DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

21 DEC 2011

FROM: HQ AFCESA/CEO
139 Barnes Drive, Suite 1
Tyndall AFB FL 32403-5319

SUBJECT: **Engineering Technical Letter (ETL) 11-26: Using Asphalt Surface Treatments as Preventive Maintenance on Asphalt Airfield Pavements**

1. Purpose. This ETL provides guidance for using asphalt surface treatments on asphalt airfield pavements on U.S. Air Force installations. Asphalt surface treatments include spray-applied materials and materials applied using a mixing unit and spreader box. Spray-applied sealers include liquid-only (fog seals) as well as liquid and sand mixtures. Microsurfacing and slurry seals are applied using a mixing unit and spreader box.

2. Application. This ETL is intended for use by all Department of Defense (DOD) organizations responsible for airfield maintenance and repair. Guidance is provided for using asphalt surface treatments as preventive maintenance for environmental deterioration of asphalt concrete airfield pavements. This ETL does not address fuel-resistant sealers, rejuvenating agents, or sealers using uncoated aggregate. Some asphalt pavements subject to fuel spills should be treated with a fuel-resistant sealer. Unified Facilities Guide Specification (UFGS) 32 12 37, *Fuel-Resistant (Coal Tar) Sealer*, provides guidance for using fuel-resistant sealers. Additionally, significantly aged pavements may benefit from rejuvenating agents. Guidance for rejuvenators is given in UFGS 32 01 22, *Bituminous Rejuvenation*. Sealers that use uncoated aggregate tend to produce foreign object debris (FOD) and therefore are not recommended for preventive maintenance measures on airfield pavements.

2.1. Authority: Air Force policy directive (AFPD) 32-10, *Air Force Installations and Facilities*.

2.2. Effective Date: Immediately. Current testing of asphalt surface treatments will provide further guidance on material property requirements and application procedures.

2.3. Intended Users:

- Major command (MAJCOM) pavement engineers.
- Base civil engineers (BCE).
- U.S. Army Corps of Engineers (USACE) and Naval Facilities Engineering Command (NAVFAC) offices responsible for design and construction of airfields.
- Army, Navy, and Marine Corps units, construction contractors, and any other organizations performing DOD airfield construction and maintenance.

2.4. Coordination: MAJCOM pavement engineers.

3. References.

3.1. DOD (http://www.wbdg.org/ccb/browse_org.php?o=70):

- UFGS 32 01 22, *Bituminous Rejuvenation*
- UFGS 32 12 37, *Fuel-Resistant (Coal Tar) Sealer*

3.2. Federal Aviation Administration (FAA):

- FAA Advisory Circular (AC) 150/5320-12C, *Measurement, Construction, and Maintenance of Skid-Resistant Airport Surfaces*, http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/MainFrame?OpenFrameSet&CFID=56957&CFTOKEN=71066012&CFID=1409204&CFTOKEN=89169026&CFID=10991906&CFTOKEN=40774853

3.3. American Society for Testing and Materials (ASTM) (http://www.astm.org/):

- ASTM C88, *Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate*
- ASTM C131, *Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine*
- ASTM D977, *Standard Specification for Emulsified Asphalt*
- ASTM D2419, *Standard Test Method for Sand Equivalent Value for Soils and Fine Aggregate*

3.4. American Association of State Highway and Transportation Officials (AASHTO) (http://www.transportation.org/):

- AASHTO T96, *Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine*
- AASHTO T104, *Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate*
- AASHTO T176, *Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test*

3.5. International Slurry Seal Association (ISSA) (http://www.slurry.org/):

- ISSA A-105, *Recommended Performance Guidelines for Emulsified Asphalt Slurry Seal*, 2010
- ISSA A-143, *Recommended Performance Guidelines for Micro-Surfacing*, 2010

3.6. Foundation for Pavement Preservation (FP^2) (http://www.fp2.org/):

- Hicks, R.G., Seeds, S.B., and Peshkin, P.G, *Selecting a Preventive Maintenance Treatment for Flexible Pavements*, 2000

4. Acronyms:

AASHTO	- American Association of State Highway and Transportation Officials
ASTM	- American Society for Testing and Materials
DOD	- Department of Defense
ETL	- Engineering Technical Letter
FAA AC	- Federal Aviation Administration Advisory Circular
FOD	- foreign object damage/debris
ISSA	- International Slurry Seal Association
lb/yd^2	- pound per square yard
MAJCOM	- major command
MSDS	- Material Safety Data Sheet
UFGS	- Unified Facilities Guide Specification

5. Recommendations for Using Surface Treatments. There is little specific guidance for determining the types of surface treatments to be used and frequency of application for optimum performance. Surface treatments, when used correctly, prolong pavement service life but the increase is difficult to quantify. Based on experiences within and outside DOD, the following recommendations for using asphalt pavement surface treatments are provided.

5.1. Surface treatments are proven to extend the service life of asphalt concrete pavements and should be considered as a routine preventive maintenance alternative.

5.2. While this ETL provides guidance for determining when to apply, when not to apply, and intervals for reapplying surface treatments, the pavement's condition should serve as the primary determining factor when opting to apply or determining when to apply surface treatments. Applying surface treatments should not follow pre-established intervals without taking the pavement's condition into consideration.

5.3. Bases can choose to use preventive measures for maintaining existing airfield asphalt pavements (except for runways) by using the following guidance. Surface treatments should be considered for use when non-load-associated surface distresses such as non-structural cracking or raveling first begin. The recommended sealer process, once non-structural cracking and/or raveling is first observed, is a fog seal (except for runways). Application of the fog seal should continue on an approximately three-year cycle, depending on pavement condition, as long as surface friction is maintained and texture depth is at least 0.03 inch (0.08 millimeter) when tested according to the grease smear test (FAA AC 150/5320-12C, *Measurement, Construction, and Maintenance of Skid-Resistant Airport Surfaces).* Once low- to medium-severity raveling or low- to medium-severity non-load-associated cracking occurs then a slurry seal or microsurfacing should be considered (except on runways). In traffic areas, microsurfacing or slurry seals should be used a maximum of two times between overlays and should be considered on five- to seven-year cycles.

5.4. As a general rule, surface treatments should not be placed on asphalt concrete pavements during the first year of service.

5.5. Once a slurry seal or microsurfacing has been applied, fog seals should no longer be considered for use.

5.6. Typically, slurry seals should not be used on airfield pavements where frequent ice/snow removal occurs. Ice/snow removal equipment can potentially tear the slurry from the underlying pavement.

5.7. Surface treatments discussed in this ETL should not be used in areas prone to fuel spillage. Alternative fuel-resistant sealers are appropriate for these areas.

5.8. The use of surface treatments does not negate the need for routine crack sealing. Crack sealing is an additional maintenance procedure required to extend the life of asphalt concrete pavements. Using a slurry seal or microsurfacing results in smaller cracks being sealed but larger cracks will likely continue to need sealing.

6. Product Selection Considerations.

6.1. Glossary and Definitions.

6.1.1. Spray-Applied Seals.

6.1.1.1. *Liquid-Only (Fog Seal)*: A light spray application of binder (a diluted slow-setting asphalt emulsion) applied to the surface of an asphalt concrete pavement. It provides some crack sealing, reduces potential for raveling, and protects weathered surfaces.

6.1.1.2. *Liquid and Sand Mixture*: A mixture of binder, usually an asphalt emulsion, and sand applied to the surface of an asphalt concrete surface. The mixture may be applied through a pressurized spray bar. This topical application provides some crack sealing and protects weathered surfaces.

6.1.2. Mixing Unit and Spreader Box Applications.

6.1.2.1. *Slurry Seal*: A mixture of well-graded fine aggregate, mineral filler (if needed), emulsified asphalt, and water applied to a pavement as preventative or corrective maintenance for asphalt pavement surfaces. A self-contained, continuous-flow mixing unit equipped with a spreader box and squeegee is required to place a slurry seal. A slurry seal provides some crack sealing, protects weathered surfaces, and may improve surface friction.

6.1.2.2. *Microsurfacing*: A type of slurry seal that uses a binder modified with polymer(s) to produce high-performance resurfacing where a durable, frictionresistant resurfacing is required. This process provides rapid surface correction. The additives in microsurfacing allow the mix to set more quickly and to develop strength so it can be placed and perform at thicknesses needed to fill low spots caused by rutting or other issues. Special rut-filling application boxes and stringent design criteria allow filling low-severity rutting in one pass. Microsurfacing provides some crack sealing, protects weathered surfaces, may improve surface friction, and can be used to fill small ruts.

6.2. Selecting Appropriate Surface Treatment.

6.2.1. Asphalt surface treatments should be used at an appropriate time to provide beneficial preventive maintenance. Placing a surface treatment too soon can prevent the surface of the asphalt mix from becoming sufficiently stiff to resist deformations under traffic. Delaying treatments too long will limit the treatment's ability to provide preventive maintenance. Severely weathered or cracked pavements are candidates for maintenance by replacement and will not significantly benefit from surface treatments.

6.2.2. Surface treatments for preventive maintenance are generally not effective in preventing load-related distresses. Preventive maintenance treatments are intended to reduce the rate of environmental degradation and reduce overall life-cycle cost. Table 1 provides guidance on appropriate placement of surface treatments. A cost analysis should be performed to select a treatment type based on material availability and cost.

Table 1. Guidance Summary for Applying Surface Treatments.

Application Method	Surface Treatment	When to Apply	When Not to Apply	Time to Reapplication[1]
Spray-applied	Liquid-only (fog seal)	First appearance of longitudinal/transverse cracking or raveling/weathering	Any occurrence of friction problems, shoving, bleeding, or rutting (in asphalt concrete layer)	2 to 4 years
	Liquid and sand	First appearance of longitudinal/transverse cracking or raveling/weathering	Any occurrence of shoving, bleeding, or rutting (in asphalt concrete layer)	2 to 5 years
Applied using mixing unit and spreader box	Slurry seal	Development of longitudinal/transverse cracking or raveling/weathering	Development of block-cracking or when greater than 25% of longitudinal/transverse cracking is at least medium severity	3 to 7 years
	Microsurfacing	From development of longitudinal/transverse cracking to first appearance of medium-severity longitudinal/transverse cracking or medium-severity raveling/weathering. Can be used to fill low-severity rutting or depressions.	Development of block cracking or when greater than 75% of longitudinal/transverse cracking is at least medium severity	3 to 9 years

1. (Hicks, Seeds, and Peshkin, *Selecting a Preventive Maintenance Treatment for Flexible Pavements*, 2000)

6.2.3. Pavements appropriate to receive asphalt surface treatments include aprons, overruns, shoulders, and taxiways. Surface treatments should not be placed on runway pavements unless approved by the MAJCOM pavement engineer since they have the potential to reduce friction and are relatively thin layers. Spray-applied sealers that do not contain sand have been shown to reduce friction when placed on asphalt concrete pavements. Microsurfacing and slurry seals have potential for debonding from the underlying pavement. Debonding can occur from high shear due to braking/acceleration of aircraft or from the detrimental effects of moisture between the surface treatment and the pavement. Additionally, asphalt concrete pavements that exhibit tenderness on the surface should not receive surface treatments. The treatment may seal the pavement surface and delay oxidative hardening, thereby prolonging the tenderness of the surface and increasing the potential for rutting and shoving. Tender pavements generally include those exhibiting surface scuffing or movement under loading for the first several days up to a few months after construction. Unless approved by the MAJCOM pavement engineer, surface treatments should not be placed on pavements less than one year old to allow necessary oxidation of the surface binder to take place before sealing.

6.3. Materials. Most asphalt surface treatments contain an emulsified binder. Solvent-based or cutback materials should not be used unless approved by the local environmental authority. Emulsions used should be appropriate for local conditions to ensure proper break and set time. Coal tar emulsions should only be used as fuel-resistant sealers and are not discussed in this ETL.

6.3.1. Grading System for Asphalt Emulsions (ASTM D977, *Standard Specification for Emulsified Asphalt*). Emulsions are classified on the basis of how quickly the asphalt droplets coalesce, resulting in “breaking” of the emulsion. RS, MS, QS, and SS refer to rapid-setting, medium-setting, quick-setting, and slow-setting, respectively. The breaking time increases from RS to SS. RS emulsions cannot be combined with aggregate. MS emulsions can only be mixed with coarse aggregate. QS and SS emulsions can be mixed with any aggregate. Designations 1 and 2 in emulsion nomenclature refer to the viscosity of the emulsion, with 2 being more viscous. The h designation refers to a base asphalt that is harder (lower penetration). Some emulsions have a HF designation, referring to high float. HF emulsions can provide a thicker asphalt film on aggregates, which is thought to enhance durability. Emulsions suspended by cationic surfactants are designated with a C. No designation refers to emulsions with anionic surfactants. Table 2 gives common emulsion grades for different types of surface treatments.

Table 2. Common Asphalt Emulsion Grades

Surface Treatment	Typical Asphalt Emulsion Grade Used
Liquid fog seal	RS-1, MS-1, HFMS-1, SS-1, SS-1h, CRS-1, CSS-1h, CQS-1h
Liquid and sand spray seal	RS-1, RS-2, HFRS-2, HFRS-2h, MS-1, HFMS-1, CRS-1, CRS-2, CRS-2h
Slurry seal	SS-1h, CSS-1h, CQS-1h
Microsurfacing	CQS-1h

6.3.2. Emulsion Breaking and Curing.

6.3.2.1. Breaking an asphalt emulsion refers to separating water from the asphalt and the evaporation of water. Some emulsions break when sufficient water has evaporated while others break through chemical means. Chemicals are added to decrease the time to breaking.

6.3.2.2. Curing of asphalt emulsions involves the development of mechanical properties as the asphalt particles coalesce and all of the water is removed through evaporation. Curing times typically range from 30 minutes to 24 hours. Cure times are most often a function of environmental conditions, application rate, substrate properties, and product dilution ratios. Closing the pavement to traffic should follow the manufacturer’s recommendations.

6.3.3. Aggregates.

6.3.3.1. Aggregate used in a slurry seal or microsurfacing should be clean, angular, and durable. The aggregate used in a slurry seal should have a minimum sand equivalent value (ASTM D2419, *Standard Test Method for Sand Equivalent Value for Soils and Fine Aggregate*; AASHTO T176, *Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test*) of 45 and a maximum Los Angeles abrasion test (ASTM C131, *Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine*; AASHTO T96, *Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine*) value of 35 in the parent rock. The aggregate used in a microsurfacing should have a minimum sand equivalent value of 65 and a maximum Los Angeles abrasion test value of 30 in the parent rock. In addition, aggregates for slurry seals and microsurfacing should have a maximum soundness (ASTM C88, *Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate*; AASHTO T104, *Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate*) value of 15 percent in the parent rock using Na_2SO_4 (sodium sulfate) or 25 percent using $MgSO_4$ (magnesium sulfate).

6.3.3.2. Slurry seals and microsurfacing use well-graded aggregates and are classified according to the gradation of the aggregate used. Table 3 gives the aggregate gradation and application rate for each type of treatment. The gradations typically includes 0.5 to 3.0 percent mineral filler. In general, only Type II and Type III gradations should be used for airfield applications.

Table 3. Aggregate Gradation for Microsurfacing and Slurry Seals (ISSA 2010).

Sieve Size	Percent Passing		
	Type I	Type II	Type III
0.375 inch	100	100	100
No. 4	100	90–100	70–90
No. 8	90–100	65–90	45–70
No. 16	65–90	45–70	28–50
No. 30	40–65	30–50	19–34
No. 50	25–42	18–30	12–25
No. 100	15–30	10–21	7–18
No. 200	10–20	5–15	5–15
Application Rate (lb/yd^2 dry aggregate)	8–12	12–20	18–30

6.3.4. Mineral Fillers. Portland cement, lime, and fly ash are commonly used as fillers in slurry seals and microsurfacing applications to control set time or stabilize the slurry. Portland cement is typically the mineral filler used in microsurfacing.

7. Construction.

7.1. Site Preparation. Corrective action should be taken to address base failures, drainage issues, and variations in width, cross-section, and profile. All potholes, cracked areas, depressions, or bleeding should also be corrected. A vacuum broom should be used to remove loose particles from the surface before applying surface treatments.

7.2. Spray-Applied Seals. A self-propelled distributor capable of maintaining a constant, even spray application should be used to distribute liquid treatments in one pass. The distributor should have internal mixing capabilities. The height of the spray bar should be adjusted to achieve double or triple coverage. When sand is used, a special distributor is needed to apply the blend of sand and liquid. These materials must be continuously mixed prior to spraying to ensure a consistent blend of the two materials.

7.3. Sealers Applied Using Mixing Unit and Spreader Box. A self-contained, continuous-flow mixing unit capable of delivering a predetermined amount of aggregate, mineral filler, and emulsion to the mixing chamber is required. The machine discharges the thoroughly mixed material onto the pavement surface in a spreader box. The spreader box is equipped with flexible squeegees for evenly applying the product.

7.4. Weather Limitations. Emulsified products should not be placed on pavement when the air temperature is below that recommended by the manufacturer. Placing these products at low temperatures can cause delays in setting. Emulsified products should not be placed when the temperature could potentially fall below freezing within 24 hours or when rainfall is projected within the expected curing time.

8. Shelf Life. Some asphalt surface treatment materials have a limited shelf life as reported by the manufacturers, so particular attention should be given to shelf life when selecting a material. Shelf life typically ranges from three months to two years and depends on storage conditions such as temperature, humidity, and integrity of the packaging.

9. Safety. Safety hazards are associated with many asphalt surface treatments, such as fire/explosion hazards, toxicity, and reactivity. Suppliers, handlers, and users of any asphalt surface treatment should ensure that a Material Safety Data Sheet (MSDS) from the manufacturer always accompanies the material. Before use, users should review the MSDS for personal protective equipment and other safety precautions.

10. DOD Field Experience with Surface Treatments.

10.1. An assessment of asphalt surface treatment usage in the United States reveals little commonality of approach. The majority of military users did not have experience with asphalt surface treatments. Those that did generally had areas where local contractors placed their commonly used product. Most of the surface treatments were coal-tar-based, fuel-resistant sealers, typically placed on asphalt concrete parking aprons.

10.2. Small Army airfields were more likely to contain pavements with asphalt surface treatments. This trend is likely related to the available pavement maintenance budget. Lack of funding for conducting more aggressive maintenance procedures has led to the use of surface treatments for prolonging pavement life. Preventive maintenance procedures are not commonly used on military airfield pavements.

10.3. Several survey responses received from Air Force civil engineering personnel indicated that asphalt surface treatments were used at their respective bases. In nearly every case the surface treatments were placed on roads or parking lots. These responses indicate that local contractors are available in many locations to place surface treatments.

10.4. An assessment of asphalt surface treatment usage in Europe was similar to that observed in the United States. No widespread common practice for performing preventive or corrective maintenance was observed. Some airfields had pavements where surface treatments had been placed. Other airfields had pavements where small test areas of products had been placed. A formal program to evaluate the effectiveness of different products was not observed. Most of the test areas were vendor initiated and were evaluated on visually perceived effectiveness. In the locations where a large area was treated with an asphalt sealer, mixed performance was observed. Many of the products were similar to those observed in the United States.

11. Advantages of Using Surface Treatments. The use of surface treatments is a beneficial strategy to pavement management when the appropriate treatment is applied at an appropriate time. Surface treatments are expected to extend the service life of asphalt pavements by several years by reducing the extent of environment-related damage. The major benefit is the increase in pavement life as a result of reducing binder oxidation in the asphalt concrete layer and reducing raveling due to the extra binder added to the surface. Surface treatments provide a low-cost preventive maintenance procedure. Additional benefits include enhanced visibility of pavement markings and overall improvement in pavement appearance. Some surface treatments may require periodic reapplications to obtain the maximum benefit.

12. Disadvantages of Using Surface Treatments.

12.1. Asphalt pavement surface treatments are typically limited on airfields not by their lack of beneficial characteristics but by the potential problems associated with their use. These potential problems are generally associated with the type of product used. The major disadvantages of surface treatments include potential for decreased friction, debonding, raveling, and development of FOD as the surface treatment is dislodged.

12.2. Decreased friction occurs when an asphalt surface treatment changes the surface characteristics of the existing pavement. Debonding occurs when the surface treatment covering the pavement becomes debonded from the existing pavement. This phenomenon typically occurs when the surface treatment is placed in a thin layer of binder and fine aggregate. Raveling occurs when aggregate becomes dislodged from the pavement material. Raveling may occur in surface treatments when small chunks of the seal become dislodged. Excessive sweeping or rubber or ice removal can accelerate this type of raveling.

12.3. Each of the surface treatment characteristics listed above has some potential for negative impact on airfield operations. Table 4 lists these impacts for each type of surface treatment. Many of the problems associated with the use of surface treatments come after the treatment has passed its service life. The service life duration depends on the type of product, application method, application rate, and/or pavement surface preparation. Some surface treatments are intended to last only a couple of years, while others should maintain effectiveness for up to nine years.

Table 4. Potential Impact to Airfield by Different Types of Surface Treatments.

Surface Distress	Liquid Spray Seal	Liquid and Sand Spray Seal	Slurry Seal	Microsurfacing
Decreased friction	H	H	P	N
Debonding	N	P	H	P
Raveling	N	P	P	P

N - not a significant concern

P - potential for minor impact

H - high potential for impact

13. Point of Contact. Recommendations for improvements to this ETL are encouraged and should be furnished to the Pavements Engineer, HQ AFCESA/CEOA, 139 Barnes Drive, Suite 1, Tyndall AFB, FL 32408-5319, DSN 523-6439, commercial (850) 283-6439, e-mail afcesar@tyndall.af.mil

ANDREW A. LAMBERT, Colonel, USAF
Chief, Operations and Programs Support Division

1 Atch
1. Distribution List

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