

As of October, 20□ the E-Krete PCMO was in excellent condition. Numerous fuel and oil/hydraulic fluid spills had occurred, however, the overall condition was excellent with considerable staining and some pooling of oil/hydraulic fluid evident. The joint reflection cracks had propagated up through the PCMO surface. The PCMO pavement marking displayed slight delamination in some areas where oil/hydraulic fluid was evident. This was likely due to wicking of pooled hydraulic fluid under the tie-downs. No softening of the PCMO was noted in these areas. Adhesion tests in areas not soaked with fluids pulled up the underlying asphalt. Frictional resistance was similar to asphalt as measured by ASTM E303.

Edwards AFB, Barstow, CA

In November, □ an E-Krete PCMO area approximately 6m by 6m (20 ft by 20 ft) was □ placed in the parking lot of the Civil Engineering office and PCMO pavement marking markings were placed on some roadways. The materials were placed under clear skies with temperatures between 27-30°C (80-85°F). Winds were light. Pavement temperatures were approximately 43-49°C (110-120°F) during placement.

In October, 20□ the condition of the E-Krete PCMO was excellent aside from the □ reflective cracks from the underlying asphalt. The reflective cracking is not related to the PCMO. □ Some minor raveling from the crack faces had occurred where there is noticeable unevenness in the substrate and in areas where the underlying asphalt cracks were about ½ inch wide. Some cracks have also reflected through the white arrow. The color of the E-Krete PCMO is darker □ than the surrounding pavement and is holding the color well. There is a white arrow of PCMO pavement marking in the middle of this section that was placed directly on top of the PCMO. This section receives car and light truck traffic only. Frictional resistance was not measured since traffic was present during the inspection. Adhesion tests conducted on the Krete PCMO □ action pulled up the underlying asphalt.

A yellow E-Krete PCMO pavement marking centerline was placed on Rosemond Avenue (a 4-lane highway), across from the northern CE exit. It is a double yellow line with one side being their conventional yellow paint. The section is about 200-ft. long and at 2 locations the lines are covered with black paint, where traffic crosses. Both the PCMO pavement marking and the paint appear to be in good condition. The paint is approximately 1 year old. PCMO pavement marking was placed on one side of a pedestrian walkway across Rosemond Ave. at the CE building. The paint is beginning to fade somewhat from wear; it is of course somewhat thinner. Generally, a paint stripe is 19-38 microns (7-15 mils) thick and PCMO pavement marking from 76-152 microns (30-60 mils) in thickness. The PCMO pavement marking is somewhat darker in the wheel paths from dirt or grime from traffic. “Stop” and “Stop Ahead” pavement markings had been placed on Rosemond Ave. approaching N. Muroc Street. They alternated the markings made of Polycon and those painted between each lane; doing 1 of each type at every location. The markings of both types are still in relatively good condition. The only distress noted was in areas where the underlying pavement had cracked, the pavement markings had also cracked. The only cracks observed were reflective.

North Island NAS, San Diego, CA

November, □ in an area approximately 15 m by 15 m (50 ft by 50 ft). The materials were placed under clear skies with temperatures between 24-27°C (75-80°F). Winds were light.

Pavement temperatures were approximately 38-43°C (100-110°F). A 203 cm wide (8 inch) PCMO pavement marking white line surrounds the perimeter and a 152 cm (6 inch) yellow PCMO pavement marking line splits the middle of the section. The section was placed on severely aged and cracked asphalt and receives traffic from light-duty aircraft (C-12s) only.

The condition in November, 2012 was excellent except for the reflective cracks from the underlying asphalt. Skid resistance was similar to the surrounding asphalt. Adhesion measurements taken on one side of the section were consistent with measurements taken at other locations (see Table I). However, measurements made at the opposite side of the section demonstrated low adhesion to the underlying asphalt. This is the only location tested where the PCMO placed on the asphalt failed due to adhesion loss. The reason is not known, however, it is possible that the pavement in that area was dirty or perhaps oily (from a spill) and prevented the PCMO from bonding well.

The overall condition of the pad is better than the surrounding pavement. A white discoloration is noticeable on the PCMO, in areas adjacent to hairline cracking. A similar condition was noted on one of the PCMO sections at Forbes Field. There were only a few areas where raveling had occurred from the crack faces and these were in areas with large underlying cracks. Generally, most of the cracks vary from hairline up to 3mm (1/8 inch). The largest cracks are up to 6mm (¼ inch) wide. These types of cracks, while widespread, did not cover the entire pad. The yellow center strip did not appear to have any cracks in it and is holding color well with little apparent fading. All of the cracks were reflecting up from the underlying asphalt.

Forbes Field, Topeka, KS

In November 2008, 2 PCMO and 1 PCMO pavement marking areas were placed. The materials were placed in poor conditions under clear skies and temperatures between F 4-10°C (40-50°). Winds were high and gusting. Pavement temperatures ranged from 10-24°C (50-75°F). These conditions were not ideal but could not be avoided due to scheduling. The PCMO pavement marking area was placed on concrete in a “Red Carpet” area for dignitaries as they exit aircraft. The “Red Carpet” area was placed in late morning. Figure 7 shows the area from October, 2012. One PCMO area is approximately 23m by 15m (75 ft by 50 ft) and was placed on severely map-cracked coal tar. Section 1 was placed in the morning when pavement temperatures were well below 16°C (60°F). The second PCMO section was placed on severely delaminating coal tar. This section was placed later in the afternoon when pavement temperatures were above 16°C (60°F). This section is approximately 6m by 6m (20 ft by 20 ft). The condition of all the sections was excellent although reflective cracking had occurred.

Whitening of the PCMO surface adjacent to the cracks has occurred in Section 1. This may be related to “effervescence” in the PCMO. This does not seem to have affected the performance. Many of the cracks from the coal tar substrate have reflected up through the PCMO. However, this only occurred with the larger cracks. The adhesion tests conducted over the concrete failed cohesively with the PCMO pulling apart rather than delaminating from the concrete. Adhesion tests pulled up the underlying coal tar. Frictional resistance was similar to asphalt.

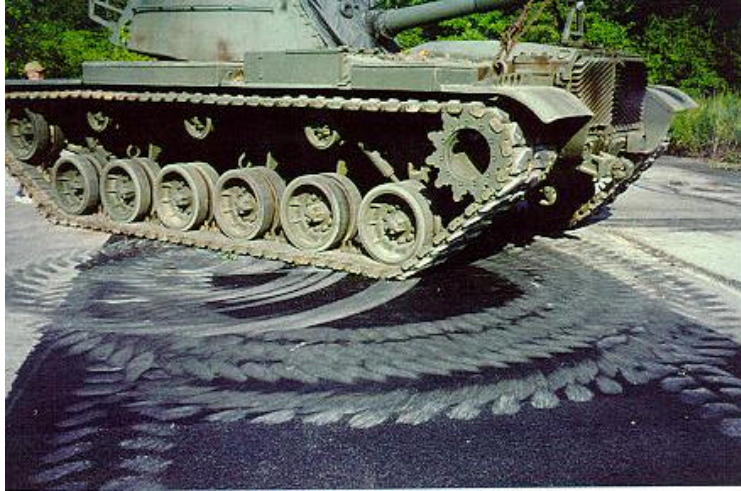


Figure 2. 106,000 lb M-60 tank conducting pivot steers on PCMO surface at US Army ERDC.



Figure 3. PCMO surface in October 2012. Some scuffing of the surface from the tank testing in August 2008 is apparent.



Figure 4. PCMO surface in October 2012 at MacDill AFB. The adjacent pavement is coal tar that is approximately 14 years old and is severely deteriorated.



Figure 5. PCMO section at MacDill AFB showing reflective cracking. Note that the crack has not widened or displayed any raveling from the crack face.

Section 2 was a small area placed over severely delaminating coal tar. The purpose was to determine if the PCMO was able to encapsulate the existing coal tar. It appears to have accomplished this by preventing further adhesion loss of the coal tar from the asphalt (Figure 7).

McConnell AFB, Wichita, KS

In November, 2008, 3 PCMO “pads” approximately 15 ft by 15 ft in diameter were constructed at B-1 aircraft parking areas B10, B11, and B12. The materials were placed in poor conditions under clear skies and temperatures between 7-16°C (45-60°F). Winds were between high and gusting. Pavement temperatures ranged from 10-27°C (50-80°F). B10 was overlaid with 3 coats of PCMO to a total thickness of approximately 3mm-5mm (1/8-3/16 inch). Two layers of PCMO with a fuel-resistant clear topcoat sealer were placed on B11. Two layers of PCMO only were placed on B12. All 3 were placed on relatively new concrete about 2 months old but with substantial hydraulic fluid staining and were pressure washed only before PCMO placement. No detergent or solvents were used to clean the surface. The concrete joints were covered with masking tape during application.

The conditions under which the PCMO must perform in service at McConnell AFB are extreme. The B-1 is a high-performance aircraft that loses considerable amounts of hydraulic and lubricating fluid. The B-1 aircraft has an auxiliary power unit (APU) exhaust port approximately 1m (3-4 feet) above the pavement surface. The exhaust gases impinge upon the pavement at an approximate angle of 45° angle and can heat the surface to near 204°C (400°F). The combination of heat and jet turbine fluid chemistry destroys the cement paste resulting in severe spalling and cracking (Anderson et al. and McVay et al, 1995) after a few years.

Two months after placement of the PCMO it was noted that delamination was occurring in some areas. A visit to the site and inspection of the areas revealed that the delamination was progressing from the concrete joints towards the center of the slabs. After discussions with Polycon representatives and the PCMO placement crew, it was discovered that the masking tape covering the joints was not removed until well after the PCMO had begun to harden. During removal of the tape some of the coating stuck to the tape and pulled away from the slab. It was in these areas that delamination was occurring. Additionally, it was also in these areas where the hydraulic fluid had stained the concrete before application of the PCMO. Thus, it was surmised that the hydraulic fluid on the concrete had prevented a proper bond of the PCMO to the concrete substrate. Removal of the masking tape from the joints pulled up some of the coating because it was prevented from bonding to the concrete by the hydraulic fluid.

In November, 2012, a detailed inspection of the B1B pads was conducted. The overall condition of the PCMO was described as good. Approximately 10 percent of the PCMO surface has delaminated, with severe staining from hydraulic fluid. In pads B10 and B12 the PCMO had turned rubbery. This rubbery condition is due to swelling of the polymer within PCMO by synthetic jet turbine fluid. The condition of the PCMO on pad B11 was better than B10 and B12 but some rubbery areas were noted. Despite this condition, the PCMO has prevented the aircraft fluids from causing serious damage to the underlying concrete substrate. Given that concrete replacement under the B1B aircraft generally occurred every 3 years, the demonstration of the PCMO coating was considered successful.

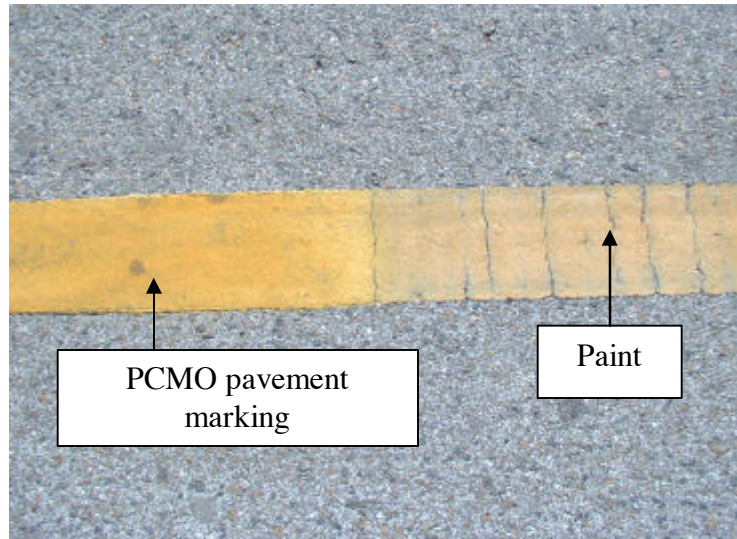


Figure 6. PCMO pavement marking line at MacDill AFB in October 2012 after 4 full years in service. Note the transverse cracking in the conventional airfield pavement marking paint. The marking paint is approximately 3 years old in this picture.



Figure 7. “Delaminated coal tar area before (2008) and after sealing with PCMO (2012) at Forbes Field, Topeka, KS.

Estimated Life of Coal Tar and PCMO

Studies conducted by both the FAA (Saraf et al., 1992) and ERDC (Shoenberger, 1993) have shown that average functional life of a coal tar based fuel resistant sealer (FRS) is 2-5 years. In most cases, the severity of cracking is such that the sealer has lost its fuel resistance in 2-3 years. Thus, the expected functional life of a coal tar based FRS is approximately 3 years. In practice, resealing typically occurs every 5-6 years because the funds are not available to reseal on a 2 or 3-year cycle.

Estimating the service life a new product such as PCMO is not simple. US Army ERDC has nearly 4 years of field experience with this product. Other pavement sections that have been sealed with PCMO for more than 5 years have been found to be in excellent condition. Based on the experiences with coal tar FRS, severe abrasion from aircraft traffic is not a significant form of distress. The majority of the PCMO demonstration sites have not had significant traffic and given that PCMO has been shown to more abrasion resistant than coal tar, high amounts of traffic should not significantly affect performance. Based on the performance of the demonstration sites an estimation of 10 years service life is not unreasonable.

Life Cycle Cost Analysis (LCCA)

A life cycle cost analysis (LCCA) for the PCMO products will be presented here compared to a typical coal tar emulsion. The life cycle cost comparison will be accomplished using net future value which estimates the life cycle cost based on the costs at the time resealing is conducted. The annual inflation rate is assumed to be 3%.

$$\text{Net Future Value} = \sum_0^n \text{Initial Cost} \times (1 + r)^n$$

Assume that a 41,806 sq.m. (50,000 sq.yd.) parking area is sealed with a coal tar emulsion that costs \$1.26/sq.m. (\$1.05/ sq.yd. or \$.12/sq.ft.) the resulting total initial project cost is \$52,500. An average *functional* life of the coal tar is assumed to be 3 years and is based on field observations (Shoenberger, 1995 and Saraf, 1992). In 6 years, the parking area would need retreating 2 times for a cost based on future value of approximately \$172,500 to maintain a viable fuel resistant surface. In 10 years, the costs for resealing would be over \$240,500. The same area sealed with PCMO at \$4.84/sq.m. (\$4.05 sq.yd.) would cost \$202,500. Using the estimated life of PCMO PCMO of 10 years, the cost compared to coal tar sealing over the ten-year period is substantially lower and requires less interruption to aircraft traffic.

SUMMARY

The Polycon E-Krete materials are approved for modified applications on Military Airfields Military Bases. Further approvals include US Government installations were necessary applications for the Polycon E-Krete are warranted.

The results indicate that the fuel and abrasion resistance of the PCMO product exceeds that of a typical unmodified coal tar emulsion. PCMO is resistant to hydraulic fluid but has been shown to soften in contact with some synthetic jet turbine fluids. The abrasion resistance is greater for PCMO PCMO compared to an unmodified coal tar emulsion. The laboratory data and field data both suggest that the material is durable and resistant to weathering. The field demonstrations have been very successful with performance at or above expectations at all sites. However, although the performance has been rated as excellent, this is based on only 3-4 years of experience with these products. Several of the demonstrations were placed on severely

cracked asphalt or coal tar and many of those cracks have reflected through the PCMO surface. No significant forms of environmental or load-related distress that are directly related to the PCMO product have been observed to date. Based on the observations at McConnell AFB and MacDill AFB, the PCMO will soften under prolonged exposure to certain types of synthetic jet turbine lubricants.

Overall, the PCMO product appears to be an excellent alternative to conventional coal tar FRS. Based on the performance of demonstration sites and inspection of other sites over 5 years old, it is estimated that the minimum service life of PCMO will be 10 years in areas with light traffic. The PCMO product exhibits a high resistant to weathering and can be expected to be extremely durable.

Although the initial cost is higher than coal tar, the estimated life cycle costs for PCMO are substantially lower assuming an average functional life of coal tar sealer to be 3 years and that of the PCMO to be 10. For a 41,806 sq.m. (50,000 sq.yd.) parking area sealed with PCMO PCMO that costs \$4.84/sq.m. (\$4.05/sq.yd. or \$0.45/sq.ft.) compared to coal tar at \$1.26/sq.m. (\$1.05/sq.yd. or \$.12/sq.ft.), the cost savings realized over a 10 year period are over \$35,000 assuming an inflation rate of 3 percent.

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At the time of preparation of this report, Director of ERDC was Dr. James R. Houston and Commander and Executive Director was COL John W. Morris, III, EN.