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Summary of Case Studies and Observations on Airport Experience with Pavement Surface Treatments

August 2023

DOT/FAA/TC-TN23/49

U.S. Department of Transportation
Federal Aviation Administration

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/TC-TN23/49		

4. Title and Subtitle SUMMARY OF CASE STUDIES AND OBSERVATIONS ON AIRPORT EXPERIENCE WITH PAVEMENT SURFACE TREATMENTS	5. Report Date August 2023
	6. Performing Organization Code
7. Author(s) Peter-Paul Dzwilewski, David Peshkin, Jeff Stempihar, Sharlan Montgomery Dunn, and Russell Ashburn	8. Performing Organization Report No.
9. Performing Organization Name and Address Applied Pavement Technology, Inc. 115 West Main Street, Suite 400 Urbana, IL 61801	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. 692M15-21-T-00027
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Airport Engineering Division 800 Independence Ave., SW Washington, DC 20591	13. Type of Report and Period Covered Technical Note
	14. Sponsoring Agency Code AAS-110

15. Supplementary Notes

The Federal Aviation Administration Airport Technology Research and Development Contracting Officer Representative (COR) was Matthew T. Brynick.

16. Abstract

The Federal Aviation Administration Airport Technology Research and Development Branch sponsored a study of pavement surface treatments with two main objectives: to identify best practices and to propose guidance for selecting surface treatments as the appropriate treatment strategy for airport pavements. Twelve airports and agencies with surface treatment experience provided information to develop case studies. Site visits were made to 11 airports, associated with 8 of the case studies, to collect additional information. This technical note summarizes key observations regarding the use of surface treatments at different airports and on different features based on those case studies. Complete case studies are included as an appendix.

17. Key Words	18. Distribution Statement
Airport, Surface treatment, Pavement maintenance, Pavement management, Pavement preservation	This document is available to the U.S. public through the National Technical Information Service (NTIS), Springfield, Virginia 22161. This document is also available from the Federal Aviation Administration William J. Hughes Technical Center at actlibrary.tc.faa.gov.

19. Security Classification. (of this report)	20. Security Classification. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	178	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

ACKNOWLEDGEMENTS

The authors would like to acknowledge the Federal Aviation Administration (FAA) Airport Technology Research and Development Branch (ATR) for sponsoring this research. The authors would like to thank the following persons for their technical guidance and administration support:

- Dr. Michel Hovan, ATR Branch Manager
- Mr. Jeffrey Crislip, Airport Design and Construction Branch Senior Airfield Pavement Engineer
- Mr. Matthew T. Brynick, P.E., ATR Pavement Section Civil Engineer

In addition, many airports and state aeronautics agencies provided access to their facilities and data. Their assistance in facilitation the collection of records and performance information is greatly appreciated.

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LIST OF ACRONYMS

42U	Morgan County Airport
8D1	New Holstein Municipal Airport
AC	Advisory Circular
AIP	Airport Improvement Program
APT	Asphalt Polymer Treatment
ATR	Airport Technology Research and Development Branch
BCT	Boca Raton Airport
BMC	Brigham City Airport
BTF	Skypark Airport
CDC	Centers for Disease Control and Prevention
CPR	Casper/Natrona County International Airport
CTB	Cement-treated Base
EKO	Elko Regional Airport
EQY	Charlotte-Monroe Executive Airport
FAA	Federal Aviation Administration
FDOT	Florida Department of Transportation
FOD	Foreign object debris
GA	General Aviation
GZS	Abernathy Field Airport
LLU	Lamar Municipal Airport
L&T	Longitudinal and transverse
LTPP	Long-term pavement performance
LUG	Ellington Airport
M17	Bolivar Municipal Airport
MoDOT	Missouri Department of Transportation
NPIAS	National Plan of Integrated Airport Systems
OKV	Winchester Regional Airport
OLS	Nogales International Airport
PCI	Pavement Condition Index
PHX	Phoenix Sky Harbor International Airport
PMP	Pavement Management Program
SCI	Structural Condition Index
STE	Stevens Point Municipal Airport
TDOT	Tennessee Department of Transportation
UDOT	Utah Department of Transportation
UV	Ultraviolet
VOC	Volatile organic compound
WisDOT	Wisconsin Department of Transportation
WRAA	Winchester Regional Airport Authority
WYDOT	Wyoming Department of Transportation

EXECUTIVE SUMMARY

While airfield pavements are designed to last for 20 years, the Federal Aviation Administration (FAA) is researching ways to extend pavement life to 40 years. Attaining longer pavement life is especially challenging for asphalt-surfaced airfield pavements, which are more susceptible to the environmental effects of daily and seasonal temperature cycling, temperature extremes, exposure to moisture, and exposure to ultraviolet rays. Environmental forces affect the performance of an asphalt pavement beginning very early in its life cycle and, over time, can lead to various environmental distresses. These appear on the surface of the pavement and, if left untreated, provide a means of accelerating the deterioration of the overall pavement structure.

A class of maintenance actions, commonly referred to as "surface treatments," describes treatments that are applied to asphalt pavements to slow deterioration caused by environmental factors. In general, surface treatments provide several benefits that warrant consideration of their use. However, the FAA's guidance on the use of such treatments for airfield pavements is limited. Without comprehensive, experience-based guidance on when and where to use the various treatment options, it is difficult to support widespread use of cost-effective surface treatments early in the life of a pavement.

The FAA's specifications for surface treatments are found in Part 8 of FAA AC 150/5370-10H, *Standard Specifications for Construction of Airports* (FAA, 2018). This section of the construction specifications covers nine treatments and each of the appropriate specifications provides some guidance on their usage. This guidance varies in how it addresses the existing pavement conditions under which each treatment is applicable. Furthermore, all but one of the treatments identifies weight restrictions, suggesting that there is a limitation in the ability of such treatments to withstand loads above a certain magnitude. The specifications also limit where on an airport facility the treatments may be used, from which it might be inferred that there are also variable operational or safety limitations on the use of surface treatments.

Under FAA contract 692M15-21-T-00027, *Surface Treatment Relative to Airfield Location,* a team investigated current practices of surface treatment use on airfield pavements and developed an experiment to further evaluate the performance of four surface treatments on airport pavements under a range of conditions. As part of that investigation, the team completed twelve case studies of surface treatment use. Each case study is either associated with a singular airport or a state agency that is responsible for many airports. This report summarizes key observations regarding the use of surface treatments at different airports and on different features based on those case studies. Case study observations about the following are of particular interest, as they address treatment selection and treatment performance:

- Where the treatment is used
- The intended purpose of the treatment
- Condition of the pavement and distresses present at application
- Condition of the pavement and distresses present during the site visit
- Performance of the treatment
- Surface texture of the treatment
- Impact on pavement markings

- Foreign Object Debris concerns
- Feedback from airport operators

In addition to the case study overviews in this report and the full summaries in Appendix A, a discussion of when surface treatments might be used is presented. The report also identifies FAA guidance on surface treatments that should be updated as more information becomes available.

BACKGROUND

While airfield pavements are designed to last for 20 years, the Federal Aviation Administration (FAA) is researching ways to extend pavement life to 40 years. However, some airports have airfield pavements that do not reach even 20 years of life without some sort of intervention or treatment. Pavement design procedures are effective in identifying structurally adequate pavement cross sections which support the anticipated aircraft loads over their lifetime. However, their ability to withstand environmental effects is not directly addressed in pavement design.

Attaining longer pavement life is especially challenging for asphalt-surfaced airfield pavements, which are more susceptible to the environmental effects of daily and seasonal temperature cycling, temperature extremes, exposure to moisture, and exposure to ultraviolet (UV) rays. Environmental forces affect the performance of an asphalt pavement beginning very early in its life cycle and, over time, can lead to one or more of the following distresses: block cracking, longitudinal and transverse (L&T) cracking, raveling, reflection cracking, and weathering. Environmental distresses, which appear on the surface of the pavement, provide a means of accelerating the deterioration of the overall pavement structure. Left untreated or inadequately treated, these distresses can provide a pathway for water intrusion and additional environmental exposure, which accelerates deterioration of both surface and sub-surface layers.

A class of maintenance actions, commonly referred to as "surface treatments," describes treatments that are applied to asphalt pavements to slow deterioration caused by environmental factors. However, the FAA's guidance on the use of such treatments for airfield pavements is limited. For example, the FAA Advisory Circular (AC) 150/5380-6C, *Guidelines and Procedures for Maintenance of Airport Pavements* (FAA, 2014a), mentions surface treatments specifically as a repair for weathering/oxidation and loss of skid resistance, but does not identify which surface treatment(s) are appropriate for these applications. There is also one reference to surface treatments in FAA AC 150/5380-7B, *Airport Pavement Management Program (PMP)* (FAA, 2014b), but no specific guidance on when to use these treatments.

In general, surface treatments provide several benefits that warrant consideration of their use. For example, compared to the construction of an asphalt overlay, a common pavement rehabilitation method, the benefits of surface treatments are:

- Construction takes less time and airfields can be opened to traffic more rapidly, and therefore have less impact on operations.
- They do not noticeably change grades or overall elevations, so they can be selectively placed in some areas, but not in other adjacent areas, without creating drop-offs or grade differentials.
- They are less expensive.

However, without more comprehensive, experience-based guidance on when and where to use the various treatment options, it is difficult to support widespread use of cost-effective surface treatments early in the life of a pavement. This guidance would also help to identify when and where the use of surface treatments is and is not appropriate. For example, consider the following:

- Some surface treatments reduce surface friction, at least initially, which might be unacceptable in certain locations.
- Some surface treatments could be more useful than others for a given pavement, depending on the types, severities, and amounts of distress present on that pavement.
- In locations of significant distress, surface treatments might provide little to no benefit.
- There are environmental concerns regarding the use of some surface treatments.

The FAA's specifications for surface treatments are found in Part 8 of FAA AC 150/5370-10H, *Standard Specifications for Construction of Airports* (FAA, 2018). This section of the construction specifications covers nine treatments and each of the appropriate specifications provides some guidance on their usage as summarized in Table 1. Note how the guidance varies in how it addresses the existing pavement conditions under which each treatment is applicable. For example, in some instances the application guidance discusses use on pavements in "FAIR or better condition," while, in others, reference is made to specific distresses (e.g., "low to moderate weathered surfaces"), pavements with better than a specific Pavement Condition Index (PCI) or Structural Condition Index (SCI) value, or to some amount (or absence of) structural deterioration. Furthermore, all but one of the treatments identifies weight restrictions, suggesting that there is a limitation in the ability of such treatments to withstand loads above a certain magnitude. The specifications also limit where on an airport facility the treatments may be used, from which it might be inferred that there are also variable operational or safety limitations on the use of surface treatments.

One objective is to develop guidelines for airports to identify evidence-based best practices and guidance to select surface treatments as the appropriate treatment strategy for different airfield pavement locations and conditions. As part of that project, a literature review and survey were performed. The results from those efforts can be reviewed in DOT/FAA/TC-TN22/13, *Airport Pavement Surface Treatment: A Literature Review* (FAA, 2022b), and DOT/FAA/TC-TN22/7, *Summary of Responses of Airport Experience with Pavement Surface Treatments* (FAA, 2022a). Twelve case studies were also completed, building on survey responses and phone interviews with airports and, in some cases, their engineers. Site visits were made to 11 airports, associated with 8 of the case studies, to collect additional information. This report summarizes key observations regarding the use of surface treatments at different airports and on different features based on those case studies. Case study observations about the following are of particular interest, as they address treatment selection and treatment performance:

- Where the treatment is used
- The intended purpose of the treatment
- Condition of the pavement and distresses present at application
- Condition of the pavement and distresses present during the site visit
- Performance of the treatment
- Surface texture of the treatment
- Impact on pavement markings
- Foreign Object Debris (FOD) concerns
- Feedback from airport operators

Twelve airports and agencies with surface treatment experience provided information to develop case studies. Figure 1shows the locations of the case studies. Table 2 identifies the airports and Table 3 identifies the case study agencies. Table 2 presents airport information such as the Long-Term Pavement Performance (LTPP) climate zone, number of runways, primary traffic type, surface treatment material(s) and pavement age at application, and treatment age at site visit (if applicable). Table 3 summarizes agency information such as the LTPP climate zone, statewide surface treatment program type, and general surface materials applied. If specific airports were visited, the surface treatment material(s) and pavement age at application, and treatment age at the time of the site visit are presented. These two tables demonstrate the varied approaches taken by airports and agencies when applying surface treatments.

Table 1. Summary of FAA AC 150/5370-10H Surface Treatments

Item	Description	Application	Existing Pavement Condition
P-608	Emulsified Asphalt Seal Coat	• High-speed taxiways and runways with aggregate to maintain surface friction. • Low-speed taxiways, aprons, shoulders, and overruns with or without aggregate; non-airside locations.	• Pavements in FAIR or better condition and low to moderate weathered surfaces, as defined in ASTM D5340, or new pavements. • A typical candidate has a SCI deduct value of less than 10 and a PCI greater than 60.
P-608-R*	Rapid Cure Seal Coat	• Taxiways and runways with aggregate to maintain surface friction. • Aprons, shoulders, and overruns with or without aggregate; non-airside locations.	• Pavements in FAIR or better condition and low to moderate weathered surfaces, as defined in ASTM D5340, or new pavements. • A typical candidate has a SCI deduct value of less than 10 and a PCI greater than 60.
P-609	Chip Seal Coat	• Not recommended for use on airfield pavements. • May be used on overruns and other areas not subject to routine turbo-prop and jet engine aircraft. • May be considered for use at airports serving aircraft 30,000 pounds or less.	No stated recommendations or requirements.
P-623	Emulsified Asphalt Spray Seal Coat	• All pavements, except runways, serving aircraft 30,000 pounds or less. • Airports serving aircraft less than 60,000 pounds, except for runways and acute-angled exit taxiways, with FAA concurrence. • Shoulders and overruns.	• Pavements in FAIR or better condition and low to moderate weathered surfaces, as defined in ASTM D5340. • A typical candidate has a SCI deduct value of less than 10 and a PCI greater than 60.
P-626	Emulsified Asphalt Slurry Seal Surface Treatment	• All pavements at airports serving aircraft 30,000 pounds or less. • All pavements, except for runways, at airports serving aircraft less than 60,000 pounds. • Shoulders and overruns.	No stated recommendations or requirements.

Item	Description	Application	Existing Pavement Condition
P-629**	Thermoplastic Coal Tar Emulsion Surface Treatments – Micro-Surface	• Apron areas that require a fuel-resistant coating serving aircraft less than 60,000 pounds. • All pavements at airports serving aircraft less than 60,000 pounds. • Pavements at airports serving aircraft greater than 60,000 pounds with FAA approval. • Shoulders and overruns.	No stated recommendations or requirements.
P-629**	Thermoplastic Coal Tar Emulsion Surface Treatments – Sand Slurry Seal	• Apron areas that require a fuel-resistant coating serving aircraft less than 60,000 pounds. • All pavements at airports serving aircraft 30,000 pounds or less. • All pavements, except for runways, at airports serving aircraft less than 60,000 pounds. • Shoulders and overruns.	No stated recommendations or requirements.
P-629**	Thermoplastic Coal Tar Emulsion Surface Treatments – Spray Seal Coat	• Apron areas that require a fuel-resistant coating serving aircraft less than 60,000 pounds. • All pavements, except runways, at airports serving aircraft 30,000 pounds or less. • Airports serving aircraft less than 60,000 pounds, except for runways and acute-angled exit taxiways, with FAA concurrence. • Shoulders and overruns.	No stated recommendations or requirements.
P-630**	Refined Coal Tar Emulsion without Additives, Slurry Seal Surface Treatment	Apron areas that require a fuel-resistant coating serving aircraft less than 60,000 pounds.	No stated recommendations or requirements.

Item	Description	Application	Existing Pavement Condition
P-631**	Refined Coal Tar Emulsion with Additives, Slurry Seal Surface Treatment	Apron areas that require a fuel-resistant coating serving aircraft less than 60,000 pounds.	No stated recommendations or requirements.
P-632*	Asphalt Pavement Rejuvenation	• Airports serving aircraft less than 60,000 pounds, except for runways and acute-angled exit taxiways. • Shoulders and overruns.	• Pavements with low to moderate weathered surfaces as defined in ASTM D5340. • A typical candidate is without structural distresses (or has provisions to correct them) and with low to moderate environmental distresses. • PCI equal to or greater than 70.

* Contains volatile organic compounds (VOCs) and application may be limited by federal, state, and local authorities.
** Many locations prohibit the use of coal tar products and application must comply with federal, state, and local requirements.

CASE STUDY OVERVIEW AND SUMMARIES

Twelve airports and agencies with surface treatment experience provided information to develop case studies. Figure 1 shows the locations of the case studies. Table 2 identifies the airports and Table 3 identifies the case study agencies. Table 2 presents airport information such as the Long-Term Pavement Performance (LTPP) climate zone, number of runways, primary traffic type, surface treatment material(s) and pavement age at application, and treatment age at site visit (if applicable). Table 3 summarizes agency information such as the LTPP climate zone, statewide surface treatment program type, and general surface materials applied. If specific airports were visited, the surface treatment material(s) and pavement age at application, and treatment age at the time of the site visit are presented. These two tables demonstrate the varied approaches taken by airports and agencies when applying surface treatments.

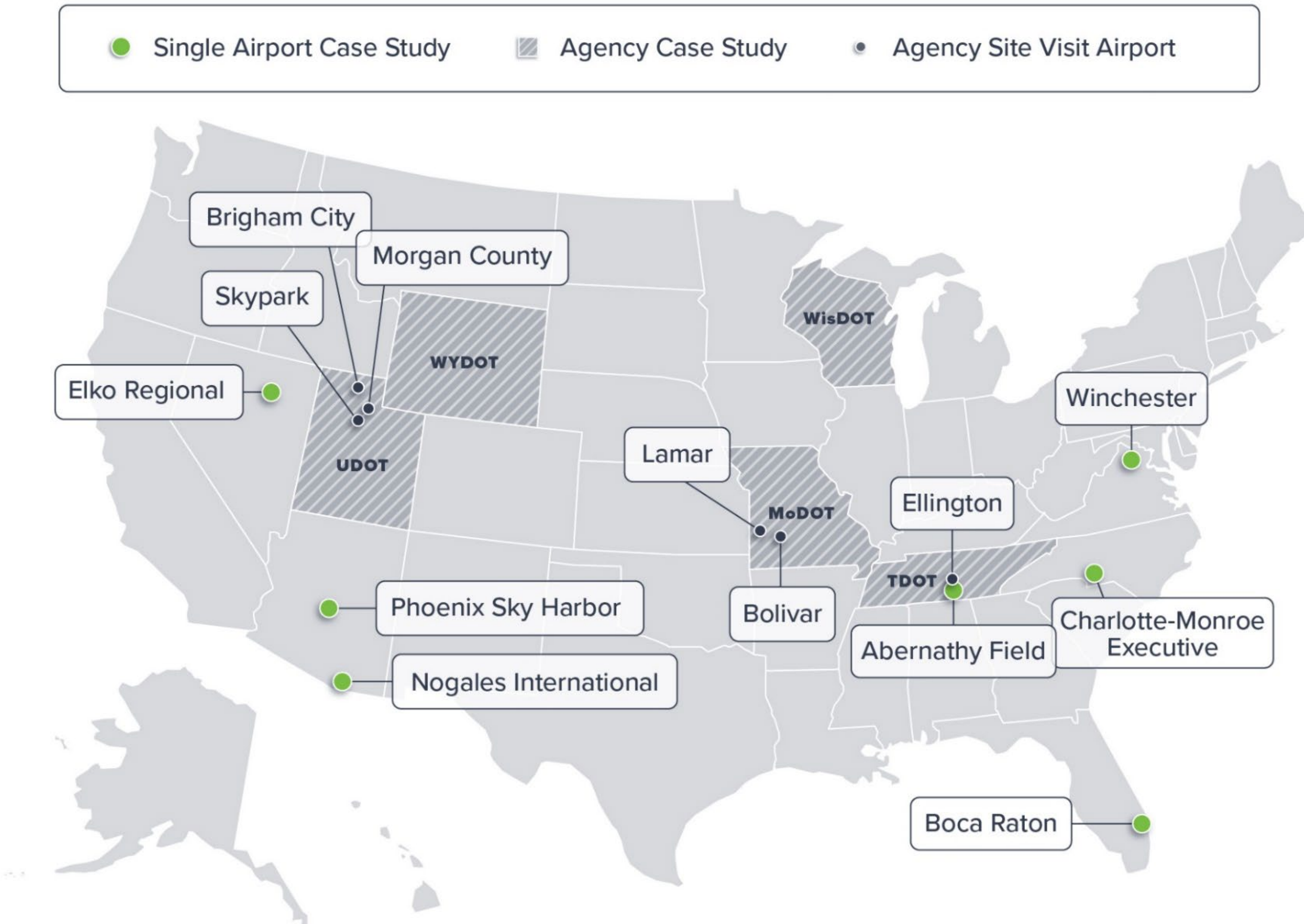

Figure 1. Location of Case Studies

Table 2. Single Airport Case Studies

Airport	Location	LTTP Climate	Airport Category	Runway(s)	Primary Traffic Type	Surface Treatment Material(s) and Pavement Age at Application	Treatment Age at Site Visit
Abernathy Field Airport (GZS)	Pulaski, Tennessee	Wet, Non-Freeze	Local	1	90% General Aviation (GA)	Non-FAA coal tar emulsion at overlay	13 years
Boca Raton Airport (BCT)	Boca Raton, Florida	Wet, Non-Freeze	National	1	93% GA	P-608-R at 10 years	-
Charlotte-Monroe Executive Airport (EQY)	Monroe, North Carolina	Wet, Non-Freeze	Regional	1	91% GA	A coal tar slurry at construction P-631 at initial construction P-632 at 10 and 25 years	Coal tar slurry at 25 years P-631 at 2 years P-632 at 4.5 years
Elko Regional Airport (EKO)	Elko, Nevada	Dry, -Freeze	Nonhub	2	71% GA	P-608 at 6, 8, 14, 20, and 30 years	2 years
Nogales International Airport (OLS)	Nogales, Arizona	Dry, Non-Freeze	Local	1	87% GA	P-608 at 15 years	2 years
Phoenix Sky Harbor International Airport (PHX)	Phoenix, Arizona	Dry, Non-Freeze	Large Hub	3	88% Commercial	Non-FAA asphalt emulsion at 3 years Non-FAA coal tar rejuvenator at 5 years	6 years 11 years
Winchester Regional Airport (OKV)	Winchester, Virginia	Wet, Freeze	Regional	1	95% GA	P-608 at 25 years P-631 at construction	-

Table 3. Agency Case Studies

Agency	LTTP Climate	Statewide Surface Treatment Program Type	General Surface Treatment Material(s)	Site Visit		
				Airports	Surface Treatment Material(s) and Pavement Age at Application	Treatment Age
Missouri Department of Transportation (MoDOT)	Wet, Freeze	National Plan of Integrated Airport Systems (NPIAS) – airports and consultants target-specific pavements Non-NPIAS – MoDOT oversees selection and application of treatments	P-629 (Micro Surface), non-FAA asphalt emulsion with aggregate	Bolivar (M17) Lamar (LLU)	P-629 (Micro Surface) at 18 and 26 years Non-FAA asphalt emulsion with aggregate at 11 and 14 years	3 years 6 years
Tennessee Department of Transportation (TDOT)	Wet, Non-Freeze	State broken into regions with most asphalt within one region targeted each year	P-608	Ellington (LUG)	P-608 at 3, 7, 19, 25, and 39 years	10 months
Utah Department of Transportation (UDOT)	Dry, Freeze	Airports and consultants target specific pavements	P-608, P-626, P-630, P-631, P-632, non-FAA coal tar emulsion, non-FAA asphalt emulsion with aggregate	Skypark (BTF) Brigham City (BMC) Morgan County (42U)	Non-FAA asphalt emulsion with aggregate at 3 years Non-FAA coal tar rejuvenator at 9, 11, 15, and 17 years Non-FAA asphalt emulsion with aggregate at 4 and 8 years	4 years 5 years 2 years
Wisconsin Department of Transportation (WisDOT)	Wet, Freeze	Airports and consultants target specific pavements Treatment selection matrix in development.	P-626, P-631, P-632, non-FAA micro surface	-	-	-
Wyoming Department of Transportation (WYDOT)	Dry, Freeze	State broken into quadrants with most asphalt within one quadrant targeted each year	P-608 P-608-R	-	-	-

SINGLE AIRPORT CASE STUDIES

ABERNATHY FIELD AIRPORT

Abernathy Field Airport (GZS), located in Pulaski, Tennessee, used a now retired Tennessee Department of Transportation (TDOT)-specific TAD-625 Coal-Tar Emulsion Seal Coat on all of its pavements immediately following construction in 2009 and an apron expansion project in 2016 (the TAD-625 is somewhat similar to the FAA's P-631 specification). A cursory visual inspection in 2022 revealed that the treatment coverage was still good considering the surface treatment's age. Only 5% to 10% of coarse aggregate was exposed and minor evidence of wearing patterns were noted, as shown in Figure 2. The condition of paint markings was not impacted by the surface treatment. Faded pockets and minor flaking were the major deterioration mechanisms noted; there did not seem to be a significant FOD concern associated throughout the surface. Cracking of the surface treatment (map cracking) ranges from none to a light pattern of map cracking that does not reach the pavement surface to a light pattern of map cracking that reaches the surface but does not visibly appear to penetrate into the pavement. In localized areas, sealant material within L&T cracks had failed, which was a concern for FOD production. Overall, GZS has determined that the TAD-625 has met its intended objective in protecting the surface for many years. In 2022, based on their satisfaction with the previous treatment, GZS is working with their airport consultant to develop a project that would include reapplication of a coal-tar product.

Figure 2. Tire Wear Pattern on GZS Runway

BOCA RATON AIRPORT

Boca Raton Airport (BCT), located in Boca Raton, Florida, used P-608-R on its runway. This airport is in a hot climate location that receives a very high level of UV exposure compared to the national average. Additionally, the airport has a demanding number of daily operations which limits available closure time. BCT rehabilitated the runway in 2009 and planned to extend its service life by applying a surface treatment after about 10 years. BCT selected P-608-R as its choice of surface treatment based on the limited curing time. In 2018, BCT applied P-608-R on its runway using nightly closures for 2 weeks. Immediately after application, BCT reported that the P-608-R was successful in improving the pavement conditions and the visual delineation with the newly applied pavement markings was very good. However, the finished runway surface had a checkerboard pattern due to the construction sequence and unevenness in the application rate. This pattern has become more noticeable over time as shown in Figure 3. At the end of the useful service life of the existing treatment, BCT plans to mill and overlay the surface.

In 2022, the pavement markings began to peel off under low pressure during a cleaning attempt made at the airport. This is possibly because the markings were applied before the P-608-R was fully cured. BCT restriped the runway shortly after the cleaning attempt. Overall, BCT views the P-608-R as meeting its intended objective by extending the pavement life; however, they were displeased with the coverage pattern, longevity of the treatment, and long-term performance of the paint markings on the P-608-R.

Figure 3. Checkerboard Appearance of P-608-R on BCT Runway 05/23 Approximately 28 Months After Application

CHARLOTTE-MONROE EXECUTIVE AIRPORT (EQY)

Charlotte-Monroe Executive Airport (EQY), located in Monroe, North Carolina, has used multiple types of surface treatments on its taxiway and apron areas, including a coal tar slurry, P-631, and P-632.

EQY applied a coal tar slurry on portions of Aprons E and F in 1996 to protect the pavement from damage due to fuel spills. Details on the specifications used for this material were not available. The treatment has been successful in protecting the asphalt surface from fuel spill damage. A cursory visual inspection in 2022 identified that chipping/raveling was very common and could lead to FOD production. Given the treatment age and condition, the treatment itself has no remaining service life and the apron is being planned to be rehabilitated.

EQY applied P-631 on portions of Aprons A, B, C, and I in 2020 immediately after they were constructed to protect them from fuel spill damage. EQY reported the initial P-631 performance was very good. A cursory visual inspection in 2022 shows that the coverage is good. Fuel spillage was observed in some locations but was not significant enough to create any damage. No distresses were observed on the apron areas and FOD creation was not a concern. Overall, the P-631 surface treatment has performed as intended on the apron areas.

EQY applied P-632 on the taxiways in 2018. This project was carried out through the North Carolina Department of Transportation Pavement Maintenance Project. EQY taxiways consist of pavements that ranged from 5 to 20 years at the time of application. All taxiways had predominantly climate-related distresses and PCIs above 74 in 2019. A cursory visual inspection in 2022 indicates that P-632 coverage was still good across all the applied surfaces with approximately 5% coarse aggregate exposure. P-632 uniformity within an application lane was also good, although some areas received less coverage during application of P-632 as shown in Figure 4. Additionally, P-632 was apparently not able to reduce the loss of fine aggregate as the performance of the P-632-treated pavement was approximately the same as the untreated pavements. Minor spalls were also observed that could lead to FOD generation.

Figure 4. P-632 Coverage Variation

<u>ELKO REGIONAL AIRPORT</u>

Elko Regional Airport (EKO), located in Elko, Nevada, used P-608 on both its runways, both parallel taxiways, and apron areas. This airport is located in a dry climate. The primary runway and primary taxiway network are 6 to 8 years old. The GA apron is 14 to 20 years old and the secondary runway and secondary taxiway network are 30 years old. The airport has implemented a 4-year maintenance cycle and in the latest cycle, P-608 was applied to their pavements in two phases between 2019 and 2020. The phasing of the project was driven by the contractor and weather constraints and was not intentional. P-608 was chosen because most of the pavements had climate- or age-related distresses. The airport's on-call engineering firm and the FAA were also consulted regarding treatment selection.

Immediately after application, EKO reported that P-608 was successful and the visual delineation with the newly applied pavement markings was very good. However, the P-608 material started fading within 1 year of application, possibly accelerated by snow-removal operations. A cursory visual inspection in 2022 revealed very little of the P-608 remaining on the surface of the grooved primary runway but P-608 was present within grooves, as shown in Figure 5. P-608 had no service life remaining at the time of inspection. The primary taxiway and apron had better P-608 coverage than the primary runway, but still between 40% and 80% of the coarse aggregate was exposed. Overall, EKO reports the P-608 did not fully meet its intended objective for these pavements based on the surface coverage.

Figure 5. P-608 Material Visible in EKO Runway 06/24 Groove

The secondary runway and its taxiway network are the oldest asphalt pavements at EKO and are lightly trafficked. These pavements also receive fewer snow-removal operations and had mostly FAIR PCIs during a 2018 inspection. The P-608 was applied during Phase 2 of the project. The coverage on these areas was very good with minimal coarse aggregate exposure. The isolated alligator cracks and other L&T cracks present in this area were not properly addressed before application of P-608. Due to this, the P-608 application did not provide as much benefit as expected. EKO does have a positive impression of the P-608 within Phase 2 due to the better coverage. Phase 2 pavements also have a shorter remaining life due to the age so the maximum benefit from the application of P-608 was less than for the Phase 1 pavements.

NOGALES INTERNATIONAL AIRPORT

Nogales International Airport (OLS), located in Nogales, Arizona, applied P-608 to its single runway and connector taxiways up to the hold bars in 2020. This airport is in a very hot climate location with a very high level of UV exposure compared to the national average. Before application, the pavements were in FAIR condition with weathering and L&T cracking the predominant distresses. This pavement was 15 years old at the time of application. With input from their on-call engineering firm and FAA advisory circulars, OLS selected P-608 with the goal of extending the pavement life. OLS used the FAA Airport Improvement Program (AIP) to fund the bulk of the application project.

Immediately after application in 2021, OLS reported that P-608 was successful in improving pavement conditions and the visual delineation with the newly applied pavement markings was very good. A cursory visual inspection in 2022 revealed that coverage over the surface was still adequate in most locations; however, coverage was noticeably lighter in high traffic areas as shown in Figure 6. Tire marks were apparent in all areas of application. The P-608 did not prevent the formation of new cracks or prevent existing cracks from widening. There were no general FOD concerns in the treated areas. Overall, OLS views the P-608 as meeting its intended objective by shielding the pavement from high UV exposure.

Figure 6. P-608 Coverage Along Taxi Line at OLS

PHOENIX SKY HARBOR INTERNATIONAL AIRPORT

Phoenix Sky Harbor International Airport (PHX) in Phoenix, Arizona, used two non-FAA surface treatments on portions of their taxiway and apron areas. PHX is a large hub airport with a high volume of traffic. Additionally, it receives a very high level of UV exposure compared to the national average, which is detrimental to the long-term performance of asphalt pavement.

PHX had used RS-44E, a non-FAA coal tar rejuvenator surface treatment, on their pavements in the past. However, in 2012 they stopped using that product due to health concerns. This treatment gave off a strong odor which negatively impacted ground crews, flight crews, and passengers, especially in hot weather shortly after application. The West Cargo Apron was constructed in 2008 and received RS-44E in 2011. A cursory visual inspection carried out in 2022 revealed that the RS-44E had reached the end of its service life with 90% of the coarse aggregate and 50% of the fine aggregate exposed. Fading of the treatment was widespread, but no flaking or peeling of the surface were noted and FOD production was not present. Climate-related cracking of the asphalt continued to develop and the crack sealant in some previously sealed cracks was in failed condition. In terms of pavement preservation, the airport had been satisfied with RS-44E.

In 2016, PHX used Acrylic Coat, a non-FAA asphalt emulsion surface treatment, on Taxiway A and the East Cargo Apron area, both of which were constructed in 2013. The treatment is an emulsion based on cationic binders and polymers and was introduced to replace RS-44E. This product maintains its color well, delineates different surfaces, and does not produce a strong odor. A cursory visual inspection in 2022 showed that Acrylic Coat had good coverage on the taxiway, with only 5% coarse aggregate exposed, but was near the end of its service life on the apron area, with approximately 75% coarse aggregate exposed. L&T cracking on the East Cargo Apron, which was partially present prior to the treatment application, was extensive. A streaking pattern was present on the surface treatment as seen in Figure 9. New cracks had continued to develop on all pavements. Fading seemed to be the major deterioration mechanism in both locations. FOD production was not a concern as no flaking or chipping was observed for the Acrylic Coat. Overall, the airport has been satisfied with the pavement performance of Acrylic Coat. The longevity of Acrylic Coat is slightly less than RS-44E, but it does not produce the strong, offensive odor of RS-44E.

Figure 7. East Cargo Apron at PHX With Acrylic Coat

WINCHESTER REGIONAL AIRPORT

Winchester Regional Airport (OKV), located in Winchester, Virginia, used P-608 on Taxiway A and P-631 on a parking apron. The approximate areas of surface treatment application on Taxiway A and the apron were 24,000 square yards and 8,600 square yards, respectively. Taxiway A was previously rehabilitated in 1995 and is planned to be relocated in phases between 2022 and 2027. With the relocation in mind, OKV wanted to extend the taxiway's service life until the start of the relocation work with the application of a surface treatment. In 2020, Taxiway A was in FAIR condition, with the following primary distresses: weathering, L&T cracking, and raveling. After consultation with the FAA, OKV decided to use P-608 on Taxiway A as this surface treatment is well-suited for application on pavements in FAIR condition with predominantly climate-related distresses. Additionally, it was believed it would be the most cost-effective maintenance strategy for OKV to preserve the Taxiway A pavement until the relocation project was completed.

The P-608 application occurred in 2020, and immediately after application, OKV reported that the P-608 was successful in improving the pavement condition. Also, with its dark color, the visual delineation with the newly applied pavement markings was very good. Some areas received double treatment due to overlap of the spray distributor, and those areas were easily visible in early 2022, as seen in Figure 8. No FOD concern was apparent at the airport. It has yet to be determined if the surface treatment has extended the life of the pavement.

Figure 8. Typical P-608 Application and Overlap on Taxiway A

In another project at the OKV, P-631 was applied to apron pavement constructed in 2015 to protect it from fuel spillage. At the time of this writing, OKV views the P-631 as meeting its intended objective.

AGENCY CASE STUDIES

MISSOURI DEPARTMENT OF TRANSPORTATION

For NPIAS airports, the Missouri Department of Transportation (MoDOT) allows airports and consultants to target specific pavements with surface treatments rather than follow a uniform approach for surface treatment application. For non-NPIAS airports, MoDOT oversees the selection and application of surface treatments. MoDOT has used P-629 micro surface at multiple airports in Missouri. Additionally, they have used MoDOT-specific MO-623 at NPIAS airports prior to 2018 and have continued to use MO-623 at some non-NPIAS airports after 2018. MO-623 met FAA specifications prior to the release of AC 150-5370-10H.

A P-629 (Micro Surface) was applied on runway, taxiway, and apron pavements at Bolivar Municipal Airport (M17) in 2019. M17 selected the treatment based on recommendations and experiences of several other airports. Application was completed without any major issues. The helicopter landing pad area needed 2 weeks of curing time to fully support the skids without damaging the material. M17 reported that the P-629 material met its intended purpose of improving pavement condition immediately after application. M17 takes extra care during snow plowing by keeping the blade ½-inch off the pavement surface so the surface treatment does not get scraped. A cursory visual inspection in 2022 revealed that the P-629 is still performing well with good coverage on all pavements. The surface is highly textured as shown in Figure 9. The treatment maintained its black color except for certain locations compromised by fuel spillage. Cracks were appearing at some locations and the cracking pattern indicates that the underlying pavement is continuing to develop new cracks and older cracks continue to widen. Sealant was also failing in some crack locations.

Figure 9. P-629 Texture on M17 Taxiway

An MO-623 Pavement Friction Seal Coat Surface Treatment was applied at Lamar Municipal Airport (LLU) in 2016 on runway, taxiway, and apron pavements constructed between 2002 and 2005. At the time of application, this material met FAA AC 150-5370-10G specifications. A cursory visual inspection in 2022 revealed that the MO-623 coverage had deteriorated over the 6 years since application, with exposed coarse aggregate present in almost half the taxiway and apron areas and a quarter of the runway area. The pavement markings placed in 2016 were very worn but the surface treatment still appeared to be black. Cracks were appearing at some locations and the cracking pattern indicated that the underlying pavement was continuing to develop new cracks and older cracks continued to widen.

Overall, MO-623 was successful in extending the pavement life. MoDOT reported that based on their experience, MO-623 is a cost-effective and longer lasting treatment than P-608. The treatment provides good visual delineation due to its black color, as shown in Figure 10. The sourcing of "Black Beauty" sand used in MO-623 is very limited. Due to this and the lack of inclusion within the FAA specifications for NPIAS airports, MoDOT is currently promoting use of P-608 or P-631 instead of MO-623. LLU believes MO-623 should be given preference as its advantages far exceed the difficulty in acquiring specialized aggregate.

Figure 10. MO-623 Texture on LLU Apron

TENNESSEE DEPARTMENT OF TRANSPORTATION

Beginning in 2020, the Tennessee Department of Transportation (TDOT) initiated a program to perform widespread crack sealing, surface treatment application, and pavement marking application for airfields in groups (based on region), with the goal of performing preventive pavement maintenance to the greatest extent possible within a constrained budget. Ellington Airport (LUG) in Lewisburg, Tennessee, was in a region included in TDOT's airfield pavement and marking maintenance program in 2021. TDOT arranged open-bidding for contractor selection with the option of using either P-608 or P-623. All of the bidders proposed P-608; therefore, it was the surface treatment applied under this program around the state. P-608 was applied to the majority of asphalt pavements at LUG. This airport has pavements with ages varying from 4 years for the runway to 39 years for the taxiway. Some apron pavements are between 19 and 25 years old. Along with the varied age of their pavements, pavement conditions at LUG also varied from POOR to GOOD. The predominant pavement distresses included weathering, L&T cracking, and raveling.

Immediately after application in 2021, LUG reported that P-608 was successful in improving pavement conditions. Since application, the treatment has faded and gives the appearance of deteriorating pavement. From a cursory visual inspection in 2022, the P-608 application was likely non-uniform as shown in Figure 11. Between 50% and 60% of the coarse aggregate was exposed throughout much of the application area. However, P-608 was applied on the apron over a previously applied P-631, which made it difficult to assess the current condition of the P-608. The P-608 application itself appears uniform and there is only 5% exposed coarse aggregate. Some white precipitates had formed within the cracks. The majority of the crack sealant was in good condition on all pavements. There is no FOD concern related to these surface treatments. Overall, however, LUG reports the P-608 failed to meet their objectives due to its early fading. TDOT, in general, has been satisfied with their approach of widespread application of P-608 across the state and its use in extending pavement life.

Figure 11. Ellington Airport Runway 02/20

UTAH DEPARTMENT OF TRANSPORTATION

The Utah Department of Transportation (UDOT) has overseen multiple FAA and non-FAA surface treatments at airports under its jurisdiction. These include P-608, P-626, P-630, P-631, P-632, a non-FAA asphalt emulsion with aggregate (Onyx Frictional Mastic), and a non-FAA coal tar emulsion (retired P-604 Coal Tar Fog Seal). UDOT allows airports and consultants to target specific pavements with surface treatments rather than having a uniform approach for surface treatment application. UDOT used the FAA surface treatments at several of its general aviation airports from 2016 to 2021. In most cases, the pavements were in SATISFACTORY condition, exhibiting predominantly climate-related distresses before application of surface treatments. Selection of a specific surface treatment for an airport is usually done in consideration of variables such as cost, climatic condition, traffic, and application time. Additionally, FAA guidance and consultant/designer recommendations are also used in the decision process. UDOT reported that all FAA materials are successful in meeting their intended purposes immediately after application by improving pavement condition and increasing marking visibility. No major construction constraints were faced during application. Overall, UDOT believes that FAA surface treatment materials are working as intended and have performed well to extend pavement life. In general, UDOT plans to reapply the same FAA treatments once their benefits diminish.

Apart from the FAA surface treatments, UDOT airports have also had non-FAA materials applied. A proprietary non-FAA asphalt emulsion with aggregate (Onyx Frictional Mastic) has been used on runways, taxiways, and aprons at general aviation airports such as Skypark Airport (BTF) and Morgan County Airport (42U). Both airports selected Onyx due to its expected performance and dark color. BTF applied Onyx 3 years after a pavement rehabilitation project and 42U applied Onyx to pavement that was 4 or 8 years old. In both cases, it was successful in improving pavement condition and the visual delineation with the newly applied pavement markings was very good. No construction issues were reported to occur during application. A cursory visual inspection at both airports in 2022, 4 years after application at BTF and 2 years after application at 42U, revealed that the frictional mastic was maintaining good coverage. Less than 5% of exposed coarse aggregate was exposed at BTF and less than 1% of the coarse aggregate was exposed at 42U. The texture of the pavement with Onyx is shown in Figure 12. Smooth areas due to snow removal operations and very slight wear in a few high traffic areas were the only deterioration observed in the inspection at both airports. FOD production of the surface treatment was not a concern. Overall, both airports had positive opinions on the performance of the frictional mastic.

UDOT also used a Coal Tar Fog Seal Coat conforming to the requirements of the cancelled FAA Engineering Brief 44B on taxiway and aprons at Brigham City Airport (BMC) in 2017. The taxiways and aprons were 9 to 11 years and 12 to 17 years old at application, respectively. A cursory visual inspection in 2022 revealed that coverage was FAIR, with 10 to 30% coarse aggregate exposed. For older pavements, L&T cracking and block cracking were common. Fading and scraping from snowplows were the most common deterioration of the coal tar. Pavement marking delineation remained good in 2022.

Figure 12. Skypark Airport Runway 17/35 Texture

WISCONSIN DEPARTMENT OF TRANSPORTATION

Wisconsin Department of Transportation (WisDOT) has overseen multiple FAA and non-FAA surface treatments at airports under its jurisdiction. These surface treatments include P-626, P-631, P-632, and WisDOT P-652 Micro-Surfacing. Historically, airports and consultants target specific pavements with surface treatments rather than a uniform approach. WisDOT is currently working on developing a matrix to select different surface treatment types. Factors considered in developing the matrix include PCI, age of pavement, user experience, cost, future rehabilitation schedule, and engineering judgement. WisDOT also currently receives recommendations for the application of surface treatments and resurfacing through consultant analysis within the airport pavement management system.

WisDOT has used P-626 on runways, taxiways, aprons, shoulders, and acute-angled exit taxiways at multiple airports. One result of that use is that WisDOT has customized the P-626 specification to reduce the amount of aggregate and thereby decrease the FOD potential. WisDOT reported that contractors sometimes encountered problems with P-626 applications, including, but not limited to: emulsion failing, temperature variation, aggregate clumping, and high moisture content. WisDOT is working on a strategy to better address these issues as they relate to future maintenance. Generally, the P-626 applications have met their intended purpose of improving pavement condition.

P-631 has been used on aprons at some Wisconsin airports to improve their resistance to fuel spillage; however, WisDOT is currently in the process of phasing out P-631 due to the ban on coal tar products by various local government agencies throughout Wisconsin.

P-632 was applied on the taxiway of New Holstein Municipal Airport (8D1) in 2019. The treatment performed as intended immediately after application and the visual delineation with the newly applied pavement markings was very good. An inspection after 2 years revealed that the P-632 was significantly worn and barely visible. WisDOT is currently not using P-632 due to its lower life expectancy and need for frequent application.

The use of WisDOT P-652 Micro-Surfacing has been gaining interest throughout Wisconsin airports since 2018. From 2018 through 2021, the number of applications per year of WisDOT P-652 surpassed those of P-626. P-652 is more expensive than P-626, but is also believed to have slightly better performance over its life. WisDOT used P-652 at Stevens Point Municipal Airport (STE) in 2014. STE reported that P-652 provides better runway visibility due to its black color when compared to an untreated surface. No crack sealants are required before the application of P-652. WisDOT reported that P-652 also provides better surface drainage than P-626. Most airports have not experienced any construction issues with WisDOT P-652 after application. WisDOT currently does not have any firm limits on P-652 placement location regarding traffic volume. They recommend using engineering judgement on a case-by-case basis to determine its suitability.

WYOMING DEPARTMENT OF TRANSPORTATION

The Wyoming airport system is split into four quadrants. The Wyoming Department of Transportation (WYDOT) performs preservation work in one quadrant per year. WYDOT has used P-608 at their airports on all pavement surfaces, including runways, taxiways, aprons, blast-pads, and shoulders. Additionally, they have also used P-608-R on some of the runways at the nine commercial service airports where pavement closure time is a concern. WYDOT feels that by splitting the state into quadrants they get better unit bidding prices from contractors. Pavements are selected for surface treatment work if PCI is generally above 70 and there is no planned major rehabilitation within the next 4 years. WYDOT's expected lifespan for the P-608 and P-608-R treatments is up to 4 years. The dilution rate for both products is 2:1 for grooved runways and 1:1 for other pavements. Sand may be added over the P-608 for some airports. WYDOT reported that both P-608 and P-608-R had mostly met their intended purpose immediately after application and the visual delineation with the newly applied pavement markings was very good. Over the life of the treatment, minor pavement distresses have decreased. Overall, WYDOT believes that P-608 and P-608-R are working as intended and have successfully extended pavement life.

OBSERVATIONS

SURFACE TREATMENT LOCATIONS

As described in the case study summaries, surface treatments are used on runways, taxiways, connecting taxiways, and aprons. The P-608 and P-608-R treatments were the most widely used treatments on runways, which corresponds to the FAA guidance on where these treatments can be used. There was one instance each of P-626 and P-629 use on runways. As noted in Table 1, this is a permitted use subject to loading limitations.

For taxiways and aprons, where surface treatments have far fewer restrictions, a broad range of treatments were reportedly used. For example, taxiways were treated with P-608, an acrylic seal, P-626, P-629, and P-632; and several state-specific materials. Aprons were reported to be treated with P-608, P-626, P-629, and P-631; and several state-specific materials. A coal tar product was more likely to be used on aprons to protect against fuel spills.

CONSIDERATIONS IN USING SURFACE TREATMENTS

There are many considerations in using surface treatments on airfield pavements. Some of the guidelines provided for use in AC 150-5370-10H (FAA, 2018) are summarized in Table 1 in the column headed "Existing Pavement Condition". These include:

- PCI rating
- Presence of specific distresses
- SCI rating
- Absence of structural distresses
- Low to moderate environmental distresses
- Protection from fuel spills

When the case study airports and agencies were asked why they had selected a specific surface treatment, many different reasons were given, including the following:

- Buy time until planned rehabilitation: This suggests that the pavement is not in very good condition and, while it is recognized that rehabilitation is needed, either the funding or the schedule of planned work does not allow it. A surface treatment may be used to bind the pavement surface together until the rehabilitation work can be performed. This can help to reduce the FOD potential (as specifically mentioned by one user) and improve the overall visual appearance of the pavement.

- Extend pavement life: Surface treatments applied while the overall pavement condition is fairly good are providing a preservation or preventive maintenance benefit and are potentially adding years to the life of the pavement; in effect, they delay the time until pavement rehabilitation or reconstruction is needed. Ellington Airport is an example of a surface treatment user that mentioned preventive maintenance as the reason for use. However, surface treatments applied as a stopgap measure later in the pavement's life are "buying time" as described above.

- Improve overall condition: Several users identified the ability of surface treatments to improve overall pavement condition (WisDOT) and address climate- or age-related distress (Elko). These reasons are, in effect, similar to extending pavement life.

- Improve visibility: Several of the airports gave this as a reason to use a specific surface treatment. Some of the treatments are very dark when applied, and these treatments improve contrast between pavement features (such as the mainline pavement and shoulder), between the pavement and markings, and between the pavement and infield areas.

- Protect pavement from fuel spills: Aviation fuel spilled on an asphalt surface softens the asphalt and contributes to pavement damage. Certain surface treatments do not break down when exposed to fuel spills, so they are likely to be considered on aprons where fueling can or has caused damage.

- Improve friction: Several airports cited improved friction as a reason to use a specific treatment. This was surprising in some cases where the treatment did not include a substantial amount of aggregate and is not expected to increase friction. Generally, the ability to improve friction would only be provided by a surface treatment with a substantial aggregate component.

- Blanket agreement: Some public agencies (e.g., cities and states) have blanket agreements with contractors or material suppliers for one or more treatments, and these agreements apply to airports that the agencies own or operate. These agreements, which can last for 1 or more years, facilitate access to specific treatments and make it more difficult, if not impossible, to use any treatment not covered by the agreement. In other words, when an airport is considering the use of a surface treatment, it is limited to using one covered by the agreement or purchase order. The approved treatments end up being applied to all pavement surfaces requiring a treatment.

In considering the various reasons given for using surface treatments, it is also important to consider some of the instances in which these surface treatments are not effective.

- Do not keep existing cracks sealed for very long.
- Do not prevent existing cracks from widening.
- Do not keep the pavement surface permanently dark.

RECOMMENDATIONS FOR MODIFICATIONS TO SPECIFICATIONS (FAA AC 150/5370-10H) AND OTHER ADVISORY CIRCULARS

The work completed to date is insufficient to recommend specific modifications to various FAA Advisory Circulars. This section provides an overview of where those changes are needed and when more definitive recommendations can be made.

FAA ADVISORY CIRCULAR 150/5370-10H, DATED DECEMBER 21, 2018: STANDARD SPECIFICATIONS FOR CONSTRUCTION OF AIRPORTS

Part 8 of this AC covers surface treatments. The focus of the specification for each surface treatment is on materials, test methods, and construction. However, each specification also includes mention of the applicability or appropriateness of the surface treatment. The following changes are needed:

- Reference PCI ranges as triggers for the treatment.
- Identify specific distresses the treatment does and does not address.
- Review the need for load restrictions, as none of the surface treatments are structural.
- Add marking and pavement delineation as a reason for selection.
- Reconsider the need for restrictions associated with the pavement branch (runway; taxiway; apron; or primary, secondary, or tertiary).
- Consider restrictions for certain treatments on grooved pavement.

With the completion of Phase 2 of this project it is expected that sufficient observation-based data will be gathered to address these bullet points.

FAA AC 150/5380-6C, DATED OCTOBER 10, 2014: GUIDELINES AND PROCEDURES FOR MAINTENANCE OF AIRPORT PAVEMENTS

In general, there is a significant emphasis on maintenance treatments but scant reference to surface treatments. Surface treatments can play a role in pavement maintenance, both as a stopgap treatment and as a preservation or preventive treatment. With that in mind, the following changes should be considered.

- Add mention of surface treatments in section 2.2.1.
- Add preservation or preventive maintenance in Chapter 5; for example, as a section 5.3.
- Make the general references to “surface treatments” in Table 6.1 more specific.
- Either add more information to this AC or add a reference to where more information on airport pavement surface treatments can be found.

With sufficient changes, this AC could be renamed as “Guidelines and Procedures for the Maintenance and Preservation of Airport Pavements.” However, it should also be noted that this project only addresses surface treatments for hot mix asphalt pavements and does not address preservation of Portland cement concrete pavements.

FAA AC 150/5380-7B, DATED OCTOBER 10, 2014: AIRPORT PAVEMENT MANAGEMENT PROGRAM,

There are two references to surface treatments in this document: as a label in Figure 2, and as a maintenance activity in section 2.4.6. It would be beneficial to airports to introduce an expanded discussion of pavement preservation, to include the impact of surface treatments on pavement condition when applied to pavements in good condition. This text could be written based on available knowledge but would be more impactful if developed based on observations made during Phase 2 of this project.

FAA AC 150/5320-12C, DATED MARCH 18, 1997: MEASUREMENT, CONSTRUCTION, AND MAINTENANCE OF SKID RESISTANT AIRPORT PAVEMENT SURFACES

Acknowledging that a draft update to this AC is available from FAA, it is noted that it would be beneficial to add appropriate surface treatments (i.e., those with added aggregate) as a means of restoring friction lost through mechanisms other than rubber build-up.

FAA AC 150/5320-12D (DRAFT), MEASUREMENT AND MAINTENANCE OF SKID-RESISTANT AIRPORT PAVEMENT SURFACES

This DRAFT has been available since 2016, creating uncertainty about applying its content versus that in 5320-12C noted above. Nonetheless, the following considerations for changes are identified:

- Section 2.6 identifies slurry seals as a temporary means of improving skid resistance. While the need for a life-cycle cost analysis is noted, is it necessary to identify this as temporary?
- If other approaches to surface texture determination in Phase 2 prove beneficial, consider adding these to this AC.
- The first paragraph of section 4.1 mentions fog seals, but is this also the case for other treatments? Does it change if aggregates are added to the treatments? Consider addressing this in the text.
- Consider identifying other surface treatments (and their P-specification) that can improve friction.

ADDITIONAL OBSERVATIONS

Guidance addressing the following aspects of surface treatments are emphasized as being needed:

- The relationship between various pavement distresses and the applicability of different surface treatments.

- Contrast between markings and other pavement branches as a reason for selecting surface treatments.
- Conditions under which surface treatments provide little benefit.
- Language explaining the difference between preventive maintenance applications and stopgap applications.
- Information on treatment life expectancy, perhaps based on condition of existing pavement.
- A timely approach and defined procedure for evaluating and approving new airport pavement surface treatments, including consideration of locally funded surface treatments with a record of successful use.

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APPENDIX A—CASE STUDIES ON AIRPORT EXPERIENCE WITH SURFACE TREATMENTS

BACKGROUND

Twelve airports and agencies with surface treatment experience provided information to develop case studies. Table A-1 identifies the airports and Table A-2 identifies the case study agencies. The locations of the case studies are shown in Figure A-1. The following case studies identify the treatments that were used by the case study airports or agencies.

To gain more insight into these surface treatments, airports falling within eight case studies were visited. Five single airports and six airports tied to three agencies were visited. As part of the visits, photographs were taken of selected conditions and observations were made of the performance of the surface treatment(s). Below is a brief description of each category of observations that were made.

- Surface Coverage: estimated percentage of coarse aggregate and binder (fine aggregate and bitumen) exposed, along with other notes such as if a superficial map cracking pattern is present. The surface coverage provides insight into the amount of protection being provided to the underlying asphalt pavement at the time of inspection.

- Surface Texture Observations: qualitative comments regarding visual appearance of macrotexture along with variation throughout the treatment. The appearance of the surface texture is compared to the apparent texture of the underlying (untreated) asphalt where possible.

- Distress Observations: identification of typical and atypical distresses present based on ASTM D 5340. Distresses from previous ASTM D 5340 inspections were referred to when available.

- Reported Duration and Impact on Friction: input from airport or agency staff regarding friction (particularly for using aircraft) where surface treatments have been applied.

- Surface Treatment Appropriate at Application: comments (based on available FAA guidance) on whether the pavement likely was a good candidate for the surface treatment applied.

- Estimated Remaining Service Life/Remaining Benefit Life: based on the condition at inspection, environmental conditions, traffic, and known history, this is an estimate of how many more years the surface treatment could provide a benefit (predominately protection of the binder).

- Uniformity of Coverage/Streakiness: assessment of the uniformity of the surface treatment coverage.

- Wearing Patterns of High Traffic and Low Traffic Areas: evaluation of the uniformity of the surface treatment associated with traffic patterns.

- Deterioration Mechanism (Wearing/Fading, Flaking, Chipping): description of how the surface treatment is deteriorating. The mechanism can vary depending on the thickness of the surface treatment and presence of aggregate.

- Noticeable Impacts on Pavement Markings: assessment of whether the pavement markings are deteriorating at a different rate compared to untreated pavement and other comments regarding the visual delineation between the pavement markings and the surface treatment.

- FOD Concerns Associated with Surface Treatment or Pavement Distresses: whether FOD is produced by the surface treatment.

- Condition of Maintenance Occurring Prior to Application and After Application: qualitative comments regarding any maintenance that has been performed.

- Estimated Pavement Condition Deterioration Since Last PCI Inspections and/or Application: when applicable, previous ASTM D 5340 inspections were referenced to identify pavement deterioration.

- Additional Interviews with Airport or Agency Staff: staff were asked about other effects of the surface treatments such as the frequency of sweepers used on the surface treatment.

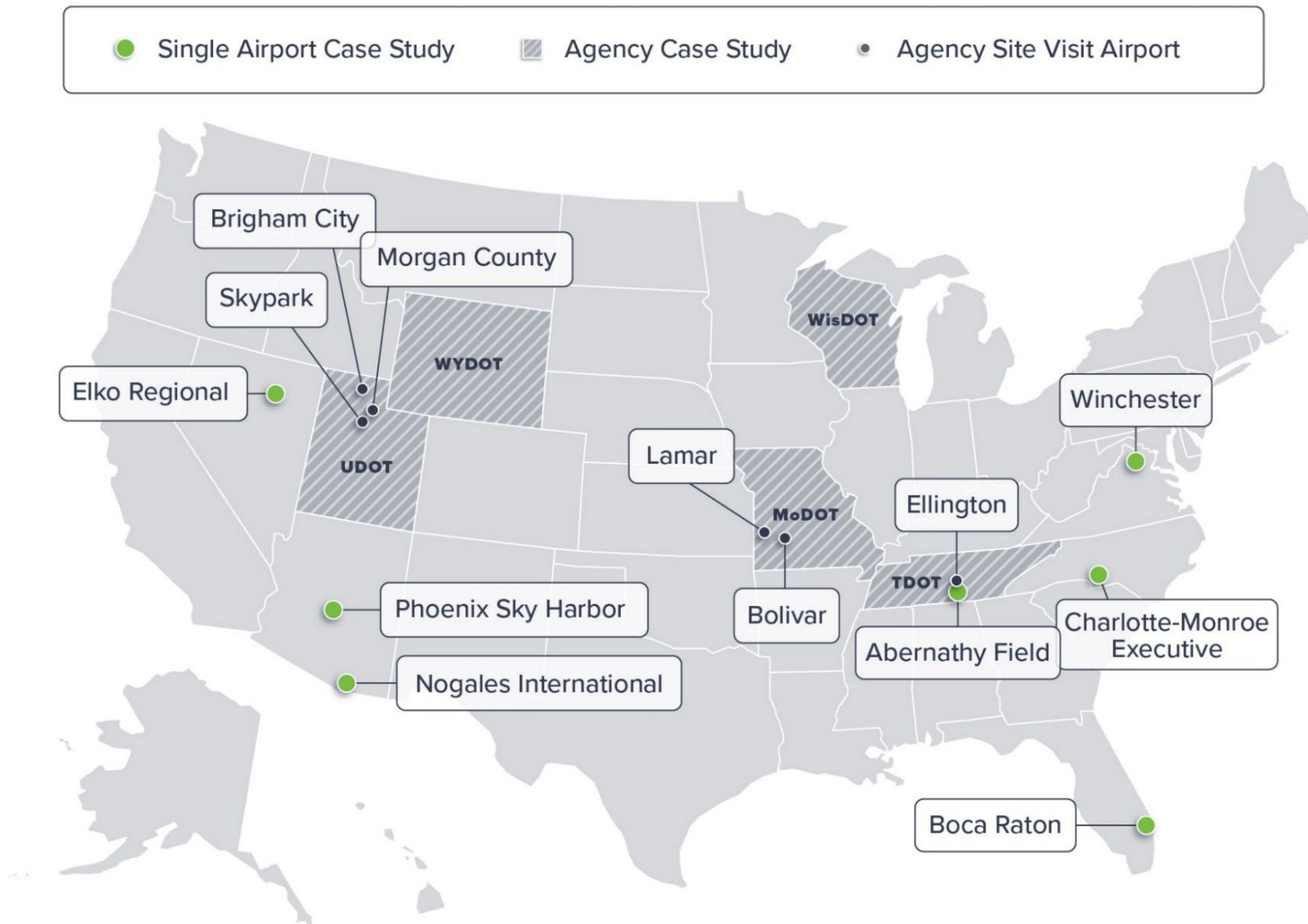

Figure A-1. Location of Case Studies

Table A-1. Single Airport Case Studies

Airport	Location	LTTP Climate	Airport Category	Runway(s)	Primary Traffic Type	Surface Treatment Material(s) and Pavement Age at Application	Treatment Age at Site Visit
Abernathy Field Airport (GZS)	Pulaski, Tennessee	Wet-No Freeze	Local	1	90% General Aviation (GA)	Non-FAA coal tar emulsion at overlay	13 years
Boca Raton Airport (BCT)	Boca Raton, Florida	Wet-No Freeze	National	1	93% GA	P-608-R at 10 years	-
Charlotte-Monroe Executive Airport (EQY)	Monroe, North Carolina	Wet-No Freeze	Regional	1	91% GA	A coal tar slurry at construction P-631 at initial construction P-632 at 10 and 25 years	Coal tar slurry at 25 years P-631 at 2 years P-632 at 4.5 years
Elko Regional Airport (EKO)	Elko, Nevada	Dry-Freeze	Nonhub	2	71% GA	P-608 at 6, 8, 14, 20, and 30 years	2 years
Nogales International Airport (OLS)	Nogales, Arizona	Dry-No Freeze	Local	1	87% GA	P-608 at 15 years	2 years
Phoenix Sky Harbor International Airport (PHX)	Phoenix, Arizona	Dry-No Freeze	Large Hub	3	88% Commercial	Non-FAA asphalt emulsion at 3 years Non-FAA coal tar rejuvenator at 5 years	6 years 11 years
Winchester Regional Airport (OKV)	Winchester, Virginia	Wet-Freeze	Regional	1	95% GA	P-608 at 25 years P-631 at construction	-

Table A-2. Agency Case Studies

Agency	LTTP Climate	Statewide Surface Treatment Program Type	General Surface Treatment Material(s)	Site Visit		
				Airports	Surface Treatment Material(s) and Pavement Age at Application	Treatment Age
Missouri Department of Transportation (MoDOT)	Wet, Freeze	National Plan of Integrated Airport Systems (NPIAS) – Airports and consultants target specific pavements Non-NPIAS – MoDOT oversees selection and application of treatments	P-629 (Micro Surface), non-FAA asphalt emulsion with aggregate	Bolivar (M17) Lamar (LLU)	P-629 (Micro Surface) at 18 and 26 years Non-FAA asphalt emulsion with aggregate at 11 and 14 years	3 years 6 years
Tennessee Department of Transportation (TDOT)	Wet, Non-Freeze	State broken into regions with most asphalt within one region targeted each year	P-608	Ellington (LUG)	P-608 at 3, 7, 19, 25, and 39 years	10 months
Utah Department of Transportation (UDOT)	Dry, Freeze	Airports and consultants target specific pavements	P-608, P-626, P-630, P-631, P-632, non-FAA coal tar emulsion, non-FAA asphalt emulsion with aggregate	Skypark (BTF) Brigham City (BMC) Morgan County (42U)	Non-FAA asphalt emulsion with aggregate at 3 years Non-FAA coal tar rejuvenator at 9, 11, 15, and 17 years Non-FAA asphalt emulsion with aggregate at 4 and 8 years	4 years 5 years 2 years
Wisconsin Department of Transportation (WisDOT)	Wet, Freeze	Airports and consultants target specific pavements Treatment selection matrix in development.	P-626, P-631, P-632, non-FAA micro surface	-	-	-
Wyoming Department of Transportation (WYDOT)	Dry, Freeze	State broken into quadrants with most asphalt within one quadrant targeted each year	P-608 P-608-R	-	-	-

Abernathy Field Airport (GZS) Surface Treatment Case Study

AIRPORT BACKGROUND

Abernathy Field Airport (GZS) is a single-runway general aviation airport, located 3.7 mi southwest of the central business district of Pulaski, in Giles County, Tennessee. The airport is owned and operated by the City of Pulaski and Giles County, and it is classified as a local airport per the Federal Aviation Administration's (FAA) National Plan of Integrated Airport Systems (NPIAS) (FAA, 2020). There are 19 aircraft based at GZS. The average daily number of operations as of 2019 was 24, and 90% of the daily movements were classified as general aviation and the remainder of the operations are air taxi services and government operations (AirNav, April 2022).

GZS falls in the Wet, Non-Freeze Long-Term Pavement Performance (LTPP) climate zone. The Köppen-Geiger climate classification of GZS is warm temperate-steppe-cool summer. The annual average daily dose of ultraviolet (UV) irradiance in Giles County is approximately 2,871 joules/m², which is only 6% higher than the national average of approximately 2,700 joules/m² (Centers for Disease Control and Prevention [CDC], 2022). The city of Pulaski experienced 56 in. of average annual precipitation during the last 5 years (National Weather Service [NWS], 2022).

TAD-625 COAL-TAR EMULSION SEAL COAT

Runway 16/34 at GZS is 5,310 ft long and 75 ft wide. A 40-ft-wide taxiway connects the runway to the apron. In 2009 the apron was expanded, and an overlay was placed on all remaining airport pavements. A coal-tar pitch emulsion seal coat (TAD-625 Seal Coat) was applied on all pavements after the 2009 overlay. Additionally, TAD-625 was applied in some areas on the apron in 2016. The TAD-625 is similar to the FAA's P-631 specification.

A visual inspection of the current condition of TAD-625 at GZS was performed in March 2022. The inspection revealed that the TAD-625 was in acceptable condition with good coverage. Binder was exposed in very few areas where scaling had occurred. Approximately 5-10% of the coarse aggregate were exposed. The macrotexture of TAD-625 was not apparent during the inspection, but a significant amount of "grit" on the surface was observed in dry conditions. In some areas, the macrotexture reflected the underlying pavement. Pavement markings were not impacted by the surface treatment. They were worn, but the delineation was still good.

Flaking was present but is not a considerable foreign object debris (FOD) concern. A map cracking pattern was also very apparent in many locations, and a tire wearing pattern was visible longitudinally along portions of Runway 16/34. Longitudinal and transverse (L&T) cracking along the longitudinal paving joints on Runway 16/34 was observed. Additionally, low-severity L&T cracking and medium-severity L&T cracking with spalling and a minor amount of suspected pumping were observed at the end of Runway 34. L&T cracking was common throughout the apron and was approaching the density of block cracking in some areas. The L&T cracking on the apron included a mixture of sealed and unsealed cracks. Most of the L&T cracking was at low severity; some medium-severity L&T cracking was present due to a mixture of failed sealant and minor spalling. Vegetation was also present in some cracks.

The Pavement Condition Index (PCI) of the pavement sections ranged between 72 and 84 in the 2019 inspection. Based on the continued deterioration of the surface treatment and the condition of the cracks, PCIs could have been between 5 and 10 points lower in 2022. In 2022, a project to reapply a coal tar product at GZS is being planned due to the satisfaction with the longevity of the surface treatment. Pictures of the GZS Runway overview, TAD-625 coverage, and tire marks in 2022 are presented in GZS-1 through 13.

Figure GZS-1. Runway 16/34 Overview with TAD-625

Figure GZS-2. TAD-625 Coverage on Runway 16/34

Figure GZS-3. TAD-625 texture on Runway 16/34

Figure GZS-4. Tire Marks on Runway 16/34

Figure GZS-5. Cracking on Runway 16/34

Figure GZS-6. Raveling on Runway 16/34

Figure GZS-7. Connector Taxiway Overview with TAD-625.

Figure GZS-8. TAD-625 Texture on Connector Taxiway

Figure GZS-9. Apron Overview with TAD-625

Figure GZS-10. TAD-625 Texture on Apron

Figure GZS-11. Map Cracking on Apron

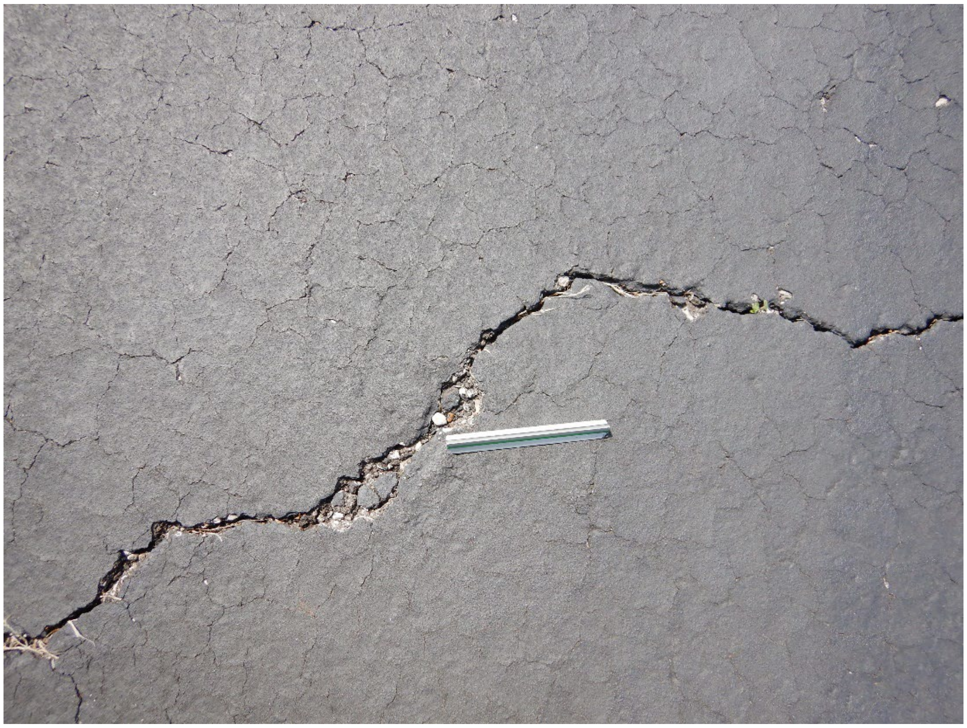

Figure GZS-12. Cracking on Apron

Figure GZS-13. Raveling on Apron

Boca Raton Airport (BCT) Surface Treatment Case Study

AIRPORT BACKGROUND

Boca Raton Airport (BCT) is a single-runway airport located 2 mi northwest of the central business district of Boca Raton, a city in Palm Beach County, Florida. The airport is owned and operated by the Boca Raton Airport Authority and is classified as a National airport per the FAA's NPIAS (FAA, 2020). There are about 200 aircraft based at BCT, and the average daily number of operations as of 2018 was 223. Ninety-three percent of the daily movements were classified as general aviation, while the remainder of the operations are air taxi services and military operations (AirNav, February 2022).

BCT falls in the Wet, Non-Freeze LTPP climate zone. The Köppen-Geiger climate classification of BCT is equatorial-monsoonal. BCT experiences high UV radiation and long seasons of high average temperatures. Within Palm Beach County, the annual average daily dose of UV irradiance is approximately 3,900 joules/m², which is 44% higher than the national average of approximately 2,700 joules/m² (Centers for Disease Control and Prevention [CDC], 2022). This level of irradiance creates a severe environment for long-term asphalt pavement performance. Palm Beach County has experienced 60 in of average annual precipitation during the last 5 years (NWS, 2022).

P-608-R RAPID CURE SEAL COAT

The single runway (Runway 05/23) at BCT is 6,276 ft long and 150 ft wide. It is supported by a full-length parallel taxiway that is 45 ft wide. The runway was reconstructed in 2009, with a design life of 20 years. The weight limit on the runway is 95,000 pounds. To extend pavement life and safeguard their investment, BCT planned to apply a surface treatment at approximately the mid-point of the runway's expected life. Florida Department of Transportation (FDOT) inspects pavement conditions at BCT biannually under the statewide airport pavement management program, which allows the pavement condition, and by extension the remaining life, to be monitored closely. Between 2017 to 2018, BCT began assessing various surface treatment options. As an airport with a single runway and a demanding number of daily operations, BCT faced major limitations in relation to closure time. BCT required a quick-setting surface treatment and selected P-608-R to apply to Runway 05/23.

The main objective in using P-608-R was to extend pavement life and to take advantage of a short construction window. The contractor was selected through a competitive bidding process, and BCT used a contracted on-call company to supervise all airport maintenance work. The runway surface was in good condition before the surface treatment application. It had very few cracks, and those that were present were filled before placing the P-608-R. BCT also experiences a high frequency of lightning strikes throughout the year. Pavement damage due to lightning strikes was also repaired before the P-608-R application.

The P-608-R application was done at night in 500-foot segments. BCT closed the runway every night at 9 p.m. and opened it the next morning at 7 a.m. The surface treatment was applied between 9 p.m. and 1 a.m. and was left to cure until 7 a.m. This length of drying was needed to accommodate humid conditions at BCT. Before opening to traffic every morning, the treated section was inspected to ensure it was sufficiently dry. Additionally, trucks were driven over the treated section to check for tracking. BCT followed this construction routine every day and finished applying P-608-R over the entire runway within 2 weeks. During application, the contractor experienced clogging issues in the distributor nozzles several times, which required heating to unclog them. This also impacted the overall application time. Figure BCT-1 shows an image of the runway shortly after the P-608-R application.

Figure BCT-1. Runway 05/23 Shortly After P-608-R Application

After application, it was reported that the surface treatment met its intended purpose of improving pavement conditions. However, the final finished runway surface P-608-R had a checkered pattern due to the construction sequence, seen in figure BCT-2. Friction tests were done before and after application, and they showed improved friction characteristics on the runway. Visibility was initially improved but premature failure was observed in June 2022. The markings began to peel off the pavement under low pressure washing during a cleaning attempt made by the airport. It is suspected that this may have occurred due to the markings being applied prior to the full curing of the P-608-R. BCT restriped the runway shortly after the cleaning attempt. Pictures of failed pavement markings are presented in figure BCT-3.

Overall, BCT views the P-608-R as having met its intended objective by extending the pavement life; however, BCT was displeased with the coverage pattern, longevity of the treatment, and long-term performance of the paint markings on the P-608-R. At the end of the useful service life of the existing treatment, BCT plans to mill and overlay the surface.

Figure BCT-2. Runway 05/23 Approximately 28 Months After P-608-R Application

Figure BCT-3. Runway 05/23 Peeling Pavement Marking

Charlotte-Monroe Executive Airport (EQY) Surface Treatment Case Study

AIRPORT BACKGROUND

Charlotte-Monroe Executive Airport (EQY) is a single runway general aviation airport located 5.5 mi northwest of the central business district of Monroe in Union County, North Carolina. The airport is owned and operated by the City of Monroe and is classified as a regional airport per the FAA's NPIAS (FAA, 2020). There are 118 aircraft based at EQY, and in 2021 the average daily number of operations was 154. Ninety-one percent of daily movements were classified as general aviation**,** while the remainder were split between air taxi and military operations (AirNav, January 2022-b). Typical aircraft traffic at EQY is general aviation turboprop.

EQY falls in the Wet, Non-Freeze climate zone. The Köppen-Geiger climate classification of EQY is warm temperate, steppe, cool summer. Union County's annual average daily dose of UV irradiance is approximately 2,947 joules/m², which is 9% higher than the national average of approximately 2,700 joules/m² (CDC, 2022). The County has averaged 50.7 in. of precipitation annually over the last 5 years (NWS, 2022).

COAL TAR SLURRY

A coal tar slurry of unknown specifications was applied on Apron E and F at EQY in 1996. The approximate area of application was 35,000 square ft. This application was placed during the apron expansion in two rows specifically to provide fuel spill protection.

After application, it was reported that the surface treatment met its intended purpose of providing fuel spill protection. Currently, pavement distresses have increased due to the age of the treatment. Overall, EQY believes that the coal tar slurry material worked as intended and extended the pavement life by providing fuel spill protection for many years. EQY plans to reconstruct the apron area in the near future to support larger private jets.

A visual inspection of the coal tar slurry surface treatment was performed in March 2022. The inspection showed that fine and coarse aggregate on the apron areas were approximately 10% exposed. The uniformity of the coal tar treatment application was good overall, with only some minor differences of coverage present on the edges. The visual delineation of the pavement markings was good. The condition of the pavement markings was not impacted by the surface treatment.

Severe chipping/raveling of the surface treatment was observed on the aprons, which can lead to FOD production. L&T and block cracking with some vegetation were also common on the apron. There was also raveling of the pavement surface where the surface treatment was worn way and the underlying pavement was exposed. Shrinkage of the surface treatment over time resulted in map cracking, which can cause tension on the asphalt concrete pavement surface and may eventually lead to the development of additional L&T cracking. Based on condition and age, the surface treatment is at the end of its service life. Pictures of the apron condition with the coal tar treatment during visual inspection are presented in figures EQY-1 through EQY-4.

Figure EQY-1. Apron Overview with Coal Tar Slurry

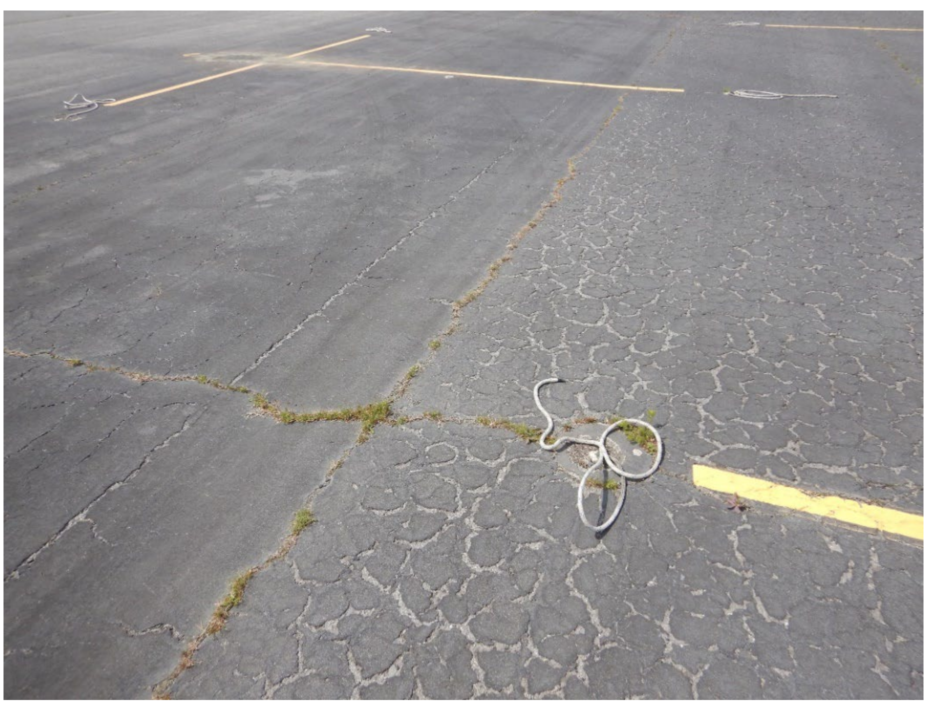

Figure EQY-2. Apron Area Overview with Coal Tar Slurry

Figure EQY-3. Coal Tar Slurry Texture

Figure EQY-4. Severe Map Cracking with Coal Tar Slurry

P-631 REFINED COAL TAR EMULSION WITH ADDITIVES, SLURRY SEAL SURFACE TREATMENT

At EQY, Aprons A, B, C, and I pavements were constructed in 2020. P-631 was selected to protect the new pavements from fuel spillage and was applied on these pavements shortly after construction.

A visual inspection of the condition of the surface treatment was performed in March 2022. Observations at the time of inspection showed that fine and coarse aggregates on the aprons were not exposed and the coverage of P-631 was very good. The uniformity of P-631 was also good. Pavement markings on the P-631 were performing very well with good visual delineation. Minor tire marks were visible on the pavement, although they may not be an imprint on the pavement. Some minor segregation was observed in areas where the underlying asphalt texture was visible. No distresses were observed on the aprons. While there were some oil spills present, they were not significant enough to damage the treatment or the pavement. Overall, the P-631 surface treatment is performing as intended on the aprons. The estimated remaining service life of the treatment appeared to be 3 to 5 years. Photographs of the P-631 on the apron are presented in figures EQY-5 through EQY-8.

Figure EQY-5. Apron Overview with P-631

Figure EQY-6. P-631 Texture on Apron

Figure EQY-7. Apron with (Left) and Without (Right) P-631

Figure EQY-8. Tire Marks on P-631

P-632 ASPHALT PAVEMENT REJUVENATION

At EQY, the taxiway pavements were treated with P-632 in 2018. The taxiway pavements are divided into two age groups: 10 to 15 years (medium age group) and 16 to 25 years (high age group). A portion of Taxiways F and G fall within the medium age group. Taxiways A, B, C, E, and a portion of F and N fall within the high age group. During the 2015 PCI inspection, the PCIs for the medium and high age group pavements were 88–100 and 74–90, respectively. Almost all distresses, at the time of PCI inspection, in both groups were climate related.

A visual inspection of P-632-treated pavements was performed in March 2022. In pavements in both age groups, the P-632 covered most of the fine aggregate and coarse aggregate. However, in the medium age group, limited locations have less P-632 coverage with the coarse aggregate being approximately 60% exposed. The P-632 had worn away sufficiently in both age groups to expose the underlying asphalt macrotexture. The medium age group area had smaller coarse aggregate; and therefore, had less macrotexture. The uniformity of the P-632 was largely in good condition, with some exceptions. The southwest end of Taxiway A and Taxiway C had low P-632 coverage, while the keel section of the taxiways appeared to have received less P-632. Pavement markings on the P-632 were performing very well and the visual delineation of the markings was good. The wearing pattern of P-632 on the parallel taxiway was noticeable but not overly defined. The only form of P-632 deterioration observed was fading; there was no flaking or chipping. In pavements in both age groups, L&T cracking was the most common distress. The majority of cracks were routed and sealed without overband. Some cracks which developed after the application of P-632 were unsealed. Overall, the crack sealant was in good condition with minor debonding and minor vegetation in some areas. Since the 2019 PCI inspection (PCI 88–92 for the medium age group and 78–90 for the high age group), it is estimated that the PCI has decreased approximately 5 PCI points, based on the increase in cracking and the progression of some cracking to medium severity.

Minor weathering may be present throughout the taxiway pavements where the coverage was lighter. Weathering was not recorded in the previous PCI inspection, which would have impacted the PCI. While the binder still retained a dark appearance from the rejuvenator penetrating the surface, there was a minor loss of fines (low-severity weathering). In high age group taxiways, medium-severity weathering was noted in areas of light P-632 coverage the weathering, which would further impact the PCI. Additionally, some secondary cracking along the longitudinal paving joints had developed on the parallel taxiway. There were a few depressions present and some of these depressions showed fatigue cracking. Fatigue cracking was also starting to develop in some of the wheel paths of Taxiway A.

For the medium age group, the estimated remaining service life of P-632 may be 1 year where coverage is less and 3 years where coverage is adequate. For the high age group, the estimated remaining service life of P-632 is 2-3 years. Pictures of the condition of the P-632 condition are presented in figures EQY-9 through EQY-15 (medium age group) and figures EQY-16 through EQY-23 (high age group).

Figure EQY-9. Medium Age Taxiway Overview with P-632

Figure EQY-10. Surface Texture of P-632 on Medium Age Taxiway

Figure EQY-11. Overview of P-632 Coverage on Medium Age Taxiway

Figure EQY-12. Overview of P-632 Coverage on Medium Age Taxiway

Figure EQY-13. Medium Age Taxiway Without (Left) and With (Right) P-632

Figure EQY-14. Cracking on Medium Age Taxiway

Figure EQY-15. Longitudinal Paving Joint on Medium Age Taxiway

Figure EQY-16. Overview of High Age Taxiway With P-632

Figure EQY-17. Overview of High Age Taxiway With P-632

Figure EQY-18. P-632 Surface Texture on High Age Taxiway

Figure EQY-19. Overview of Edge of P-632 Application on High Age Taxiway

Figure EQY-20. P-632 Coverage on High Age Taxiway

Figure EQY-21. Cracking on High Age Taxiway

Figure EQY-22. Depression and Fatigue Cracking on High Age Taxiway

Figure EQY-23. Fatigue Cracking on High Age Taxiway

Elko Regional Airport (EKO) Surface Treatment Case Study

AIRPORT BACKGROUND

Elko Regional Airport (EKO) is a dual runway general aviation airport located 1.5 mi southwest of the central business district of Elko, Nevada. The airport is owned and operated by the City of Elko and is classified as a non-hub commercial service airport per the Federal Aviation Administration's FAA's NPIAS (FAA, 2020). There are 77 aircraft based at EKO, and in 2018 the average daily number of operations was 59. Seventy-one percent of daily movements were classified as general aviation, while the remainder of operations were split between air taxi and commercial services, with occasional military operations (AirNav, January 2022-a). Typical aircraft traffic is narrow-body jets under 60,000 pounds.

EKO falls in the Dry, Freeze LTPP climate zone. The Köppen-Geiger climate classification of EKO is arid-steppe-cold. Elko County's annual average daily dose of UV irradiance is approximately 2,892 joules/^{2}, which is 7% higher than the national average of approximately 2,700 joules/m^2 (CDC, 2022). The County has averaged 10 in. of precipitation annually over the last 5 years (NWS, 2022). Pavement surfaces are subjected to snowplows, brooms, and de-icing material to clear snow and ice during the winter season.

P-608 EMULSIFIED ASPHALT SEAL COAT

Runway 06/24 at EKO is 7,454 ft long and 150 ft wide. The crosswind runway 12/30 is 3,015 ft long and 60 ft wide. Beginning in 2019, P-608 was applied to all asphalt surfaces at EKO in a single project, including both runways, Taxiway A and B networks, and ramps. The project was completed over 2 years to accommodate the short construction season in Elko (typically April to September). Phase 1 included Runway 06/24 and the Taxiway A network and lasted from July to September 2019. Phase 2 included Runway 12/30, the Taxiway B network, and ramps and occurred between June and September 2020. Some minor touch-up work was done in summer 2021.

EKO typically applies surface treatments on a 4-year maintenance cycle. This surface treatment project was initiated by the city as part of their regular capital improvement plan and was supported by the FAA's Airport Improvement Program (AIP). The surface treatment was applied by a contractor selected through an open bidding process, and the airport's on-call engineering consultant designed and inspected the project.

The main objectives for using P-608 were to prevent distress propagation, maintain or improve friction, and to extend pavement life. The factors considered when selecting the surface treatment type were:

- Previous positive experiences with P-608
- Recommendations from the engineering consultant
- FAA guidance for surface treatments on runways with aircraft over 60,000 pounds
- Treatment and application costs
- Climatic conditions
- Construction duration

Prior to treatment, distresses were primarily climate and age-related, including L&T cracking and weathering. Crack sealing was performed prior to application. The surface treatment was applied during daytime hours and coordinated with commercial flights so as not to affect daily flight schedules. The contractor applied the surface treatment around runway markings to keep them visible and operational for daily flights. Equipment malfunctions affected the application process, and project delays were experienced due to disagreements and misunderstandings between the contractor and the city regarding work scope and procedures.

After application, the engineering consultant found no issue with the P-608 material. Pavement condition, surface drainage, friction quality, and pavement marking visibility all improved after treatment. However, significant oxidization occurred after one year, and the frictional characteristics also returned to pre-treatment conditions after just one year of service. The material applied during Phase 2 has performed better than that applied during Phase 1, but it has experienced less traffic and environmental exposure, along with one less season of snow removal operations. Observations of P-608 condition on the various pavements at EKO are presented in the following subsections.

RUNWAY 06/24

Runway 06/24 was last overlaid in 2012 and 2014. P-608 was applied in 2019, and the surface was inspected in 2022. At the time of P-608 application, the PCI of the runway ranged from 80 to 90. The runway is highly textured. Macrotexture between grooves appeared to be that of an untreated asphalt. The P-608 material was visible in the grooves, but the fine and coarse aggregates between the grooves were entirely exposed. The treatment was not visible on the runway surface. Sand was used with the application and was well-adhered to the treatment within grooves.

Most longitudinal paving joints on Runway 06/24 have opened. Some openings were sealed but they continued to widen after crack sealing. Transverse cracking (except at construction joints) was not present. The crack sealant applied in 2019 had started to fail and was letting water enter the pavement. FOD production was not a concern at the time of inspection. The pavement marking delineation was fine but was limited just between the pavement and paint. Most pavement markings were the same age as the surface treatment applied in 2019. The center line was remarked in 2021.

Runway 06/24 has the highest priority for snow removal at EKO. The runway is also cleaned by sweepers several times a year after rains. The airport operations use brooms, deicer, and plows (one rubber blade and two steel blades). Friction issues reported by pilots are only present during snow and ice buildup in larger storms.

At the current condition, the P-608 surface treatment on Runway 06/24 has no remaining service life. The P-608 material visible within the runway grooves does not help to preserve the pavement. The city commented that the rapid fading of P-608 may have been accelerated by snow removal operations. Figures EKO-1 through EKO-7 showcase the condition of the runway.

Figure EKO-1. EKO Runway 06/24 Overview

Figure EKO-2. EKO Runway 06/24 Texture

Figure EKO-3. P-608 Condition Between and Within Runway 06/24 Grooves

Figure EKO-4. P-608 Material Within Runway 06/24 Grooves

Figure EKO-5. Sealed Longitudinal Paving Joint on Runway 06/24

Figure EKO-6. Cracked Longitudinal Paving Joint on Runway 06/24

Figure EKO-7. Transverse Construction Joint on Runway 06/24

TAXIWAY A AND APRON

At the time of inspection, Taxiway A and the general aviation apron areas were between 14 and 20 years old and neither pavement was grooved. P-608 was applied on these pavements in 2019 when the PCIs ranged from 70 to 85.

The texture of the pavements mostly reflected the asphalt macrotexture, but the texture was less than untreated asphalt with infilling of treatment over fine aggregate. The mix appeared homogeneous, and the maximum aggregate size was approximately 0.75 in. throughout most of the application. The pavement felt slippery when wet despite sand being added at application. The amount of exposed coarse aggregate varied from approximately 40% to as high as 80%. Taxiway A had more exposed coarse aggregate than the apron areas, perhaps because the taxiways receive more traffic and snow removal operations. Fine aggregates remained covered in all areas. Overall, the treatment was mostly uniform, but streaks were noticeable in some areas. Thickness was more noticeable in at least one area, possibly due to hand touchups in 2021. Pavement markings on these pavements were the same age as the surface treatment applied in 2019. The delineation between pavement marking and pavement was good.

Fading was the major deterioration mechanism observed during the inspection. It may have accelerated due to snow removal operations. No flaking or chipping was observed that may raise concerns for FOD production. Some longitudinal paving joints had opened, and some had been sealed but continued to open. Isolated transverse cracking was observed. Wheelpath cracking was starting to develop on one portion of Taxiway A. The pavements are cleaned by sweepers several times a year after rains. The airport operations use brooms, deicer, and plows (one rubber blade and two steel blades). Overall, it is estimated that the P-608 has 1 year of service life left on the Taxiway A and apron areas. Pictures of P-608 condition on the Taxiway A and Apron areas are presented in figures EKO-8 through EKO-19.

Figure EKO-8. Taxiway A Overview

Figure EKO-9. Taxiway A Texture

Figure EKO-10. Thicker P-608 Application on Taxiway A

Figure EKO-11. Wheelpath Cracking on Taxiway A

Figure EKO-12. Opened Longitudinal Joint on Taxiway A

Figure EKO-13. Failed Crack Sealant on Taxiway A

Figure EKO-14. Apron Overview

Figure EKO-15. Apron Texture

Figure EKO-16. P-608 Coverage on Apron

Figure EKO-17. Cracking Development on Apron

Figure EKO-18. P-608 Treated and Untreated Areas

Figure EKO-19. P-608 Streaking on Apron

RUNWAY 12/30 AND TAXIWAY B

At the time of inspection, Runway 12/30 and Taxiway B at EKO were at least 30 years old and neither pavement was grooved. P-608 was applied on these pavements in 2020. At the time of P-608 application, the PCIs of these pavements ranged from 50 to 70. The surfaces were at least 28 years old in 2020, and applying P-608 at that time provided marginal benefit. Patching of alligator cracking and placing mastic in wide cracks prior to application would have been beneficial.

The pavement textures only partially reflected the asphalt macrotexture. P-608 application on these pavements appeared to be thicker compared to the treatments applied in 2019. Sand was used during P-608 application and slightly contributed toward the macrotexture. The mix appeared to be homogeneous, and the maximum aggregate size was approximately 0.75 in. on most of the application areas. The treatment felt slippery when wet. The application seemed to be mostly uniform, but there were locations where the coarse aggregate was exposed. The amount of exposed coarse aggregate was around 5%. Fine aggregate remained covered.

Fading was the major deterioration mechanism observed during the inspection. It may have happened due to snow removal operations. No flaking or chipping was observed that may raise concerns for FOD production. Some locations had wide L&T cracking, which was approaching block cracking density. Isolated alligator cracking had continued to develop. The crack sealant applied in 2020 had started to fail and was letting water enter the pavement. Minor concerns of FOD production were present at the time of inspection due to fragmented alligator cracking. Since the 2018 PCI inspection, the pavement condition had deteriorated approximately 10 PCI points with the continued development of alligator cracking and failing crack sealant.

The pavements are cleaned by sweepers several times a year, usually after rains. The airport operations use brooms, deicer, and plows (one rubber blade and two steel blades). Overall, the P-608 has 2 to 3 years of service life left on these pavements. Pictures of P-608 condition on Runway 12/30 and Taxiway B are presented in figures EKO-20 through EKO-32.

Figure EKO-20. Runway 12/30 Overview

Figure EKO-21. Runway 12/30 Overview

Figure EKO-22. Runway 12/30 Texture

Figure EKO-23. Crack Sealant Condition on Runway 12/30

Figure EKO-24. Failed Crack Sealant on Runway 12/30

Figure EKO-25. Fatigue Cracking on Runway 12/30

Figure EKO-26. Vegetation on Runway 12/30

Figure EKO-27. Taxiway B Overview

Figure EKO-28. Taxiway B Overview

Figure EKO-29. Taxiway B Texture

Figure EKO-30. Fatigue Cracking on Taxiway B

Figure EKO-31. Crack Sealant Condition on Taxiway B

Nogales International Airport (OLS) Surface Treatment Case Study

AIRPORT BACKGROUND

Nogales International Airport (OLS) is a single-runway general aviation airport located 8 mi northeast of the central business district of Nogales, in Santa Cruz County, Arizona. The airport is owned and operated by Santa Cruz County, and it is classified as a local general aviation airport per the FAA's NPIAS (FAA, 2020). There are 15 aircraft based at OLS, and the average daily number of operations as of 2020 was 128. Eighty-seven percent of the daily movements were classified as general aviation. The remainder of the operations are air taxi services and government operations. (AirNav, January 2022-d).

OLS falls in the Dry, Non-Freeze LTPP climate zone. The Köppen-Geiger climate classification of OLS is arid-steppe-cold arid. OLS experiences high UV radiation, long seasons of high average temperatures, and relatively low humidity and precipitation (the county averaged 12 in. of precipitation annually over the last 5 years) (NWS, 2022). The annual average daily dose of UV irradiance in Santa Cruz County is approximately 3,922 joules/m², which is 45% higher than the national average of approximately 2,700 joules/m² (CDC, 2022). This level of irradiance can have an adverse effect on the long-term performance of asphalt pavement.

P-608 EMULSIFIED ASPHALT SEAL COAT

The single runway at OLS, 04/22, is 7,200 ft long and 100 ft wide. It is supported by a full-length parallel taxiway which is 50 ft wide. In 2020, P-608 was applied on the runway and connector taxiways up to the hold bars. Runway 04/22 was previously rehabilitated in 2004 and had not received a surface treatment prior to 2020. At the time of application, the runway was in FAIR condition with a PCI between 55 and 70. The predominant distresses on the runway were climate and age-related, including L&T cracking and weathering. Load-related distresses were not present. The largest aircraft that use this runway are narrow-body jets over 60,000 pounds.

The main objective in using P-608 was to extend pavement life. The asphalt was 16 years old at the time of the surface treatment application. The expected service life of the treatment is 5 years. Santa Cruz County used their on-call engineering firm to design and oversee the surface treatment application. The surface treatment was applied by a contractor selected through an open bidding process. The majority of funding for the project was from the FAA's AIP. The on-call engineering firm, FAA Advisory Circulars, and the contractor were consulted for guidance on the use of surface treatments. Climatic conditions, construction duration, cost, desired performance, FAA specifications, and previous experience were other factors that were considered in the process of selecting P-608. Aggregate was applied over the P-608 application to improve the friction characteristics of the treatment.

The application was completed in May 2020. Minor cracks were sealed two days prior to the P-608 application. The P-608 was applied using a distributor with a spray bar, and the work was performed during both daytime and nighttime work shifts. During application, the runway outer edges did not receive good seal coat coverage, which is believed to be due to the distributor nozzles being partially clogged. To correct the issue, the contractor re-applied the seal coat on the runway outer edges within a few months of the first application.

After application, it was reported that the surface treatment met its intended purpose of improving pavement conditions. The friction and visibility of paint markings were also improved. The pavement experienced decreased FOD potential and reduced pavement distresses/distress severity, while no changes in the drainage or ride quality properties have been noted.

A visual inspection was performed on March 2022 to check the current condition of the P-608 at OLS. The inspection revealed that the P-608 was in acceptable condition with approximately 90%coverage still visible. The P-608 was beginning to wear off along the center wheel path. The P-608 was also getting significantly lighter on high traffic areas, including the impact zone at the end of Runway 04/22. A notable wearing pattern was visible in the high traffic areas. Some connectors close to the 04/22 end had coverage of approximately 30%–50%. The P-608 was in better condition on the parallel taxiway D with approximately 90% coverage. The P-608 coverage was light around the pavement marking areas. Tire marks were visible on the connectors. The P-608 seemed darker at the edges and lighter towards the center of the runway and connectors. Pictures of the P-608 on Runway 04/22 are presented in figures OLS-1 through OLS-6.

Figure OLS-1. Runway 04/22 Overview

Figure OLS-2. Wearing Pattern on Runway 04/22

Figure OLS-3. P-608 Coverage on Runway 04/22 and Connector

Figure OLS-4. P-608 Coverage on Connector

Figure OLS-5. Tire Marks

Figure OLS-6. Pavement Designation Marking

The overall macro texture of the P-608 at OLS appeared uniform. The application of P-608 did not appear to slow new crack formation and existing cracks from widening. The majority of the crack sealants were in satisfactory condition**,** with some showing signs of oxidation but no FOD potential. Wearing was the major form of deterioration observed on the P-608-treated surfaces. No fading, flaking, or chipping were observed. The OLS operator reported satisfaction with the current performance of the P-608. The estimated remaining service life of the P-608 at OLS is 3 years. Due to the malfunction of the mechanical sweeper, OLS is currently cleaning the surface manually one to two times a month with a broom and shovel. Some pictures of P-608 texture, crack sealant, and cracks are presented in figures OLS-7 through OLS-9.

Figure OLS-7. Runway Pavement Texture

Figure OLS-8. Crack Sealant Condition

Figure OLS-9. Runway 04/22 Edge

Phoenix Sky Harbor International Airport (PHX) Surface Treatment Case Study

AIRPORT BACKGROUND

Phoenix Sky Harbor International Airport (PHX) is a three-runway international commercial airport owned and operated by the City of Phoenix. PHX is located within Maricopa County, and the western edge of the airfield is approximately 2 mi east of downtown Phoenix. PHX is classified as a large-hub airport according to the FAA's NPIAS (FAA, 2022). In 2019, the average daily number of operations was approximately 1,200 with 88% of the daily movements classified as commercial airline operations (AirNav, December 2021-b). The remainder of the operations are a mixture of cargo, air taxi, military, and general aviation operations. From 2011 through 2019, over 40 million passengers passed through PHX each year (Phoenix Sky Harbor International Airport, 2021).

This major transit hub for passengers and cargo falls in the Dry, Non-Freeze LTPP climatic zone. The Köppen-Geiger Climate Classification of PHX is arid-desert-hot arid. PHX experiences high UV radiation, long seasons of high average temperatures, and relatively low humidity and precipitation. The annual average daily dose of UV irradiance is approximately 3,700 joules/m², which is 37% higher than the national average of approximately 2,700 joules/m² (CDC, 2022). PHX receives approximately 7 in. of average annual precipitation (NWS, 2022). The average daily maximum air temperature is above 100°F from June through September. This combination of environmental factors accelerates the deterioration of asphalt surfaces. Therefore, PHX relies heavily on surface treatments to control asphalt oxidation and deterioration.

SURFACE TREATMENT HISTORY

At PHX**,** nearly all shoulders, blast pads, paved islands, and airfield service roads are asphalt pavements. The majority of the Taxiway A and associated connector taxiways as well as two cargo aprons are also asphalt pavements. The pavements with surface treatments at PHX have aircraft as large as a Boeing 757 traverse them at typical taxi speeds.

PHX used coal tar-based surface treatments in the past, but due to a coal tar project in which passengers and ground crews reported feeling unwell from the odor, PHX stopped using coal tar surface treatment products in 2012. Since 2016, PHX has used a variety of surface treatment products, including Brewer Coat Acrylic Coat, Seal Master, PMM, PMM RTU, and Master Seal MTR Plus. Additionally, PHX has experimented with FAA-specified products such as P-608, P-608-R, and P-629.

PHX maintenance crews are generally responsible for applying surface treatments. Surface treatments are not applied from roughly February through mid-October due to high air temperatures. PHX maintenance crews routinely perform minor patching and crack sealing on their asphalt pavements. Prior to surface treatment application, targeted maintenance activities in the application area are completed.

BREWER COTE OF ARIZONA – RS-44E

Until 2012, PHX used RS-44E, which is categorized as a coal tar rejuvenator. Per the product specification, RS-44E is a three-component coal-tar rejuvenator sealer for asphalt pavements. This product is promoted as being able to rejuvenate, seal, and provide fuel resistant surfaces. RS-44E is designed to seal and rejuvenate pavements without changing the surface structure of asphalt. The manufacturer also recommended use of this product on a surface where a coal-tar emulsion would be too slippery. Additional details of this product can be found on the manufacturer's website (Brewer Cote of Arizona, 2022).

The surface treatment on the West Cargo Apron (AWCARG-02 and -03) area was inspected in March 2022. This apron pavement was constructed in 2008**,** and RS-44E was applied approximately 3 years later. The inspection showed that coverage of the surface treatment was poor, with approximately 90%of the coarse aggregate and 50% of the fine aggregate fully exposed. The apron texture also entirely reflected the asphalt macrotexture without any noticeable "grit." The application of RS-44E appeared somewhat uneven without significant streaking.

No wearing patterns were observed across the apron pavement areas. Fading was the major deterioration mechanism across all the pavements. FOD production was not a concern, as no flaking or chipping was observed for the RS-44E. In 2022, PHX had re-applied pavement markings on these pavements, so the visual delineation of the markings was very good.

Most paving joints were found in open condition in the inspection. Crack sealing had been completed by an overband application without routing and had failed in most locations. Transverse cracking was very common in most of the pavement and continued to develop after the most recent crack sealing effort. The PCIs on AWCARG-02 were 92 in 2013, 91 in 2016, and in 2019. The PCIs on AWCARG-03 were 95 in 2013, 88 in 2026, and 74 in 2019. Currently, RS-44E has no remaining service life on the West Cargo Apron. Pictures of RS-44E on the West Cargo Apron are presented in figures PHX-1 through PHX-4.

Figure PHX-1. Overview of West Cargo Apron With RS-44E

Figure PHX-2. Overview of West Cargo Apron With RS-44E

Figure PHX-3. West Cargo Apron Texture

Figure PHX-4. New Crack Formation on West Cargo Apron

BREWER COTE OF ARIZONA – ACRYLIC COAT

PHX used an Acrylic Coat surface treatment on Taxiway A and East Cargo Apron areas in 2016. Per the product specification, the acrylic coat is a highly milled emulsion that uses cationic binders and polymers. The product includes mineral fibers and plasterers in a stable Performance Graded Asphalt. This material can be customized with aggregate to support different conditions. The manufacturer advertises the product as flexible, fast drying, easy to apply, and resistant to cracking. Additional details about this product can be found on the manufacturer's website (Brewer Cote of Arizona, 2022).

PHX has used the acrylic coat with the goal of keeping moisture out of the pavement structure and limiting UV exposure. The treatment application is usually done in concert with crack sealing work completed prior to surface treatment application. PHX reports that the acrylic coat may last up to 5 years in low traffic areas and 2 years in high traffic areas. Their protocol is to apply this surface treatment every 5–7 years on the apron areas, but that is not always accomplished, possibly due to budgetary constraints. Brewer Cote provides the acrylic coat material with 1:1 dilution with aggregate (approximately 2–4 pounds per gallon). Approximately 0.15 gallons/yd² of material is sprayed on the pavements. On an uninterrupted day, the contractor can cover approximately 40,000 ft² of pavement in a single shift. The contractors typically use a spray distributor to apply the acrylic coat. A hand wand is used by in-house crews whenever there are nozzle clogging problems on the spray distributors.

A visual inspection of the condition of the surface treatments on Taxiway A and the East Cargo Apron was done at PHX in March 2022. Those pavements were constructed in 2013, and the acrylic coat was applied to these pavements 3 years after construction. The coverage of this seal coat was better on the taxiway than the apron. Approximately 5% of the coarse aggregate were exposed on Taxiway A, with fine aggregates fully covered. On the apron pavement, approximately 75% of the coarse aggregate and 25% of the fine aggregate were exposed. On all pavements, the treatment exhibited some unevenness and streaking. Taxiway A's surface texture mostly reflected the asphalt macrotexture. The East Cargo Apron texture entirely reflected the asphalt macrotexture. The asphalt macrotexture on Taxiway A appeared less than untreated asphalt with infilling of treatment over the fine aggregate. A small amount of "grit" was visible on the surface of Taxiway A.

Some light wearing patterns were observed along the centerline of Taxiway A, while no wearing was observed on the apron areas. Fading was the major deterioration mechanism across all pavements. FOD production was not a concern, as no flaking or chipping was observed for the acrylic coat. In 2022, PHX reapplied pavement markings on these pavements, so the visual delineation of the markings was very good.

Partially open L&T cracking, mostly along paving joints, was present on Taxiway A. Additionally, some transverse cracking was also present on the taxiway. Cracks had continued to develop on Taxiway A after the application of the surface treatment. Extensive L&T cracking was present on the East Cargo Apron area, which was unusual given the age of the pavement. Many of the cracks formed prior to the application of the acrylic coat in 2016. Most paving joints had opened. Similar to Taxiway A, new cracks continued to develop on the Apron. Crack sealing across all pavements from 2016 failed; most seem to have been re-sealed, possibly either in 2019 or 2020. The observed distresses did not raise any concern for FOD production.

Since the 2016 application, the PCIs for Taxiway A and East Cargo Apron have continued to decline at a steady rate. The PCIs of Taxiway A were 100 in 2013, 89 in 2016, and 78 in 2019. The PCIs of the East Cargo Apron were 81 in 2016 and 74 in 2019 (the East Cargo apron was not inspected in 2013, as construction was ongoing at the time). However, anecdotally, PHX reported that the PCI of the East Cargo Apron was lower than expected shortly after construction due to the formation of cracking, possibly because the cement-treated base (CTB) was too stiff, cracked, and initiated reflection cracks in the asphalt.

At the time of the 2022 visual inspection, the estimated service life of the Taxiway A acrylic coat was 1–2 years, and it had no remaining service life on the East Cargo Apron. Photographs of the acrylic coat condition on Taxiway A and East Cargo Apron areas are presented in Figures PHX-5 through PHX-12.

Figure PHX-5. Overview of Taxiway A With Acrylic Coat (East Facing)

Figure PHX-6. Overview of Taxiway A With Acrylic Coat (West Facing)

Figure PHX-7. Taxiway A Texture

Figure PHX-8. New Cracking on Taxiway A

Figure PHX-9. East Cargo Apron Overview With Acrylic Coat

Figure PHX-10. East Cargo Apron Overview With Acrylic Coat

Figure PHX-11. East Cargo Apron Texture

Figure PHX-12. Crack Development on East Cargo Apron

Winchester Regional Airport (OKV) Surface Treatment Case Study

AIRPORT BACKGROUND

Winchester Regional Airport (OKV) is a single-runway general aviation airport located 3 mi southeast of downtown Winchester, in Frederick County, Virginia. OKV is owned and operated by the Winchester Regional Airport Authority (WRAA), which was founded in 1987. Previously, the airport was owned and operated by the City of Winchester. It is classified as a regional general aviation airport per the FAA's NPIAS (FAA, 2020). There are 98 aircraft based at OKV, and the average daily number of operations as of 2018 was 118 (AirNav, December 2021-a). Ninety-five percent of the daily movements are classified as general aviation. The remainder of the operations are mostly air taxi services, with occasional military operations. The airport also routinely provides support to the nearby Winchester Medical Center.

OKV falls in the Wet, Freeze LTPP climate zone. The Köppen-Geiger climate classification of OKV is warm temperate-fully humid-hot summer. The airport generally requires eight to twelve snow removal operations per year, with one or two being significant winter weather events. Within the City of Winchester, the annual average daily dose of UV irradiance is approximately 2,400 joules/m², which is 12% lower than the national average of approximately 2,700 joules/m² (CDC, 2022). The city experienced 49 in. of average annual precipitation (NWS, 2022). The mean annual freezing degree days and mean length of freezing season days are 63 and 16, respectively (Pavement-Transportation Computer Assisted Structural Engineering [PCASE], 2022).

P-608 EMULSIFIED ASPHALT SEAL COAT

Runway 14/32 is 5,498 ft long and 100 ft wide. It is supported by Taxiway A, a full-length parallel taxiway that is 35 ft wide. The northwest 1,000 ft of the taxiway was constructed in 1993, and the remaining 4,500 ft were rehabilitated in 1995. Since 1995, no significant rehabilitation work has been performed on Taxiway A, but crack sealing of minor cracks has been completed. By 2019, WRAA had developed a plan to relocate the taxiway in phases from 2022 to 2027 so that the Runway Safety Area conforms to FAA standards. With this project in mind, WRAA was not looking to invest heavily in maintenance or rehabilitation efforts that would have a relatively short lifespan. However, the importance of maintaining the pavement condition and limiting FOD until the relocation was acknowledged. After consultation with the FAA, it was decided that an application of P-608 on the taxiway would be the most cost-effective maintenance strategy to meet the goals of preserving the pavements in a serviceable condition until the relocation project occurred.

P-608 was applied to the full length of Taxiway A and runup pads in 2020. The total area of application was 24,000 yd². The largest aircraft that typically use these taxiways are narrow-body jets over 60,000 pounds. Additionally, snow removal vehicles frequently clear Taxiway A during eight to twelve winter weather events each year. At the time of application, the typical pavement condition was FAIR, with PCIs between 55 and 70. The predominant distresses were climate and age-related, including L&T cracking, raveling, and weathering.

The expected service life of the treatment was 4 years. The project was funded with an AIP grant at 90%, with supporting funds from the Virginia Department of Aviation and WRAA. The airport received five bids, three of which were from companies whose main business is pavement sealing and marking. The contract award was made based on the lowest bid. P-608-R was initially considered and bid based on its rapid curing advantage; however, prior to construction it was determined that application specifics, including forecasted weather and phasing, would allow the use of P-608 without any issues. This substitution resulted in a reduction in price of over 30%. The consultant/designer, FAA Advisory Circulars, FAA personnel, and some industry organizations were consulted for guidance. Additionally, climatic conditions, construction duration, cost, material availability, and surface treatment application constraints were considered in the final process of selecting P-608.

The work was completed in May 2020. Taxiway markings were thin enough to not require removal before application of the P-608. Cracks in the pavement were cleaned utilizing high-pressure air but were not routed or sealed, and no other special pavement preparation was completed prior to construction. The application of the P-608 was done using a distributor with a spreader. Favorable weather conditions (temperature, wind, humidity, and sunlight) allowed the P-608 to cure within a few hours, confirming there would have been minimal benefit to using the original P-608-R material. Light aircraft (planes less than 12,500 lb) were allowed on Taxiway A within hours of the application without any tracking issues.

After the application, it was reported that the surface treatment met its intended purpose of improving pavement conditions. The visibility of paint markings was also improved. The application was such that some areas received a double treatment due to overlap in the spray. As of February 2022, these areas have clearly maintained color and coverage of the asphalt better than the single application areas. Figure OKV-1 shows typical conditions on Taxiway A; P-608 fading and distributor patterns are clearly visible, and an area with double coverage is highlighted by the dashed line.

No friction testing was done after the P-608 application. OKV authority currently does not suspect any significant friction difference among various locations on the taxiway regarding P-608 application rate or coverage. At the time of this writing, it is undetermined if the surface treatment has extended the life of the pavement.

P-631 REFINED COAL TAR EMULSION WITH ADDITIVES, SLURRY SEAL SURFACE TREATMENT

P-631 was placed over 8,600 yd^2 of a newly constructed apron in 2015. The largest aircraft that use the treated apron area are general aviation turbo prop aircraft. Additionally, snow removal vehicles use the apron during winter events, but less frequently than Taxiway A.

The main objective for using P-631 was to protect the newly constructed apron from fuel spill damage. The expected service life of the treatment was 6 years. The project was funded with an AIP grant at 90% with supporting funds from the Virginia Department of Aviation and WRAA. The consultant/designer and FAA Advisory Circulars were consulted for guidance by WRAA, which made the decision to apply P-631 on the apron. Additionally, construction duration, surface treatment application constraints, consultant recommendation, FAA guidance, desired performance, and previous experience were some other factors that were considered in the decision process of selecting P-631.

The application of P-631 began after the 30-day curing period for the newly constructed asphalt surface. The P-631 was applied using a distributor with a spreader. The application area was limited to parking spots. So far, the airport views the P-631 as meeting its intended objective.

Figure OKV-1. Typical P-608 Application and Overlap (Red Dashed Rectangle) on Taxiway A—February 2022

Missouri DOT Surface Treatment Case Study

BACKGROUND

Missouri boasts nearly 500 aviation facilities, including publicly owned airports. Of those, 107 are eligible to receive Missouri Department of Transportation (MoDOT) funding (MoDOT, 2022-a). MoDOT funds are used to prepare surface treatment specifications, perform pavement inspections, and conduct maintenance planning for all eligible airports within the State of Missouri. The most commonly used surface treatments for MoDOT-maintained airports are FAA P-629 Micro Surface and MoDOT MO-623 seal coat mixture.

Missouri falls in the Wet, Freeze LTPP climate zone. The Köppen-Geiger climate classification of Missouri is warm temperate, steppe, and hot summer. Within the state, the annual average daily dose of UV irradiance is approximately 2,587 joules/m², which is 4% lower than the national average of approximately 2,700 joules/m² (CDC, 2022). The state experienced 45 in. of average annual precipitation during the last 5 years (NWS, 2022). The annual freezing degree days varies from 75 to 1,200 days, while the mean length of freezing season varies from 23 to 124 days (PCASE, 2022).

MODOT AIRFIELD SURFACE TREATMENT GENERAL PRACTICES

MoDOT does not oversee maintenance projects for the airports within the State that are part of the NPIAS. The NPIAS airports typically target specific pavements with surface treatments, rather than follow a uniform approach for surface treatment application. MoDOT only performs regular checks at NPIAS airports to verify that construction and maintenance are completed according to the FAA funding contracts.

MoDOT does oversee construction and maintenance work at all non-NPIAS airports within the State. These airports typically use FAA specified surface treatments and MoDOT specified surface treatments such as MO-623. MO-623 is not approved to be used in any FAA-funded airports; only the non-NPIAS airports in Missouri are allowed to use it. Specific details about the MO-623 specification can be found on the MoDOT website (MoDOT, March 2022-b).

Maintenance work for the non-NPIAS airports is done by MoDOT using package programs. Under the "Pavement Maintenance Package," MoDOT prepares a shortlist of airports that can receive surface treatments based on their current pavement condition and last treatment age. The airports within this shortlist are grouped by surface treatment types. Previously, MoDOT used 5 years since the previous treatment as a default period for any airport to receive a new surface treatment. Due to budget constraints brought about by COVID, MoDOT is currently putting more emphasis on the current condition of an airport pavement, rather than age, to be put into the shortlisted group. MoDOT believes they will be able to rectify the budget constraint issues in the near future and will move back to their original maintenance scheduling protocol.

For each shortlisted group, MoDOT hires a consultant to supervise the surface treatment work. The selection of a contractor for a group is done through a bidding process. MoDOT reported that the grouping protocol has resulted in favorable bid prices from contractors. This also helps MoDOT to effectively manage their maintenance program finances.

P-629 (MICRO SURFACE) TREATMENT

Bolivar Municipal Airport (M17) is a city-owned public-use airport located 4.6 mi east of the central business district of Bolivar, Missouri. The airport has a single runway (Runway 18/36) that is 4,000 ft long and 75 ft wide. The runway is supported with a full-length parallel taxiway. Helicopters with skids operate at this airport and have dedicated pavement areas for takeoff and landing.

M17 previously applied a surface treatment on its pavements in 2012. By 2019, the surface treatment had worn off completely. To extend the life of their pavement, M17 began exploring surface treatments options and eventually selected P-629 (Micro Surface variant) based on recommendations from several other airports. M17 selected a consultant for the treatment work, and a contractor was hired to apply the surface treatment through a bidding process.

P-629 was applied on the runway, taxiway, and apron of M17. These pavements have varying construction histories with the original construction date of the surface course ranging from 1995 to 2012. Prior to treatment application, pavement surfaces were cleaned, and all markings were removed. No problems were encountered during application. However, at the landing locations for helicopters with skids, the P-629 took almost two weeks to cure to properly support the helicopter skids without damaging the treatment. Any damage done by skids was repaired by the contractor under the warranty requirements. After allowing proper curing time, no additional issues were reported by M17.

M17 reported that the P-629 material met its intended purpose immediately after application. The treatment is very durable, and it improved the pavement friction. Additionally, M17 appreciates the black color of the P-629 material and the complete coverage that limits oxidation. M17 also believes that the black color of P-629 helps in melting any snow accumulation. However, snow plowing needs to be done carefully on the P-629. M17 has installed “shoes” on the plows to keep the blade ½ in. off the pavement surface so the surface treatment is not scraped.

A visual inspection in 2022 revealed that the P-629 was still performing well. The surface texture was not uniform, but the level of variation was not significant. Nearly all (about 97%) of the treated pavement was covered; there were minor locations showing evidence of scrapes that had removed the treatment. The treatment was maintaining its black color, except for some locations which had been compromised by fuel spillage. Indentations from helicopter skids at the helicopter parking area were common. Few locations exhibit tire imprints during hot weather. Pavement markings installed in 2019 were still performing well. Cracks were appearing at some locations. The cracking pattern indicated that the underlying pavement was continuing to develop new cracks, and older cracks were continuing to widen. There were also locations on the taxiway exhibiting beginning stages of fatigue cracking, and some crack sealant was failing as cracks continued to open, leading to subsidence of sealant and surrounding treatment. Many of these cracks were wider than 1 in, and some were approaching 2 in. The sealing was also failing in some cracks that were routed prior to sealing. Other than the cracking, the P-629 surface treatment itself was performing very well. Significant deterioration of the overall surface treatment had not yet occurred, and it appears to have at least three more years of remaining service life.

Figure MoDOT-1. Overview of M17 Runway 18/36 With P-629

Figure MoDOT-2. P-629 Texture on M17 Runway 18/36

Figure MoDOT-3. Overview of M17 Taxiway With P-629

Figure MoDOT-4. P-629 Texture on M17 Taxiway

Figure MoDOT-5. Overview of M17 Apron With P-629

Figure MoDOT-6. P-629 Texture on M17 Apron

Figure MoDOT-7. Helicopter Skid Indentation on P-629

Figure MoDOT-8. Tire Imprint on P-629

Figure MoDOT-9. Possible Fatigue Cracking on P-629

Figure MoDOT-10. M17 Taxiway Cracking With Failed Sealant

MO-623 PAVEMENT FRICTION SEAL COAT SURFACE TREATMENT

Lamar Municipal Airport (LLU) is a public airport located 2 mi southwest of Lamar, Missouri. It is categorized as a local/basic airport as per FAA NPIAS. The airport has two runways: Runway 17/35 is 4,000 ft long and 75 ft wide, and Runway 03/21 is 2,900 ft long and 60 ft wide.

In 2016, LLU used a MO-623 pavement friction seal coat surface treatment on its asphalt-surfaced runways, taxiways, and apron. These pavements had previously received a surface treatment in 2006. The apron was last paved in 1994, while the taxiways and runways were last paved in 2002. The MO-623 seal coat mixture can be MicroPave, Ultra Seal, or an approved equivalent with sand, properly proportioned, mixed, and spread evenly on the existing wearing course in accordance with MoDOT specifications. LLU reported that MO-623 was a cost-effective treatment that is expected to have good performance for at least four years, with deterioration occurring between five and eight years.

LLU has experienced good performance from their MO-623 application. The airport appreciates the black color and the near-complete coverage of the MO-623 that limits oxidation. MO-623 also requires less black paint for remarking works. Due to its black color, black paint is only applied around hold bars, as it is an FAA requirement. For any other treatment, black paint needs to be applied around all markings.

A visual inspection in 2022 indicated that the runway, taxiway, and apron areas of LLU remain mostly covered by MO-623, but almost half the taxiway and apron area and a quarter of the runway area have exposed coarse aggregate. Surface macrotexture had some “grit” resembling sandpaper. The surface texture largely reflected the underlying pavement and did not provide significant water runoff channels. The coverage of MO-623 was mostly uniform. The pavement markings were placed in 2016 and were very worn. The surface treatment itself was very black, perhaps due to the use of “Black Beauty” sand.

Cracks were appearing at some locations of the treated pavement. The cracking pattern indicated that the underlying pavement continued to develop new cracks, and older cracks continued to widen. Most of the cracking can now be classified as block cracking. Cracks with existing overbanded sealant were failing and as cracks with sealant continue to widen, subsidence of sealant and surrounding treatment was leading to fragmentation, FOD production, of the treatment.

The surface treatment appears to have extended the service life of the pavement. Since the last PCI inspection in 2019, it is estimated that most sections have decreased 4–8 PCI points due to the continued development/deterioration of cracking. Compared with previous PCI inspections (e.g., 2014, 2016, 2019), the PCIs have been close to steady over an 8-year period. There does not appear to be any remaining service life of MO-623 on the taxiway, as the treatment is covering the binder yet allowing water to enter the pavement surface. The MO-623 on the runway and apron may have 1–2 years of remaining life. The MO-623 on the runway and apron were in comparatively better condition than the treatment on the taxiway.

MoDOT is currently promoting the use of P-608 and P-631 instead of MO-623, in part because the “Black Beauty” sand used in MO-623 can only be sourced from one supplier within the state, and this limitation is not preferred by MoDOT. LLU believes that the performance advantages of

MO-623 far exceed its aggregate sourcing limitation and encourages MoDOT to continue to allow the use of MO-623 at smaller general aviation airports.

Figure MoDOT-11. Overview of LLU Runway 03/21 With MO-623

Figure MoDOT-12. MO-623 Texture on LLU Runway 03/21

Figure MoDOT-13. Overview of LLU Taxiway With MO-623

Figure MoDOT-14. MO-623 Texture on LLU Taxiway

Figure MoDOT-15. Overview of LLU Apron With MO-623

Figure MoDOT-16. MO-623 Texture on LLU Apron

Figure MoDOT-17. Untreated Pavement (Left) and Pavement Treated With MO-623

Figure MoDOT-18. LLU Runway 03/21 Cracking With Failed Sealant

Figure MoDOT-19. LLU Runway 03/21 Cracking

Figure MoDOT-20. LLU Runway 03/21 Raveling

Figure MoDOT-21. MO-623 Application Pattern at LLU

Tennessee Department of Transportation (TDOT) Surface Treatment Case Study

BACKGROUND

Beginning in 2020, Tennessee Department of Transportation (TDOT) initiated a program to perform widespread crack sealing, surface treatment application, and pavement marking application for airfields in groups (based on region), with the goal of performing preventive pavement maintenance to the greatest extent possible subject to budgetary constraints. Ellington Airport (LUG) in Lewisburg, Tennessee was in a region included in TDOT's airfield pavement and marking maintenance program in 2021. TDOT arranged open-bidding for contractor selection with the option of using either P-608 or P-623. All the bidders proposed P-608; therefore, it was the surface treatment applied under this program around the State.

LUG is a single-runway airport, located 3 mi north of the central business district of Lewisburg, in Marshall County, Tennessee. The airport is owned and operated by the City of Lewisburg. It is classified as a local general aviation airport per the FAA's NPIAS (FAA, 2020). There are 48 aircraft based at LUG, and the average daily number of operations as of 2018 was 44 (AirNav, January 2022-c). Ninety-three percent of the daily movements were classified as general aviation. The remainder of the operations were mostly air taxi services with occasional military operations.

LUG falls in the Wet, Non-Freeze LTPP climate zone. The Köppen-Geiger climate classification of LUG is warm temperate-fully humid-hot summer. Marshall County's annual average daily dose of UV irradiance is approximately 2,814 joules/m², which is 4% higher than the national average of approximately 2,700 joules/m² (CDC, 2022). The city experienced 71 in. of average annual precipitation during the last 5 years (NWS, 2022). The mean annual freezing degree days and mean length of freezing season days are 44 and 7, respectively (PCASE, 2022).

P-608 EMULSIFIED ASPHALT SEAL COAT

Runway 02/20 at LUG is 5,001 ft long and 100 ft wide. It is supported by a full-length parallel taxiway that is 40 ft wide. P-608 was applied to the majority of the airfield in May and June 2021 as part of the TDOT Aeronautics Division Airfield Pavement and Marking Maintenance Contract. As noted above, most of the airfield pavements at LUG received P-608. However, an area of approximately 30,000 square ft on the northern end of the parallel taxiway was omitted from the P-608 application as it was slated to be used as a demonstration strip for P-608H. At the time of P-608 application, the runway and southern connector taxiway were in good condition with a PCI above 85 (they were resurfaced in 2015). The runway and southern connector taxiway had not previously received a surface treatment. The only distresses present were weathering and L&T cracking.

The parallel taxiway and mid-field connector taxiway were in POOR condition with PCIs less than 40. These pavements were paved in the late 1980s and have not been rehabilitated but did receive a surface treatment application approximately 15 years prior to the 2021 application. Detailed information regarding the prior surface treatment was not available, but it is believed to have been a coal tar product. The predominant distresses were climate and age-related, including L&T

cracking, and raveling of the existing surface treatment. Minor quantities of fatigue cracking and rutting were also present.

Most of the aprons that received a surface treatment were in fair condition with PCIs between 55 and 70. The apron pavements have a mixed construction history, but most sections had previously received a surface treatment application. The predominant distresses were climate and age-related, including L&T cracking and weathering. Minor quantities of raveling, block cracking, depressions, fatigue cracking, and rutting were also present. The largest aircraft that use these pavements are narrow-body jets over 60,000 lb.

The main objective in using the P-608 was to extend pavement life and to increase the quality of visual pavement delineation. The TDOT Aeronautics Division did not apply criteria based on condition or age when selecting pavements that were included in the TDOT Pavement and Marking Maintenance Contract. Instead, they perform maintenance work at entire airports within selected regions in the state based on available funding and project cost. Airports within the selected area must meet certain conditions to be eligible for such maintenance work. The criteria are as follows: a) the selected area must not have had any treatments during last 5 years and b) there must be no major rehabilitation/reconstruction work planned in the near term.

The P-608 application work was completed in July 2021. The darkened pavements visible in figure LUG-1 indicate the project limits. Independent crews were used to perform crack sealing, surface treatment application, and pavement marking work throughout the TDOT Pavement and Marking Maintenance Contract. The surface treatment was applied shortly after crack sealing. The contractor used a distributor with a spray bar to apply the P-608. The initial curing time for the surface treatment was 24 hours. After the initial curing, temporary paint markings were applied, and permanent paint markings were applied approximately 30 days later.

Immediately after application, it was reported that the surface treatment met its intended purpose of improving pavement conditions. Over time, however, the treatment began to fade, giving the appearance of deteriorating pavement. Two complaints from tenants related to fine sand were noted following the application. High winds caused fine sand applied on the P-608 to blow into the hangars and cause pitting on wooden props. Negligible change was reported for pavement distress and surface drainage.

In March 2022, a visual inspection of the condition of the P-608 at LUG was performed. LUG's pavements cover a wide range of ages, so observations of P-608 condition at LUG are grouped into three age ranges: low (less than 4 years), medium (19 to 25 years) and high (over 39 years).

LOW-AGE GROUP

Runway 02/20, Taxiway A1, and T-Hangar 4 are in the low-age pavement group (less than 4 years). In this group, the pavement surfaces were still mostly covered with P-608, but approximately 50% of the coarse aggregate was exposed. Coverage of P-608 on the coarse aggregate was uneven, and the overall coverage of P-608 was not uniform. The variation in the thickness of the P-608 layer could be easily identified, and the underlying pavement was becoming visible. This level of visibility is not expected for a 1-year-old treatment. Pavement markings on the P-608 were performing very well. The visual delineation of the markings was good. Single tire tracks were noticeable in some areas. Overall, the only deterioration mechanism observed was fading; there was no flaking or chipping, so there were no FOD concerns. Very limited weathering was observed in some areas. L&T cracks were present on the pavement but mostly at low-severity level. Some new cracks had continued to develop along the paving lane joints. Crack sealants were in good condition. Since the last PCI inspection in 2019, it is estimated that these sections remained at the same PCI or increased less than 5 PCI points due to the reduction in the amount of weathering at locations where the P-608 treatment covers the asphalt. The remaining service life of P-608 was estimated at approximately one year, mostly due to its non-uniform thickness and pavement exposure. Pictures of P-608 condition in this pavement age grouping are presented in figures LUG-1 through LUG-10.

Figure LUG-1. Overview of Runway 02/20 With P-608

Figure LUG-2. P-608 Texture on Runway 02/20

Figure LUG-3. P-608 Coverage on Runway 02/20

Figure LUG-4. Crack Sealant on Runway 02/20

Figure LUG-5. Tire Tracks on Runway 02/20

Figure LUG-6. Overview of Taxiway A1 With P-608

Figure LUG-7. P-608 Texture on Taxiway A1

Figure LUG-8. Overview of T-Hangar Pavement With P-608

Figure LUG-9. P-608 Texture on T-Hangar Pavement

Figure LUG-10. Coverage on T-Hangar Pavement

MEDIUM AGE GROUP

Aprons 1 and 2 fall within the medium age pavement group (19 to 25 years). In some areas on these two aprons, P-608 was applied on top of P-631, which had been applied in 2019. The P-608 coverage over all previous P-631 was good, with only 5% of the coarse aggregate exposed in areas with previous P-631 and 20% coarse aggregate exposed in areas without the underlying P-631. The overall coverage of the P-608 was uniform. Pavement markings on the P-608 were performing very well with good visual delineation. Single tire tracks were noticeable in some areas. Fuel truck paths to fuel pumps were very clear. It is not known if the tracks were formed shortly after application, caused by high trafficking, or developed due to trafficking during very hot weather. Overall, the primary deterioration mechanism was fading. No flaking or chipping was observed to raise FOD concerns. Very limited weathering was observed in some areas. Apron 1 was not crack sealed before applying P-608 and had low-severity block cracking. White precipitate was also present throughout the cracks in Apron 1. LUG reported that the precipitate developed after the first rain and had slowly reduced afterwards. Some new cracks continued to develop in Apron 2. Overall, the crack spalling on Aprons 1 and 2 was minor. Crack sealant that can become dislodged was not a concern, and the crack sealing was in good condition. The treatments on Aprons 1 and 2 were in good condition. The remaining service life of the P-608 on areas with underlying P-631 was estimated at three to four years and is 1 year on areas without underlying P-631. Pictures of P-608 conditions in this pavement group are presented in figures LUG-11 through LUG-18.

Figure LUG-11. Overview of Apron With P-608

Figure LUG-12. Apron Overview With P-608 With White Precipitate

Figure LUG-13. P-608 Texture on Apron

Figure LUG-14. Fuel Truck Track on P-608 Over P-631

Figure LUG-15. Map Cracking on Apron

Figure LUG-16. Crack Sealant on Apron

Figure LUG-17. Closeup of White Precipitate on Apron

Figure LUG-18. Overview of White Precipitate on Apron

HIGH-AGE GROUP

LUG Taxiway A and A2 fall within the high-age pavement group (over 39 years). On these taxiways, P-608 coverage was fair, with 60% of the coarse aggregate exposed. The coverage of P-608 on the coarse aggregate was uneven, and the overall coverage of P-608 was not uniform. Thickness variations of the P-608 layer can be easily identified. The underlying pavement was becoming more visible in areas with a thin P-608 layer. Pavement markings on the P-608 are performing very well. The visual delineation of the markings is good. Single tire tracks were noticeable in some areas. Overall, the primary form of deterioration is fading. No flaking or chipping was observed that would raise FOD concerns. The pavements had cracks with overband sealant. Raveling on the pavement was visible during inspection but had been partially filled in by the P-608 surface treatment. The P-608 surface treatment did not address the raveling due to the thickness of the treatment. FOD concerns were also apparent from the aggregate raveling. The P-608 treatment may not have been appropriate for these pavements based on the amount and severity of the raveling; a slurry seal or micro-surface treatment could have worked better. Since the last PCI inspection in 2019 (PCI in the range of 20–22), it is estimated that the PCI has increased approximately 10–15 PCI points. The amount of raveling recorded during a PCI survey would have likely been reduced based on the difficulty in seeing all areas with aggregate missing. Additionally, the crack sealing had shifted some cracks from medium to low severity. It is difficult to estimate the remaining service life of the P-608 treatment on Taxiway A and A2, as application of this treatment is not typical for the age and deteriorated surface condition of the pavement. Some benefits may remain for approximately one to two more years in specific areas where the treatment is thicker. Pictures of P-608 condition on these pavements are presented in figures LUG-19 through LUG-23.

Figure LUG-19. Overview of Taxiway A With High Age P-608

Figure LUG-20. Texture of Taxiway A in High Age Area

Figure LUG-21. Tire Tracks on Taxiway A in High Age Area

Figure LUG-22. Crack Sealant on Taxiway A in High-Age Area

Figure LUG-23. P-608 Coverage on Taxiway A Edge in High-Age Area

P-608H HEAVY-EMULSIFIED ASPHALT SEAL COAT

An area of approximately 30,000 ft² on the northern end of the Taxiway A was used as a demonstration strip for a product referred to as P-608H (not currently an FAA specification), primarily to assess its performance in relation to P-608. As seen in figure LUG-24, the P-608H was noticeably lighter in color compared to the P-608. Some pictures of the P-608H are presented in figures LUG-24 through LUG-27.

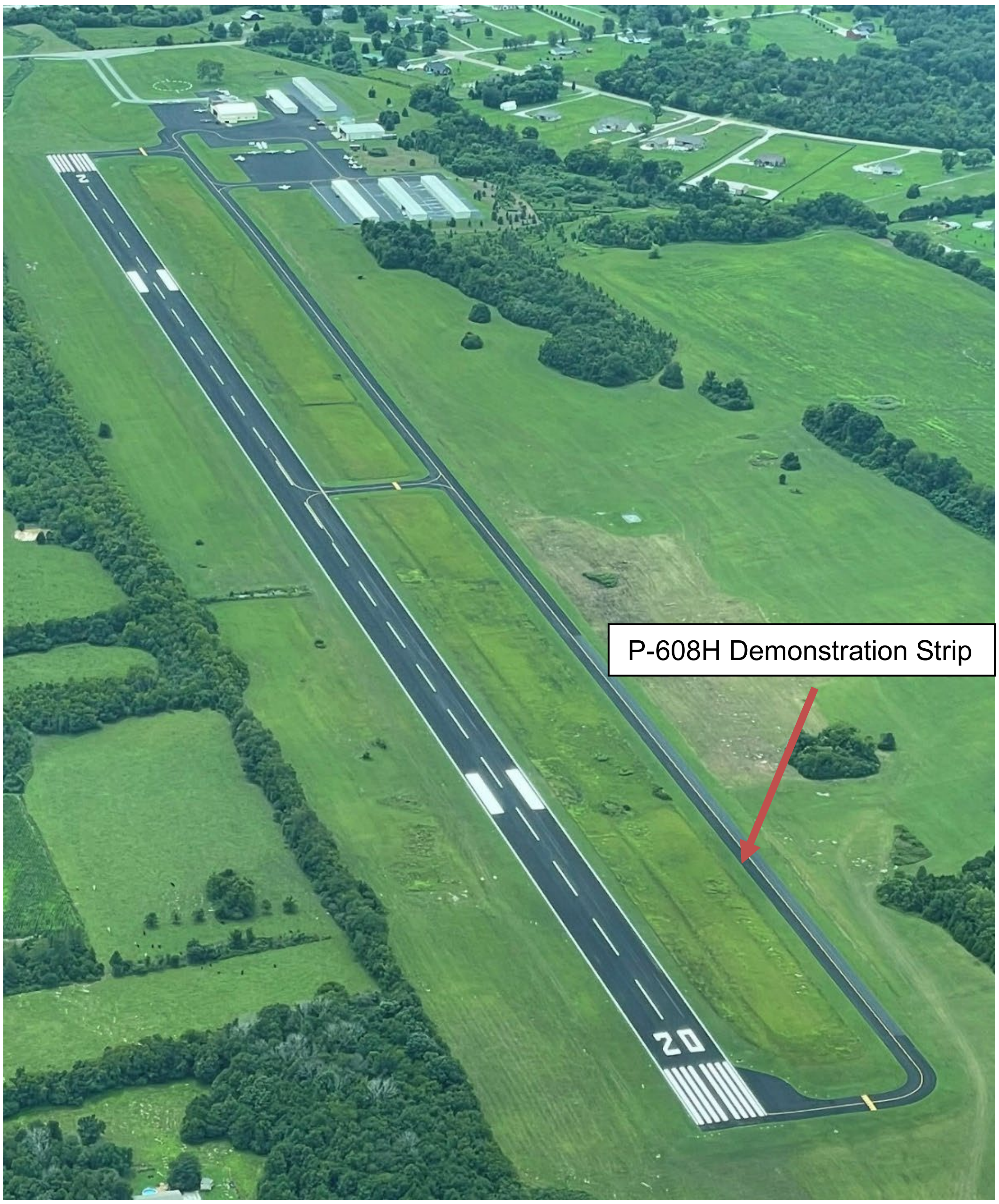

Figure LUG-24. Aerial Image of LUG Showing the Location of the P-608H Demonstration Strip (August 2021)

Figure LUG-25. Taxiway A With P-608H

Figure LUG-26. Comparison of P-608H (Left) and P-608 (Right)

Figure LUG-27. P-608H Texture on Taxiway A

Utah DOT Surface Treatment Case Study

BACKGROUND

The Utah Department of Transportation (UDOT) Aeronautics Division provides oversight for forty-three airports throughout Utah. In recent years, the airports within the state have used several surface treatments, including FAA designated materials such as P-608, P-626, P-631, and P-632 as well as other non-FAA specified treatments such as frictional mastics. Utah falls in the Dry, Freeze LTPP climate zone. The Köppen-Geiger climate classification of Utah is mostly arid-steppe-cold arid. Utah's annual average daily dose of UV irradiance is approximately 3,100 joules/m², which is 15% higher than the national average of approximately 2,700 joules/m² (CDC, 2022). According to the NWS, the state experienced 15 in. of average annual precipitation during the last 5 years; however, totals vary widely (CDC, 2022). Portions of the Wasatch Range, which lies east of Ogden, Salt Lake City, and Provo, may receive over 70 in. of precipitation annually, while areas within the Great Salt Lake Desert receive less than five in. of precipitation annually. The NWS also notes that the average annual snowfall varies from a couple of inches in southern Utah to over 450 in. in Alta. The annual freezing degree-days vary from under 40 to over 2,500 days, while the mean length of the freezing season varies from 6 to 200 days (PCASE, 2022).

UDOT AIRFIELD SURFACE TREATMENT GENERAL PRACTICES

The UDOT Aeronautics Division reported on the use of several FAA-specified surface treatments at Utah airports, including P-608, P-626, P-630, P-631, and P-632.

Reasons for using these treatments include extending the pavement life until future major rehabilitation work, preventing distress, improving pavement conditions, and improving and/or maintaining pavement friction characteristics. Factors considered in selecting treatments include cost, climatic conditions, FAA guidance, consultant/designer recommendation, and desired performance results. Table UDOT-1 provides additional detail about the use of these treatments.

Table UDOT-1. Summary of UDOT use of FAA-specified Surface Treatments

Descriptor	P-608	P-626	P-630	P-631	P-632
Years of Use	2018–2020	2019–2021	2017–2020	2017–2019	2016–2021
PCI at Application	70–85	50–70	50–70	50–70	70–85
Load-Related Distress Present	No	Isolated	No	No	No
Environmental Distress Present	L&T cracking, weathering, some oil spills	L&T cracking, block cracking, weathering	L&T cracking, weathering	L&T cracking, raveling, weathering	L&T cracking, weathering
Expected Life	4 years	5 years	4 years	5 years	4 years

The following sections summarize the general use of FAA-specified surface treatments at airports under the oversight of UDOT's Aeronautics Division. It is followed by more extensive descriptions of the use and performance of two non-FAA specified surface treatments.

P-608 EMULSIFIED ASPHALT SEAL COAT

Approximately 3.5M ft^2 of P-608 was used on runways, taxiways, and aprons at various Utah general aviation airports between 2018 and 2020. The largest aircraft operating on these pavements are general aviation turboprops. Before application, most of the pavements were in SATISFACTORY condition (i.e., $70 < PCI \leq 85$) and did not have any load-related distresses. Climate-related distresses such as L&T cracking and weathering were present, and oil spills were also present on some pavements.

The main objectives of using P-608 were to extend pavement life until any major rehabilitation work could be completed, prevent pavement distress, and improve and/or maintain pavement friction characteristics. Major factors considered for selecting P-608 include cost and climatic conditions. Additionally, FAA guidance, consultant/designer recommendations, and desired performance results were considered in the selection process. The expected lifespan of the P-608 treatment was 4 years. The FAA's P-608 specification was not customized for these applications.

P-626 EMULSIFIED ASPHALT SLURRY SEAL SURFACE TREATMENT

P-626 was used on a range of pavements at various Utah airports between 2019 and 2021. The largest aircraft operating on these pavements are general aviation turboprops. Before application, most of the pavements were in FAIR condition (i.e., $50 < PCI \leq 70$). The pavements exhibited some isolated load-related cracks and climate-related distresses such as L&T cracking, block cracking, and weathering.

The main objective of using P-626 was to extend pavement life until any major rehabilitation work could be completed, prevent distress, correct existing distresses, and improve and/or maintain pavement friction characteristics. Major factors considered for selecting P-626 include cost, climatic conditions, and recommendations from various airports that had previously used P-626. Additionally, FAA Advisory Circulars, consultant/designer recommendations, and desired performance results were also considered in the selection process. The expected lifespan of the P-626 treatment was 5 years.

P-630 REFINED COAL TAR EMULSION WITHOUT ADDITIVES, SLURRY SEAL TREATMENT

P-630 was used at various Utah general aviation airports between 2017 and 2020. The largest aircraft operating on the runways, taxiways, and aprons where the P-630 was applied are general aviation turboprops. Before application, most of the pavements were in FAIR condition (i.e., $50 < PCI \leq 70$). The pavements did not have any load-related distresses. Climate-related distresses such as L&T cracking and weathering were present on the pavements.

The main objectives of using P-630 were to extend pavement life until rehabilitation and to prevent distress. Major factors considered for selecting P-630 include climatic conditions and recommendations from various airports that have previously benefited from using P-630. Additionally, FAA Advisory Circulars, consultant/designer recommendations, desired performance results, and previous experience were also considered in the selection process. The expected lifespan of the P-630 treatment was 4 years.

P-631 REFINED COAL TAR EMULSION WITH ADDITIVES, SLURRY SEAL TREATMENT

P-631 has been used at various Utah general aviation airports during the period from 2017 to 2019. The largest aircraft operating on the runway, taxiway, and apron pavements where P-631 has been used are general aviation turboprops. Before application, most of the pavements were in FAIR condition (i.e., $50<PCI\leq 70$). The pavements did not have any load-related distresses. Climate-related distresses such as L&T cracking, raveling, and weathering were present on the pavements.

The main objectives of using P-631 were to extend the pavement life until rehabilitation and prevent pavement distress. The major factors considered for selecting P-631 application include cost, climatic conditions, and recommendations from airports that have previously used P-631. Additionally, FAA Advisory Circulars, consultant/designer recommendations, desired performance results, and previous experience were also considered in the selection process. The expected lifespan of the P-631 treatment was 5 years.

P-632 ASPHALT PAVEMENT REJUVENATION

P-632 has been used at various Utah general aviation airports during the period from 2016 to 2021. The largest aircraft operating on the runways, taxiways, and aprons where it has been used are general aviation turboprops. Before application, most of the pavements were in SATISFACTORY condition (i.e., $70<PCI\leq 85$). The pavements did not have any load-related distresses. Climate-related distresses such as L&T cracking and weathering were present.

The main objectives of using P-632 were to extend pavement life until any future major rehabilitation work and prevent distress. Major factors considered for selecting P-632 application included cost and climatic conditions. Additionally, FAA Advisory Circulars, consultant/designer recommendations, desired performance results, and previous experience were considered in the selection process. The expected lifespan of the P-632 treatment was 4 years.

ONYX (FRICTIONAL MASTIC SURFACE TREATMENT)

Onyx is a proprietary product identified by the manufacturer as a Frictional Mastic Surface Treatment. It is an engineered mixture of fine aggregates, clay, polymers, other additives, and an asphalt emulsion. The material is advertised by the manufacturer to improve friction, durability, and provide a black pavement surface. The details of Onyx material can be found at the manufacturer's website (Ergon Asphalt & Emulsions, 2022). Due to similarities between specifications, Onyx can be used as an Asphalt Polymer Treatment (APT), which is a UDOT-specific surface preservation treatment material. UDOT's designation of APT is 02790S, and specifications can be found in UDOT's Materials Specification manual (UDOT, 2019)

SKYPARK AIRPORT

Skypark Airport (BTF) is a privately owned airport in Bountiful. Approximately 99% of the traffic at BTF is general aviation, while the rest is air-taxi. The majority of the aircraft operating from BTF are less than 12,500 lb, although there are a few close to 25,000 lb.

In 2019, Skypark Airport used Onyx on their single 4,634-ft long Runway, 17/35. The runway had previously been rehabilitated in 2017. Skypark was looking for a surface treatment to protect their rehabilitation investment. At the Utah Airport Operators Association conference, Morgan Pavement, who had previously used Onyx on the causeway to Antelope Island, Utah, introduced the airport to Onyx. Upon visiting the site, the Airport was impressed by the performance and color, which led to them selecting Onyx for their runway.

The surface treatment project at BTF was budgeted to be $80,000, with 60% funding sourced from the state. The runway and connector taxiways were the main locations where Onyx was applied, along with some hangar locations. Because it was relatively new, the runway did not have any cracks requiring sealing prior to treatment application.

BTF reported that Onyx has performed as intended, and no cracks have developed on the runway. Sandblasting of Onyx in localized areas was successfully done in 2021 for pavement remarking. Usage of Onyx has created some limitation in snow plowing. The airport now must use a rubber blade instead of a steel blade on their snowplows to keep the Onyx material intact. The pavement at the hangar locations was already in POOR condition and experienced debonding after application of Onyx.

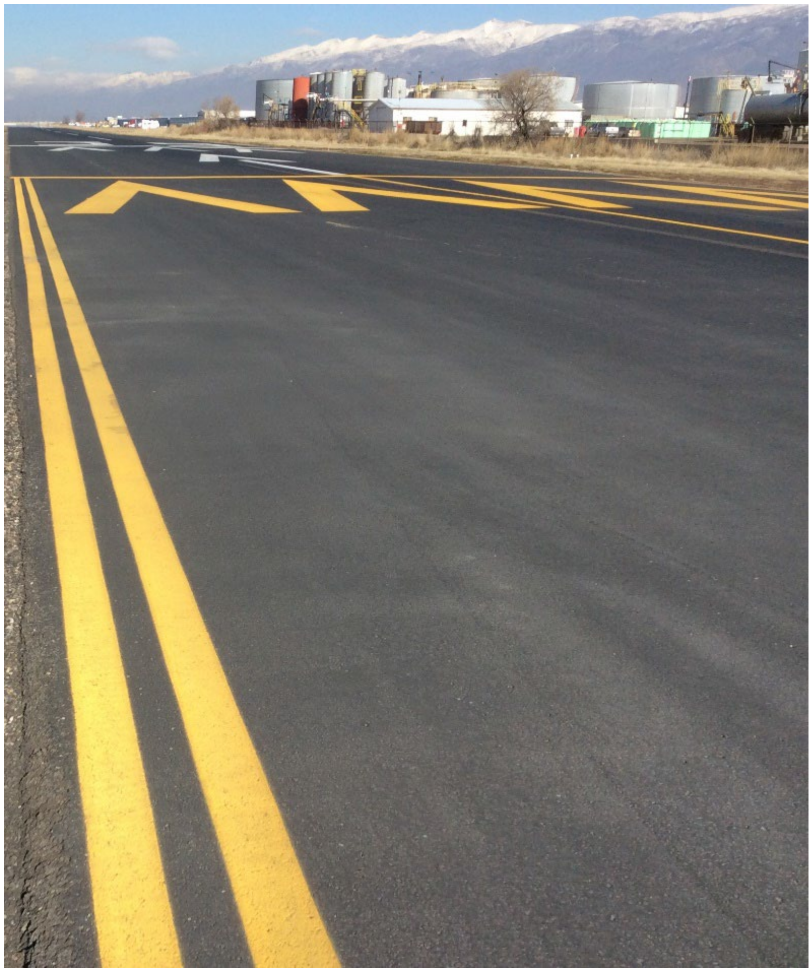

Figure UDOT-1. BTF Runway 17/35 With Onyx

Figure UDOT-2. BTF Connector (right) With Onyx and Parallel Taxiway (Left) Without Onyx

A visual inspection of pavement surfaces at BTF was performed in April 2022. At the time of inspection, Runway 17/35 was approximately seven years old, and the Onyx was approximately four years old. When the Onyx was applied, the PCI of the runway was in the mid- to high-90s.

The inspection showed that the runway macrotexture mostly reflected the texture of the aggregate. Some areas had slightly less macrotexture where the application was thicker. The surface had a "grit"-like feeling, due to the sand mixed into the treatment. The coverage of the Onyx on coarse aggregate varied, with coarse aggregate being exposed approximately 0–5%. Fine aggregates were well covered in all areas. The Runway 35 end had the highest concentration of exposed aggregate. In spots where the coarse aggregate was exposed, some aggregates were in fractured condition while others were missing. In some instances, the surface treatment had filled in locations of missing coarse aggregate. Overall, the coverage of Onyx appeared to be uniform.

Longitudinal paving joints on the runway were mostly closed, but a few were open. On the surface, very slight wear was observed in a few higher traffic areas. FOD production was not a concern at the time of inspection. Pavement markings had not been reapplied and remained clearly delineated.

Some tenant aprons also received Onyx, but the pavements in the apron areas were already in poor condition at the time of application and were not good candidates for any type of surface treatment. Additionally, the apron surfaces were not well prepared before application of the treatment and exhibited substantial debonding/flaking distress. Onyx did not perform well on these pavements.

BTF currently does not use any sweepers on the runway. "Shoes" were used on plows, but BTF abandoned them due to quick wear of the Onyx treatment. The runway has only been plowed with a steel blade twice to date. Some pictures of the Onyx conditions at BTF are presented in figures UDOT-3 through UDOT-16.

Figure UDOT-3. Overview of BTF Runway 17/35 With Onyx

Figure UDOT-4. Overview of BTF Runway 17/35 With Onyx

Figure UDOT-5. BTF Runway 17/35 Texture

Figure UDOT-6. Slight Wear of Onyx on BTF Runway 17/35

Figure UDOT-7.Overview of Edge of BTF Runway 17/35 With Onyx

Figure UDOT-8. Exposed Coarse Aggregate on BTF Runway 17/35

Figure UDOT-9. Opened Longitudinal Paving Joint on BTF Runway 17/35

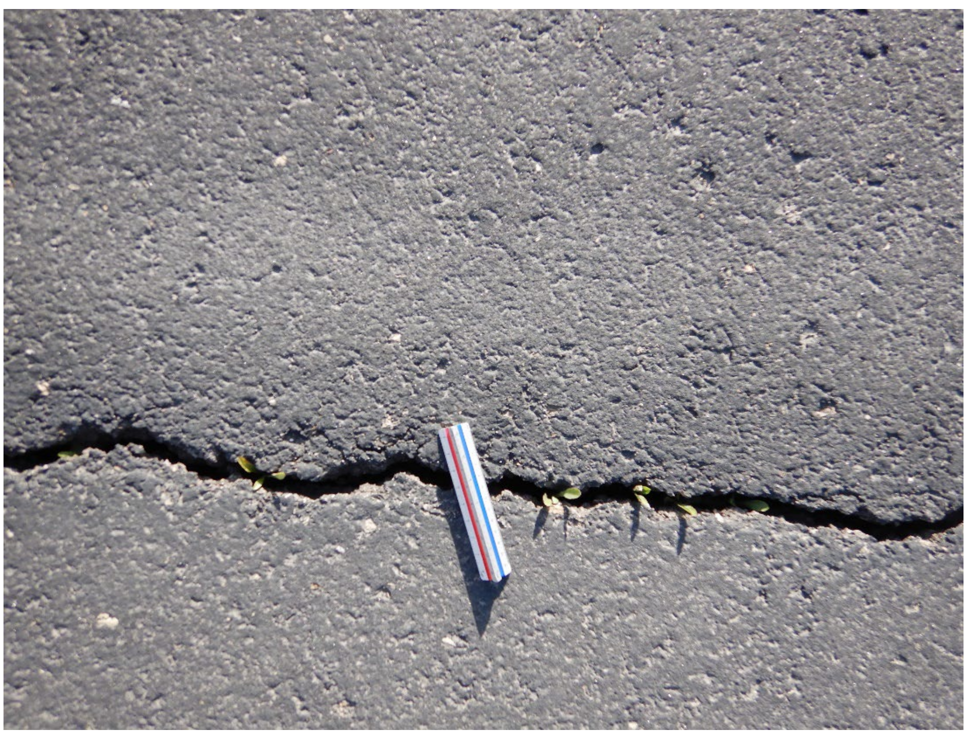

Figure UDOT-10. Closeup of Opened Longitudinal Paving Joint

Figure UDOT-11. Closed Longitudinal Paving Joint on BTF Runway 17/35

Figure UDOT-12. Sandblasted Area on BTF Runway 17/35

Figure UDOT-13. Overview of BTF Apron With Onyx

Figure UDOT-14. Debonding on BTF Apron

Figure UDOT-15. Raveling on BTF Apron

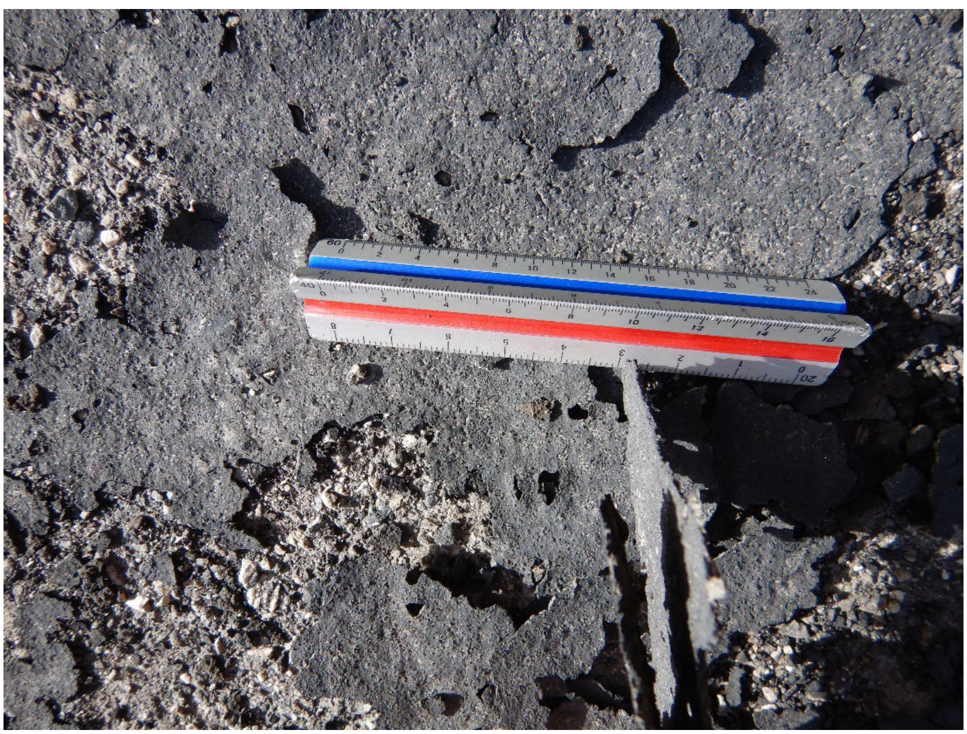

Figure UDOT-16. Onyx Thickness on BTF Apron

MORGAN COUNTY AIRPORT

Morgan County Airport (42U) in Morgan County, Utah used Onyx on their runway, taxiway, and apron in 2020. 42U is a general aviation airport with a single 3,904 ft runway (Runway 03/21). The airport is publicly owned by Morgan County. Approximately 99% of the traffic at 42U is general aviation, while the remaining 1% is air-taxi.

Runway 03/21 had been rehabilitated in 2016, and the taxiway and aprons were rehabilitated in 2012. The airport authority selected Onyx to protect their rehabilitation investment. The runway surface was 4 years old, and the taxiway and apron pavements were 8 years old at the time of Onyx application. The taxiway and apron pavements had previously received a surface treatment.

42U was visited in April 2022 to inspect the condition of the surface treatment. The pavement macrotexture mostly reflected the texture of the aggregate. The surface had a "grit"-like feeling, which was due to the sand mixed into the treatment. The coverage of Onyx on coarse aggregate was good, with only 1% exposed coarse aggregate. Fine aggregates were well covered in all areas. The color of Onyx was slightly different on the runway just past the northeast connector taxiway, probably due to a break in the timing of the application. Overall, the Onyx coverage appeared to be fairly uniform throughout all pavements; there were a few areas where it was slightly thicker.

Prior to the application of Onyx in 2020, edge cracking and at least one longitudinal paving joint on the runway were crack sealed with overband. The longitudinal paving joints on the runway were mostly closed, although there were a few in open condition. The runway had fewer distresses than the taxiway or apron pavements, which had both sealed transverse cracks and edge cracks. Previously placed crack seals were starting to fail. Sealant in some transverse cracks was re-applied after the treatment work. There were also some unsealed cracks on these pavements that likely occurred after the Onyx application. Smoothed surfaces were observed in some areas, which may have been caused by snowplow steel blades. No traffic-induced wearing was observed. The pavement markings had not been reapplied and remained well delineated. FOD production was not a concern at the time of inspection. However, some of the edge cracking on the taxiway was fragmented, which could become a concern for FOD production in the future. Wider transverse cracks can also become an FOD concern if they continue to develop.

The 2020 PCI inspection prior to the application of Onyx showed PCIs of 88, 66, and 73–81 for the runway, taxiway, and apron, respectively. The 2022 inspection showed that Onyx helped preserve and improve the condition of the pavements at 42U. The PCI at the time of visual inspection in 2022 was estimated to be in the mid to high 90s for the runway and in the low 80s for other pavements. Onyx is expected to have 3–5 years of remaining service life. Pictures of Onyx at 42U are presented in figures UDOT-17 through UDOT 27.

Figure UDOT-17. 42U Runway 03/21 Overview With Onyx

Figure UDOT-18. Overview of 42U Runway 03/21 With Onyx

Figure UDOT-19. Surface Texture of 42U Runway 03/21

Figure UDOT-20. 42U Runway 03/21 Longitudinal Paving Joint

Figure UDOT-21. Closeup of Longitudinal Paving Joint on 42U Runway 03/21

Figure UDOT-22. Surface Smoothening Due to Snowplowing on 42U Runway 03/21

Figure UDOT-23. Onyx Color Difference Due to Application Phase Break

Figure UDOT-24. Overview of 42U Taxiway With Onyx

Figure UDOT-25. Transverse Crack on 42U Taxiway

Figure UDOT-26. Edge Cracking on 42U Taxiway

Figure UDOT-27. Overview of 42U Apron With Onyx

COAL TAR FOG SEAL COAT

Coal tar fog seal coat is a surface treatment conforming to the requirements of FAA Engineering Brief 44B (since cancelled). It is a coal tar sealer/rejuvenator which can be applied on a previously prepared bituminous surface. The primary purpose of this material is to provide a fuel-resistant surface and to protect the asphalt binder. The bituminous material in this treatment is specified as coal tar oils and coal tar prepared from high-temperature coal tar pitch, conforming to the requirements of ASTM D 490, Grade 12. More details on this treatment can be found elsewhere (FAA, 2008).

BRIGHAM CITY AIRPORT

Brigham City Airport (BMC) is a city-owned public-use airport located 6 mi northwest of the central business district of Brigham City, in Box Elder County, Utah. BMC is a general aviation airport with a single 8,900 ft runway (Runway 17/35). Approximately 98% of the traffic at BMC is general aviation, while the remaining 2% is air-taxi.

Taxiways at BMC were rehabilitated in 2006 and 2008, and the aprons were rehabilitated around 2000. BMC used the coal tar Fog Seal Coat in 2017 on their taxiways and apron. A visual inspection in April 2022 showed that the taxiway macrotexture mostly reflected the texture of the aggregates. The coal tar treatment did not contain any aggregate and the surface lacked any “grit.” Exposure of coarse aggregate on the 14-year-old taxiway was approximately 10%, and was 30% on the 16-year-old pavement. Fine aggregates were well covered in all areas. Only one location had a streaking pattern, possibly due to clogged nozzles in the spray applicator. Overall, the coverage of the coal tar was fairly uniform on the taxiway.

Longitudinal paving joints on the 14-year-old taxiway were mostly closed; joints were partially open on the 16-year-old taxiway, which also had occasional centerline cracking. Additionally, longitudinal wheel path cracking had started to form in one location on the older pavement. Areas were observed where the treatment had been scraped off the coarse aggregate from snowplow operations. Fading was also observed on the surface. No wearing due to aircraft traffic was observed. FOD production was not a concern at the time of inspection. Pavement markings had not been reapplied and were in poor condition, mostly due to snowplow scraping. The delineation of pavement markings was fair.

The 2018 PCI inspection reported taxiway PCIs in a range from 85 to 96, which puts it in VERY GOOD condition. An estimate of the PCI from the 2022 visual inspection was 80–93. It is expected that this treatment has one to two years of service life left for the 14-year-old pavement and 1 year of service life left for the 16-year-old pavement. Photographs of the coal tar fog seal coat conditions at BMC taxiway are presented in figures UDOT-28 through UDOT-39.

Figure UDOT-28. Overview of BMC Taxiway (Rehabilitated in 2008) With Coal Tar Fog Seal

Figure UDOT-29. Closeup of BMC Taxiway (Rehabilitated in 2008) Surface

Figure UDOT-30. BMC Taxiway (Rehabilitated in 2008) Surface Texture

Figure UDOT-31. BMC Taxiway (Rehabilitated in 2008) Longitudinal Paving Joint

Figure UDOT-32. BMC Taxiway (Rehabilitated in 2008) Showing Uneven Coverage of Coal Tar Fog Seal

Figure UDOT-33. Snowplow Wear on BMC Taxiway (Rehabilitated in 2008)

Figure UDOT-34. Overview of BMC Taxiway (Rehabilitated in 2006) With Coal Tar Fog Seal

Figure UDOT-35. BMC Taxiway (Rehabilitated in 2006) Surface Texture

Figure UDOT-36. BMC Taxiway (Rehabilitated in 2006) Longitudinal Paving Joint

Figure UDOT-37. Wheelpath Cracking on BMC Taxiway (Rehabilitated in 2006)

Figure UDOT-38. Snowplow Wear on BMC Taxiway (Rehabilitated in 2006)

Figure UDOT-39. Thick Coal Tar Fog Seal Application on BMC Taxiway (Rehabilitated in 2006)

The 2022 visual inspection on the apron showed that the apron macrotexture mostly reflected the texture of the aggregates. Similar to the taxiway application, the treatment on the apron did not contain any aggregate. Approximately 30% of the coarse aggregate on the apron was exposed. Fine aggregates were well covered in all areas. Overall, the coverage of the coal tar fog seal on the apron appeared to be fairly uniform.

L&T cracking and patching were common throughout the apron area. Block cracking was also defined in some areas, and continued development of new cracking was noted. Previously placed overband crack sealant was mostly failed. Areas were observed where the treatment had been scraped off coarse aggregate from snowplow operations. Additionally, the surface color had faded. Wearing due to aircraft traffic was not observed in any location. FOD production was not a concern at the time of inspection. Pavement markings had not been reapplied and were in poor condition, again mostly due to wear from snowplow operations. Pavement marking delineation was fair, but there were limited markings on the apron.

The 2018 PCI inspection reported the apron PCI in the range of 78–94. The PCI in 2022 was estimated to be in the high 60s. The coal tar fog seal was estimated to have approximately one year of remaining service life. Some pictures of coal tar fog seal conditions on the BMC apron are presented in figures UDOT-40 through UDOT-43.

Figure UDOT-40. Overview of BMC Apron With Coal Tar Fog Seal

Figure UDOT-41. BMC Apron Surface Texture

Figure UDOT-42. L&T Cracking on BMC Apron

Figure UDOT-43. Block Cracking on BMC Apron

Wisconsin DOT Case Study

BACKGROUND

Wisconsin Department of Transportation (WisDOT) Bureau of Aeronautics is responsible for providing support to eight commercial service airports and 124 general aviation public-use airports throughout the State. Over the past decade, Wisconsin airports have used various types of surface treatments including P-626, P-631, P-632, and WisDOT P-652. Surface treatments have been applied to runway, taxiway, apron, shoulder, and acute-angled exit taxiway pavements.

Wisconsin falls in the Wet, Freeze LTPP climate zone. The Köppen-Geiger climate classification throughout Wisconsin is mostly snow-fully humid-warm summer. Within the state, the annual average daily dose of UV irradiance is approximately 2,050 joules/m², which is 24% lower than the national average of approximately 2,700 joules/m² (CDC, 2022). The state experienced 36 in. of average annual precipitation during the last 5 years (NWS, 2022), The average annual snowfall varies from 32 in. in southern Wisconsin to over 100 in. within Iron County in the north.[2] The annual freezing degree days varies from 740 to 2,070 days, while the mean length of freezing season varies from 90 to 140 days (PCASE, 2022).

The majority of WisDOT's surface treatment application work is funded by the FAA's AIP. State funds are the primary funding source for airports not within the NPIAS. Contractors are selected through a bidding process and must pass WisDOT's prequalification process to be eligible to bid for any contract. Typically, most contracts include surface treatment work that covers multiple airports within a selected region.

WisDOT is currently developing a matrix to select different surface treatment types. Factors considered in developing the matrix include PCI, the age of the pavement, user experience, cost, future rehabilitation schedule, and engineering judgement. WisDOT also currently receives recommendations for the application of surface treatments and resurfacing through consultant analysis within the airport pavement management system.

P-626, EMULSIFIED ASPHALT SLURRY SEAL SURFACE TREATMENT

Prior to 2018, P-626 was the most widely used surface treatment at WisDOT airports (Wisconsin 2021 IDEA, 2022). P-626 has been used on runways, taxiways, aprons, shoulders, and acute-angled exit taxiways, primarily to extend pavement life. Factors considered in selecting P-626 include airport location, site soil condition (impacts drainage conditions), cost, and user experience. Over time, WisDOT customized the P-626 specification to reduce the amount of aggregate, promote longer tire life spans, and decrease FOD production from the treatment. Guidance from the manufacturer is followed related to the required weather conditions at application.

The expected lifespan of the P-626 treatment is 5 years. Before application of P-626, all surface cracks are sealed. The curing time for crack sealants is typically less than one day. Localized slurry material was applied to level areas with subsidence around cracking prior to the primary application. Due to financial constraints, there have been isolated occurrences where the P-626 was applied only to the keel of the runway instead of the whole pavement width.

WisDOT reported that contractors sometimes encountered problems with P-626 applications, including, but not limited to, emulsion failing, temperature variation, adverse weather, aggregate clumping, and high moisture content. WisDOT is working on a strategy to better address these issues as they relate to future maintenance.

Generally, the P-626 applications have met their intended purpose, generally resulting in an overall improvement in pavement condition. Additional benefits have included decreased FOD potential and reduced pavement distresses/distress severity, while surface drainage, visual pavement delineation, and ride quality properties improved.

WISDOT P-652, MICRO-SURFACING

WisDOT P-652 Micro-Surfacing has been gaining interest and use throughout Wisconsin airports since 2018. From 2018 to 2021, the number of applications per year of WisDOT P-652 surpassed those of P-626 (Wisconsin 2021, 2022). While the WisDOT P-652 is more expensive than P-626, it is believed to have slightly better performance over its life in relation to pavement conditions, FOD production from the surface treatment, and aircraft tire wear. WisDOT follows its own state specification for applying the WisDOT P-652 treatment.

A WisDOT P-652 pilot project was completed in 2015 at Stevens Point Municipal Airport (STE), in Portage County, Wisconsin. This included an application of WisDOT P-652 on Runway 03/21, while P-626 was applied on Runway 12/30. Photographs of each material approximately two years after their application are presented in figure WisDOT-1.

Figure WisDOT-1. P-626 (left) and WisDOT P-652 (right) at STE (September 2017)

Pavement management inspections prior to the application in 2014 and after the applications in 2017 and 2020 showed similar PCI values for both runways. In other words, after 6 years, there has not been a discernible difference between the PCIs of the runways receiving P-626 and WisDOT P-652. Airports have reported that they appreciate WisDOT P-652 for its black appearance, which increases the visibility of the runway, especially in locations with sandy soil. It was also reported that WisDOT P-652 performs better than P-626 in respect to surface drainage. WisDOT currently does not have any firm limits on where this material can be placed with respect to aircraft type. Rather, they use engineering judgement on a case-by-case basis to determine if it is suitable for application, given the aircraft traffic mix.

The expected lifespan of WisDOT P-652 treatments is 5 years. Like their use of P-626, WisDOT's main objective in using WisDOT P-652 is to extend pavement life. Major factors considered for selecting WisDOT P-652 application include pavement structure, airport location, site soil condition, and cost. No crack sealants were required before the application of WisDOT P-652. Contractors are required to follow a strict quality control protocol for the surface treatment set by the WisDOT, which includes taking daily emulsion samples for testing. Most airports have not experienced any construction issues with WisDOT P-652 after application. A few airports reported isolated delamination in areas where the underlying pavement was in poor condition prior to application.

In addition to extending pavement life, further benefits from the use of P-652 include decreasing FOD potential and reducing pavement distresses/distress severity, while surface drainage, visual pavement delineation, and ride quality properties have improved.

P-631, REFINED COAL TAR EMULSION WITH ADDITIVES, SLURRY SEAL TREATMENT

P-631 has been used on aprons at some Wisconsin airports to improve their resistance to fuel spillage; however, WisDOT is currently in the process of phasing out the use of P-631 due to environmental considerations, frequent maintenance requirements, and increased FOD production. Coal tar products have been banned by various local government agencies in Wisconsin.

P-632, ASPHALT PAVEMENT REJUVENATION

P-632 was applied at New Holstein Municipal Airport (8D1) in Calumet County, Wisconsin. The treatment was applied on the taxiway of the airport in 2019. The treatment performed as intended immediately after application and increased the visual delineation of the paint markings. Two years after the initial application, P-632 was significantly worn and barely visible. P-632 has a lower life expectancy and lower cost than the P-626 and WisDOT P-652 surface treatments. The need for frequent reapplication has not made this treatment appealing to WisDOT and airport operators.

Wyoming DOT Surface Treatment Case Study

BACKGROUND

Wyoming Department of Transportation (WYDOT) Aeronautics Division assists publicly owned state airports with state and federal funding needs for use in airport improvements, planning, and construction. WYDOT coordinates between local and federal agencies in maintaining and promoting a safe and efficient aviation system. To preserve and extend pavement life, most airports in Wyoming have been treated with either a P-608 or P-608-R surface treatment.

Wyoming falls in the Dry, Freeze LTPP climate zone. The Köppen-Geiger climate classification of Wyoming is mostly arid-steppe-cold arid. Within the state, the annual average daily dose of UV irradiance is approximately 2,740 joules/m^2, which is nearly equivalent to the national average of approximately 2,700 joules/m^2 (CDC, 2022). The state experienced 15 in. of average annual precipitation during the last 5 years (NWS, 2022). For the WYDOT airports, the annual freezing degree days vary from 580 to 3,170 days, while the mean length of freezing season varies from 92 to 160 days (PCASE, 2022).

WYOMING DOT AIRFIELD SURFACE TREATMENT GENERAL PRACTICES

The Wyoming airport system is split into four quadrants, as shown in figure WYDOT-1. The airports are classified as commercial service airports, business airports, intermediate airports, local airports, and non-paved airports. WYDOT performs preservation work in one quadrant per year. Airports within the quadrant are typically inspected through the pavement management program the year before the application of surface treatments and crack sealant. WYDOT has an on-call consultant with a 5-year contract who is responsible for overseeing crack sealing work. The crack sealing work is contracted and performed separately from the surface treatment work. WYDOT has crack sealing completed usually one to two months before the application of surface treatments and is required to be completed by the end of June. This crack sealing work is contracted directly with the airport, with 80% of the construction costs funded from WYDOT and 20% from the local airport funding source. WYDOT funds 100% of the engineering and consultant fees.

WYDOT has reported that performing preservation work in one quadrant a year has enabled them to receive better bid prices from contractors. Specific pavement sections within an application quadrant generally need to fulfill two criteria to be considered a candidate for surface treatment: a) have PCI above 70 and b) have no planned major rehabilitation scheduled within the next four years. Exceptions will be made to pavement sections not meeting these criteria based on site conditions, proximity to other sections receiving preservation work, and engineering judgement.

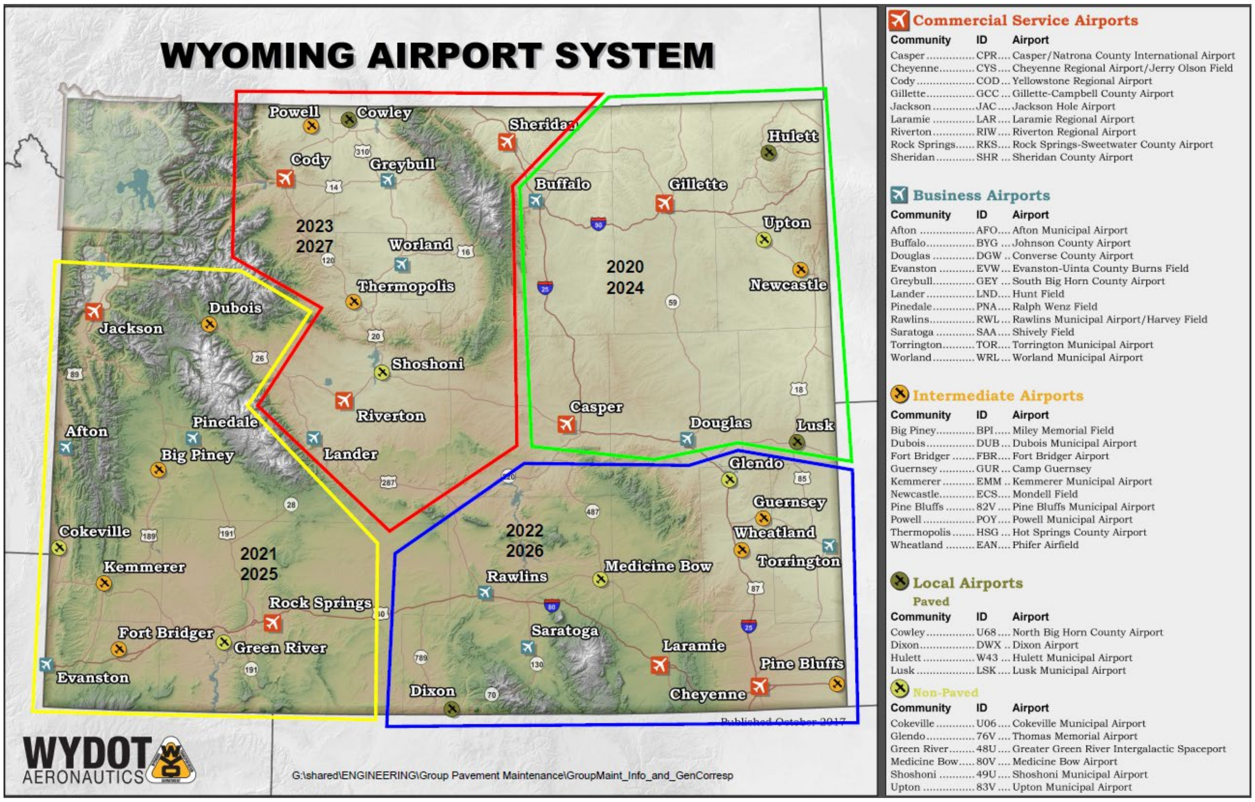

Figure WYDOT-1. Wyoming Airport System's Four Quadrants

P-608 EMULSIFIED ASPHALT SEAL COAT AND P-608-R RAPID CURE SEAL COAT

P-608 and P-608-R are not differentiated from a pavement application or preservation perspective by the WYDOT. The nine commercial service airports may elect to use P-608-R based on operational considerations, while P-608-R is not presented as an option for business, intermediate, and local airports. P-608 has been used at various airports over the last 10 years. P-608-R has only been used since it was implemented as an FAA specification in 2018. Typical locations for P-608 and P-608-R include runways, taxiways, aprons, blast-pads, and shoulders. Over the last 4 years, more than 1.4 million ft^2 of pavement at Wyoming's airports have received P-608 and approximately 900,000 ft^2 have received P-608-R. The largest aircraft operating on these pavements are narrow body jets over 60,000 lb. Before application, most of the pavements were in SATISFACTORY condition (i.e., 70<PCI≤85), but many of the pavements had minor amounts of load-related cracks. Additionally, climate-related distresses such as longitudinal and transverse cracking and weathering were present on the pavements. Depressions and patching were also present on some pavements.

The main objectives of using P-608 and P-608-R were to extend pavement life until any future major rehabilitation work could be performed and meet FAA expectations for pavement maintenance. Major factors considered for selecting P-608 and P-608-R application include cost, climatic conditions, construction duration, and recommendations from other airports. Additionally, applicable FAA Advisory Circulars and consultant/designer recommendations were also considered in the selection process. WYDOT's expected lifespan for the P-608 and P-608-R treatments is up to four years. The dilution rate for both products was 2:1 for grooved runways and 1:1 for other pavements, but the on-call consultant can select a 2:1 dilution rate based on pavement characteristics. Sand may also be applied with the P-608. No deviations to the P-608 and P-608-R specification were made.

WYDOT selects the contractor to apply this surface treatment through a bidding process. The lowest overall bidder is selected, even if they are not necessarily the lowest bidder at specific individual airports. Funding for the surface treatment work is split, with 90% coming from WYDOT and 10% from the local airport funding source. Work is required to be completed by the end of September, before the onset of cooler temperatures.

WYDOT reported that the P-608 material met its intended purpose immediately after application. Improved friction and better marking visibility were some of the immediate effects of applying P-608. Additionally, WYDOT also reported that minor pavement distress decreased due to the combination of crack sealing and surface treatments. The pavement friction also increased over the life of the surface treatment. Negligible change was noticed in foreign object debris production, surface drainage, and ride quality. Overall, WYDOT believes that P-608 material is working as intended and has successfully extended pavement life. Wyoming DOT plans to reapply the P-608 every 4 years until the pavement needs to be rehabilitated and recommends P-608 be applied at other airports with similar conditions.

CASPER/NATRONA COUNTY INTERNATIONAL AIRPORT (CPR)

WYDOT did not have a positive experience with a P-608-R application at Casper/Natrona County International Airport (CPR). The product was applied to a runway, taxiway, and aprons in September 2020. The P-608-R did not properly adhere to the surface of the runway and taxiways and peeled away shortly after application. The treatment on the apron areas performed as desired. Within one month of application, the underlying pavement was clearly visible in many locations, as shown in figures WYDOT-2 and WYDOT-3. On-site observations by the manufacturer concluded that the treatment did penetrate the top layer of pavement, which should have led to adhesion. The manufacturer concluded that the issue stemmed from a rapid cure component from one specific truck load. The manufacturer resealed the failed areas in 2021 at no additional cost, and no further issues were reported by the airport regarding adhesion during or after re-application of P-608-R in 2021.

Figure WYDOT-2. P-608-R Shortly After Initial Application—September 2020

Figure WYDOT-3. Drone View of P-608-R Shortly After Initial Application—October 2020

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