.

14. The abrasion test was run on all specimens within 5 minutes of completion of the fuel drip test. The abrasion test is an adaptation of the "wet track abrasion test", ASTM D 3910 (ASTM 1982). Two changes required to this method included shortening the abrasion hose from 5.0 in. to 1.5 in. and increasing the depth of the metal pan from 2.0 in. to 2.5 in. The shorter hose was required for use with the 6-in, specimens and the depth increase was to allow the specimens to be completely submerged in water. At the completion of the abrasion test, the specimens were allowed to dry to a constant weight or for 24 hours, whichever was shorter. This weight is recorded along with noting any loss of aggregate particles from the specimens. Whenever the material takes longer than 24 hours to obtain a constant weight, this signifies that fuel or water has penetrated the sealer. The two possible causes of fuel penetration are: (a) the specimen is not completely sealed, or (b) the fuel has softened the sealer and penetrated the specimen.

## PART IV: LABORATORY TEST RESULTS

15. The products tested covered several material types and varied greatly in effectiveness. The material was difficult to apply with a brush when the materials required heating before application. When heating was necessary, this generally required that a thick layer of sealer be applied to the asphalt concrete sample.

16. No. 21 epoxy is a two-part coal tar epoxy. As suggested by the Manufacturer, the mix ratio for laboratory testing was 1 part binder to 1 part activator by weight. The sealed specimen was subjected to two cycles of fuel dripping and abrasion. The specimen showed no distress during the fuel drip and abrasion tests and there was essentially no weight loss from the tests (Table 2).

17. Chem-Crete coal tar is a RT-12 tar modified by the Chem-Crete Corporation. This material could not be properly applied to the specimen cores with the brush. It was heated to 210$^0$F, but when it was applied by the brush it cooled quickly and could not be thinly spread which resulted in a thick coating. Then Chem-Crete coal tar did not bind to the specimen and could be easily be peeled from it. After the specimen was subjected to one cycle of fuel and abrasion, there was no visual damage to the specimen. There were several places where the sealer had broken away from the asphalt core and fuel could penetrate into the asphalt mix. The specimen developed hairline cracks over its entire surface once it had dried following the fuel drip and abrasion test. After testing, this material was considered unsatisfactory as a fuel resistant sealer.

18. Koppers coal tar emulsion (non-winterized) was applied full strength to a specimen. The intial fuel test did little damage, although the specimen which was originally black turned a brownish color. During the initial abrasion test, a small amount of the sealer was removed from the abraded surface. Five days later, a second fuel and abrasion test was conducted on the same specimen. The specimen failed in this second cycle of tests. There was a loss of asphalt and aggregate from the area of the specimen where the abrasion test was conducted. A soft spot also developed in the bottom of the specimen where fuel apparently entered and leached out asphalt from the core.

19. Koppers coal tar emulsion (winterized, contains antifreeze) was applied to a specimen after being diluted with an equal amount of water. The specimen which was cured for 24 hours before testing failed after one cycle of fuel and abrasion. During the fuel drip test, the fuel appeared to dissolve and remove a large amount of sealer and/or asphalt. Abrasion removed a small amount of aggregate and left a rough

exposed surface where the abrasion occurred.

20. Koppers coal tar super seal emulsion was applied undiluted to a specimen in four coats over two days time to obtain the desired sealer thickness. This coal tar emulsion contains 3 percent rubber by weight of coal tar. The specimen was subjected to two cycles of fuel and abrasion. The amount of material removed during the fuel tests was minimal. The abrasion tests did little damage to the surface of the specimen.

21. Koppers RT-14 is a paving grade road tar. The material was heated to 225°F (107.2°C) for application to the specimen. This material which acted similar to the Chem-Crete coal tar could not be properly applied to the asphalt cores. The applied coating was too thick and the material did not adhere satisfactorily to the specimen. The specimen was subjected to one cycle of the fuel and abrasion tests with no visible damage occurring to the sample. This material was considered unsatisfactory as a sealer because it would not properly coat the asphalt mix.

22. Sulflex 233 is a plasticized sulfer material. Difficulty was encountered in sealing the core specimen with the Sulflex as observed with the Chem-Crete coal tar and Koppers PT-14. The Sulflex was heated to 280°F (137.8°C) for application to the specimen. A heavy coating of the material had to be applied and it hardened very slowly, remaining soft to the touch up to 48 hours after application. The material was tested 24 hours after application by one cycle of fuel and abrasion. The tests performed had no apparent effect on the specimen. This material was considered unsatisfactory as a sealer; however, because of difficulty in coating the specimen.

23. An unsealed specimen core had a fuel drip test performed on it as a comparison to the sealed specimen. The fuel leached out the asphalt binder during the fuel drip test and the sample disintegrated prior to conducting the abrasion test.

## PART V: FIELD APPLICATIONS

24. Although no tests were conducted in the field to verify the laboratory test results, a brief discussion of expected performance is presented.

25. All of the materials investigated with the exception of No. 21 epoxy can be applied with a conventional asphalt distributor. There are distributors available that can apply epoxies. This equipment must have a chamber for each of the two components and be designed to mix the components in the proper proportion when spraying.

26. Based on laboratory test results three of the materials investigated (Chem-Crete tar, Koppers RT-14, and Sulflex) would be difficult to properly apply in the field. These materials must be heated to relatively high temperatures in order to properly spray and when these materials are sprayed onto the pavement, they cool quickly and do not evenly cover the pavement surface. Even though these materials are fuel resistant, they cannot be used as a sealer.

27. The four materials investigated that can be properly sprayed onto the pavement surface are the three tar emulsions and Product No. 21. The winterized coal tar emulsion which was diluted before application to the asphalt core did not perform satisfactory in the laboratory. It is believed however that a thicker application of this material could result in improved performance. Until further laboratory tests are conducted, it is not recommended for field testing.

28. This study did not evaluate the durability of the various materials; however, from a resistance to fuel point of view, the product No. 21 clearly outperformed the other materials. Based on this limited laboratory study, it appears that the use of tar emulsion sealer would require more applications than Product 21 throughout the life of a pavement.

29. Regardless of what material is used, it is necessary that an asphalt pavement which is going to be subjected to fuel spillage be

sealed with a fuel resistant material prior to fuel spills. Once the damage to the asphalt mixture has occurred, a sealer helps very little, unless the asphalt mixture is still structurally sound and is properly cleaned before sealing.

## PART VI: CONCLUSIONS

30. The Product No. 21 performed very well in the laboratory and should provide satisfactory performance in the field.

31. Tar emulsion resisted the effects of fuel to some extent; however, the fuel gradually dissolved the tar. Those materials which are relatively inexpensive (approximately $1.00/gallon) may be used; however, periodic applications would be required.

32. RT-14, Chem-Crete tar, and Sulflex are fuel resistant; however, spraying and handling techniques make them impractical for use as a fuel resistant sealer.

## PART VII: RECOMMENDATIONS

33. There is a need to evaluate fuel resistant sealers in the field so that cost and performance data for various materials can be analyzed to determine which sealers would provide the most cost-effective solution to the fuel spillage problem on asphalt concrete pavements.

34. This will be accomplished as part of the Facilities Technology Applications Test Program that will commence in FY 84.

# REFERENCES

1. Shoenberger, J. E., 1983, "Fuel Resistant Porous Friction Surface," unpublished report, USAE Waterways Experiment Station, CE, Vicksburg, Miss.

2. ASTM, 1982, "Standard Practices for Design, Testing, and Construction of Slurry Seal," Designation D 3910-80a, 1982 Annual Book of ASTM Standards, Part 15, Philadelphia, Penn.

Table 1

**Products Tested as Fuel Resistant Pavement Sealers**

| Product | Manufacturer | Material | Mixture | Application rate Gal/yd$^2$ | Price per Gallon | † Approximate Price per Square Yard |
|---|---|---|---|---|---|---|
| No. 21 epoxy | American Protective Coating Corp. Cleveland, Ohio | Coal gar epoxy | *1 part binder to 2 parts activator | 0.1 | $18.52 | $1.85 |
| Tar | Chem-Crete Corp. | Tar | None required | 0.2 | >$ 2.00 | $ .40 |
| Coal tar emulsion (non-winterized) | Koppers Inc. Pittsburgh, PA | Coal tar emulsion | No water added | (.1 to .3) 0.2 | $ .92 | $ .18 |
| Coal tar emulsion (winterized) | Koppers, Inc. Pittsburgh, PA | Coal tar emulsion | 1 part emulsion to 1 part water | 0.4 | $ .92 | $ .18 |
| Super Seal coal tar emulsion | Koppers Inc. Pittsburgh, PA | Coal tar emulsion with rubber | No water added | 0.2 | $ .95 | $ .19 |
| RT-14 | Koppers Inc. Pittsburgh, PA | Tar | None required | 0.2 | >$ 2.00 | $ .40 |
| Sulflex 233 | Southwest Research Institute, San Antonio, Texas | Plasticized Sulfer | None required | 0.2 | ** | |

* The manufacturer now suggests a 1 to 1 mixture.
** No price available but probably $3.00 to $4.00 per gallon.
† These price estimates are not directly comparable due to unknowns concerning the life of the sealers.

Table 2

Fuel Resistant Pavement Sealers

| Product | Original Weight of Sample | Weight After Sealing | Weight of Material Applied | Weight After First Cycle | Weight After Second Cycle | Remarks |
|---|---|---|---|---|---|---|
| No. 21 Exoxy | 2257.8 | 2273.0 | 15.2 | 2273.2 | 2272.8 | Specimen received two fuel drip tests before first abrasion test. |
| Chem-Crete** processed coal tar | 2250.2 | -- | -- | -- | -- | Weight not recorded; fuel penetrated specimen where sealer separated from core. |
| Koppers coal tar emulsion (non-winterized) | 2247.8 | 2259.2 | 11.4 | 2258.2 | 2191.0 | Some material removed by abrasion head. |
| Koppers coal tar emulsion (winterized) | 2271.0 | 2282.6 | 11.6 | 2196.8 | -- | Failed after one cycle. |
| Koppers* coal tar super seal emulsion | 2256.5 | 2288.2 | 26.3 | -- | 2294.1 | Applied in four coats; test surface marked or indented by abrasion head. |
| RT-14** | 2234.8 | 2325.3 | 90.5 | 2325.6 | -- | No apparent damage to specimen after testing. |
| Su flex 2≥≥** | 2244.8 | 2342.9 | 98.1 | -- | -- | Weight not recorded; fuel penetrated specimen where sealer separated from core. |
| Untreated specimen | 2225.5 | -- | -- | Failed | | During abrasion test aggregate dislodged from surface and test ended. |

* Contains 5 percent rubber by weight of coal tar.

** These products had to be heated for application. The application technique used (brushing prevented a satisfactory sealing of the specimens, except by obtaining extremely thick coatings.

# TEST PROCEDURE FOR EVALUATING THE QUALITY OF FUEL RESISTANT SEALERS IN THE LABORATORY

## 1. SAMPLING AND TESTING:

1.1 Sampling: The samples obtained for laboratory testing shall be representative of the material to be used for construction. These samples shall be stored in clean, airtight containers and maintained in a dry environment within a temperature range of 40°F to 120°F. The samples shall be furnished to the testing laboratory at least 30 days prior to planned use.

1.2 Test Methods:

1.2.1 Test Specimens: Test specimens shall consist of PCC concrete base cylinders with a one inch compacted AC cap.

The base cylinder shall be prepared utilizing PCC concrete. Each cylinder shall be 5.95 ± 0.05 inches in diameter with a thickness of 2 ± 0.1 inches. A 6-inch concrete core provides an excellent source for the base cylinders.

AC caps of one inch thickness shall be constructed on the concrete base cylinders. Compaction of the AC caps is accomplished with 10 revolutions of a gyratory compactor (ASTM D 3387) with a one-degree angle of gyration and a 200-psi foot pressure setting of the machine.

The AC specimen cap shall conform to the job mix formula as to gradation and optimum asphalt content. AC 20 asphalt may be used where the type to be used is uncertain.

The controlling criteria for the amount of coating material applied will be based on the manufacturer*s recommendation.

After the AC cap to be coated is prepared, the material shall be applied with a brush or sprayed when applicable. Care must be exercised to assure uniform and complete coverage. The test method requires coating the top of the AC and completely covering the sides of the specimens. The final weight of the sealed specimens shall be recorded after the coating dries.

The temperature of all test specimens at the time of testing and during cure periods shall be maintained within a temperature range of 70°F ± 10°. The time required for a complete cure will depend on the type of material used and should be based on the manufacturer*s recommendations. An initial set shall be obtainable within 4 to 24 hours, and the material shall be rejected if it remains tacky after 24 hours. The specimens shall be maintained in a dry environment when not being tested.

1.2.2 Fuel-Drip Test:

The AC core sample is placed under a dripping flow of 1000 ml of fuel contained under 5 ± 0.5 pounds per square inch (psi) of pressure for 10 ± 0.5 minutes.

A container of any convenient size shall be used, provided it can hold a minimum of 1000 ml of Reference Fuel B. This container shall be capable of being pressurized at a constant 5 ± 0.5 psi and possess valving capable of being calibrated to deliver 1000 ml in 10 ± 0.5 minutes. The discharge on this container shall be capable of dripping the fuel to evenly cover the entire core surface for the required time.

The balance shall be capable of weighing 5000 grams to within ±1.0 grams.

The fuel used in the fuel-drip test shall be Reference Fuel B (70 percent isooctane plus 30 percent toluene, industrial grade) (ASTM 0 471).

A wire mesh or screen shall be used, on which the sample is placed, to allow drainage of fuel away from the sample.

Utilizing the container described above, apply to a sample within 10 ± 0.5 minutes 1000 ml of fuel contained under 5 ± 0.5 psi of pressure. The sample shall be rotated 90 degrees every 2.5 minutes to assure equal fuel coverage to the sample.

Afterward, test the sample by abrasion within 30 ± 1 minutes of completion of the fuel-drip test.

Record any visible damage or loss of AC aggregate from the specimen.[1]

1.2.3 Abrasion Test: The specimens shall be tested by abrasion using an adaptation of the “Wet Track Abrasion Test,” ASTM 0 3910. The following test method contains sections of ASTM D 3910 either copied verbatim, adapted to this test method, or completely eliminated.

The specimen is abraded at the temperature requirements given in Section 1.2.1. After abrasion, the specimen is dried to a constant weight as specified, and the weight is recorded.

[1] When a specimen loses pieces of aggregate during the fuel test, the abrasion test may be waived and the product failed when approximately 10 percent or more of the AC aggregate is lost.

A balance capable of weighing 5000 grams to within ± 1 .0 grams shall be used.

The Planetary Type Mechanical Stirrer[2] (such as the Hobart C-100 made by Hobart Mfg. Co., Troy, Ohio) shall be equipped with a (5-pound) weighted rubber hose holding device (abrasion head) with approximately ½ inch free up-and-down movement in the shaft sleeve.

A heavy (1/8-inch) flat-bottom metal pan shall be selected that is approximately 13 inches in diameter with 2-inch vertical side walls (20-gage or heavier) having four equispaced screw clamps capable of securing the 11 1/4-inch-diameter specimen holders to the bottom of the pan.

A specimen holder constructed with polymethylmethacrylate (PMMA) shall hold the specimens securely in the metal pan. The device is 1/4 inch in thickness with an outside diameter of 11 inches and an inside diameter of 6.1 ± 0.1 inches to be centered under the rotating head of the mechanical stirrer when the pan is attached to it. This device shall be capable of holding the samples immpbile during the abrasion test.

Reinforced rubber hose[3] (two braid, 300 psi, green oil-resistant cover), with a 3/4-inch inside diameter and 1-7/32 inch outside diameter, shall be cut into 1-1/2-inch lengths.

Wooden prop block or equivalent is required for supporting the platform assembly into position during testing.

Place the sample in the holder and secure it in the large pan by the provided fasteners. Add water at room temperature to cover the sample by at least 1/4-inch.

Secure the pan containing the specimen on the platform of the device. Lock the rubber hose abrasion head on the shaft of the Hobart maching. Elevate the platform until the rubber hose fully contacts the sample with the total weight of the head on the surface of the specimen. Use the prop block to support the platform assembly during testing.

Switch to the low speed of the machine (approximately 144 shaft rpm at 61 turns of the planetary). Operate the machine for 5 minutes ± 2 seconds running time.[4]

Remove the specimen and rinse it thoroughly with water to remove all loose debris. Then place the specimen in a clean, dry area and allow it to dry to a constant weight.

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[2] The Hobart C-100 stirrer, available from Hobart Manufacturing Co., World Headquarters, Troy, Ohio 45374, has been found suitable.

[3] The Uniroyal P-290 general purpose air hose, available from Uniroyal, Inc., P. 0. Box 1126, Wall Street Station, New York, NY 10005, has been found suitable.

Record the final weight of the specimen after abrasion noting any loss of aggregate particles from the specimen.

## 2. ACCEPTANCE OF PRODUCT:

### 2.1 Fuel and Abrasion Resistance:

2.1.1 The product shall be rejected if at any time during the fuel /abraision tests there is a weight loss (loss of aggregate/coating material) from any of the specimens which exceeds the weight of the coating originally applied. If this weight loss is exceeded on one of the three AC specimens, the product shall be retested.

[4] Install a fresh section of hose after completion of eash test to prevent any material buildup on the base. It is allowable to rotate the hose one-half turn after one test so that two tests can be conducted with each piece of hose.