# THIRD-PARTY PERFORMANCE VERIFICATION AND INDEPENDENT TEST RESULTS

# EK35®

**A COMPILATION OF INDEPENDENT PERFORMANCE AND TEST RESULTS FROM:**

Norwegian University of Science and Technology
U.S. Army Corps of Engineers: Engineer Research and Development Center (ERDC)
U.S. Environmental Protection Agency (EPA)
University of Alaska Fairbanks (UAF) / Alaska University Transportation Center (AUTC)
Alaska Department of Transportation and Public Facilities (DOT&PF)

MIDWEST®

# CONTENTS

# I. MECHANICAL PROPERTIES OF ROADS UNBOUND TREATED WITH SYNTHETIC FLUID BASED ON ISOALKANE AND TALL OIL

*Norwegian University of Science and Technology (Transportation Geotechnics 32)*

Link: Mechanical properties of roads unbound treated with synthetic fluid based on isoalkane and tall oil

NTNU
Norwegian University of Science and Technology

# EK35® INDEPENDENT PERFORMANCE SUMMARY

## FREEZE-THAW DURABILITY TESTING

*Based on "Mechanical properties of roads unbound treated with synthetic fluid based on isoalkane and tall oil" (Transportation Geotechnics 32)*


### ABSTRACT

This performance summary reports freeze–thaw durability results independently collected by the Norwegian University of Science and Technology (NTNU) for EK35®-treated unbound granular aggregate subjected to 10 controlled freeze–thaw (FT) cycles and subsequently tested using repeated load triaxial testing (RLTT) at 0% moisture. At matched stress states, post-conditioning resilient modulus was comparable to pre-conditioning values, indicating no meaningful stiffness loss occurred after repeated FT cycles. Resistance to permanent deformation was similarly maintained, with the elastic limit angle (ρ) and failure limit angle (φ) showing negligible change after FT cycling. Retention of these performance properties indicates EK35® stabilization was not degraded by FT conditioning under the evaluated conditions. The results support EK35® use in cold-region pavement and runway layers where FT-driven deterioration is a primary design concern.


### BACKGROUND

This study's freeze–thaw component addresses the known susceptibility of unbound granular layers to freeze-thaw damage, particularly in cold regions. Repeated freeze–thaw cycles can reduce stiffness and bearing capacity, degrading overall pavement performance and lifecycle. Although many traditional and nontraditional stabilizers are currently used, standardized test methods and design guidance for assessing durability under these conditions remain limited. To address this gap, the study incorporates controlled freeze–thaw cycling into its laboratory program to evaluate whether EK35®-stabilized aggregate can maintain improved mechanical performance after exposure to multiple freeze-thaw cycles. This is particularly relevant for cold climates, where repeated freeze–thaw cycles are a dominant driver of deterioration, and where a stabilizer must not only enhance initial properties but also resist degradation over time. By testing treated specimens before and after freeze–thaw exposure using repeated load triaxial testing, the study aims to determine if EK35® resists the typical structural weakening associated with freezing conditions, thereby supporting its applicability for roads and airfields in harsh, cold-region environments.

### FREEZE-THAW DURABILITY TEST

EK35®'s freeze–thaw durability was evaluated by subjecting stabilized aggregate specimens to a controlled series of 10 freeze–thaw cycles to simulate moisture and temperature cycling representative of cold-region conditions. After the specimens completed 10 cycles, Repeated Load Triaxial Testing (RLTT) was performed. RLTT is a performance-based laboratory method that applies cyclic confining and deviatoric stresses to replicate traffic loading and measure key properties including resilient modulus (stiffness) and permanent deformation. Comparing RLTT results before and after freeze–thaw exposure at the same stress states shows whether the stabilizer retains mechanical integrity during cyclic freezing and provides a quantitative measure of durability for cold-climate road and runway applications.

## TEST PROCEDURE

The freeze–thaw durability test procedure in this study consisted of conditioning EK35®-stabilized aggregate specimens through a standardized sequence of 10 freeze–thaw (FT) cycles, followed by Repeated Load Triaxial Testing using the same protocol applied prior to conditioning.

Each FT cycle included four steps: (1) short-term water submersion (5 minutes at ~23 °C) to introduce moisture, (2) drainage/rest period (5 minutes) to remove excess water, (3) freezing at –15 °C for 24 hours, and (4) thawing at 23 °C for 24 hours, with provisions at the top and bottom of the specimen to allow water movement and minimize handling disturbance. The specimens were fully dried before testing (w = 0%) to isolate structural effects rather than moisture variability. To quantify durability, the study conducted RLTT both before and after FT conditioning, applying cyclic confining and deviatoric stresses to simulate in-service loading and measure resilient modulus (MR) and permanent deformation behavior. By directly comparing these properties pre and post FT exposure under identical loading conditions, the procedure provides a controlled, performance-based evaluation of how freeze–thaw cycles influence the structural integrity and mechanical response of the EK35®-treated aggregate system.

## TEST OBJECTIVES

The freeze–thaw durability test procedure in this study consisted of conditioning EK35®-stabilized aggregate specimens through a standardized sequence of 10 freeze–thaw (FT) cycles, followed by Repeated Load Triaxial Testing using the same protocol applied prior to conditioning.

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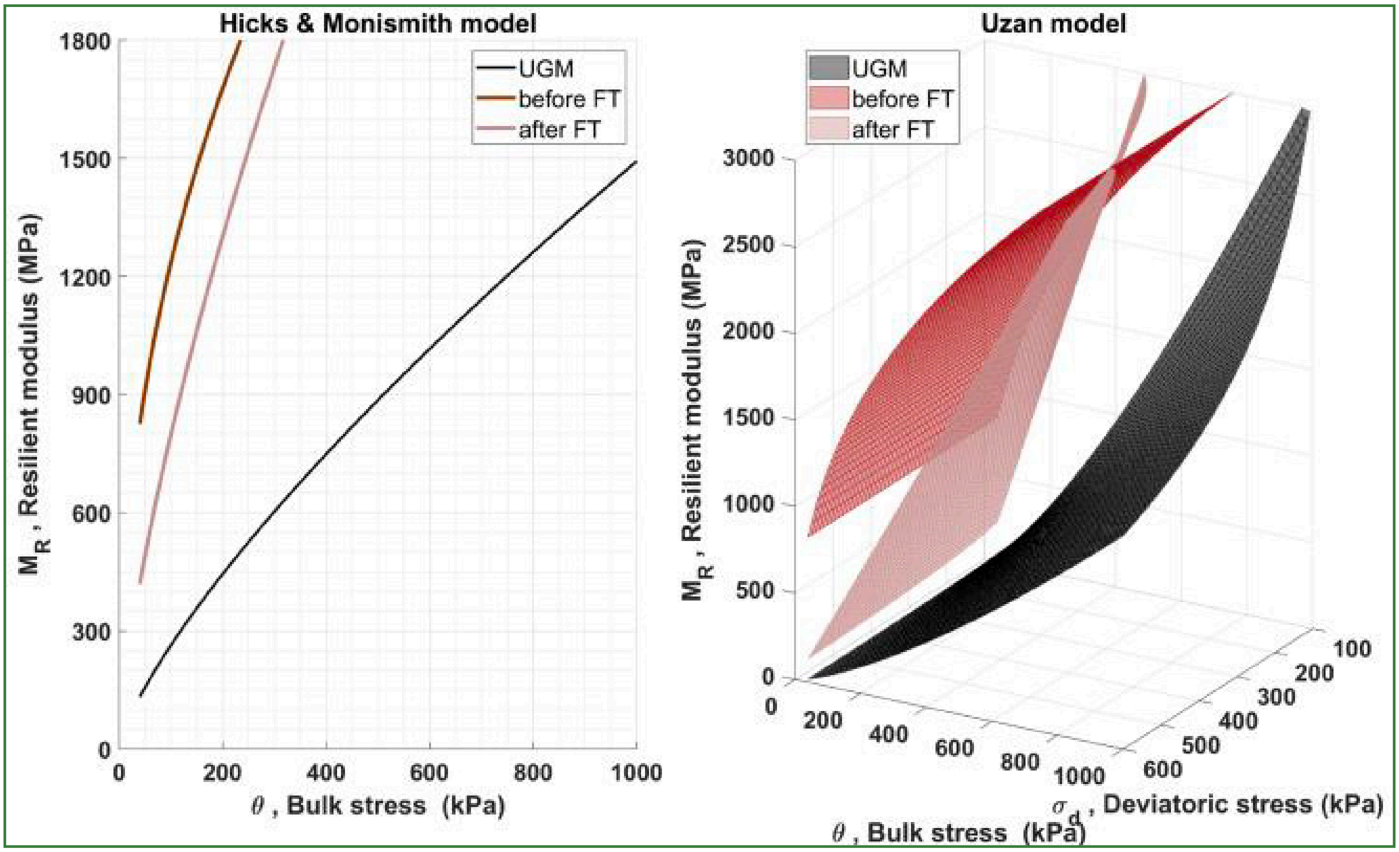
## FINDINGS

- EK35® did not lose effectiveness under freezing conditions, likely due to its non-freezing behavior and water-resistant coating characteristics.
- A clear stabilization effect was maintained both before and after freeze-thaw exposure when tested at 0% moisture.
- Resilient modulus (MR) of treated samples remained relatively consistent before and after 10 freeze–thaw cycles, indicating little to no degradation in stiffness.
- Resistance to permanent deformation showed negligible change, with elastic limit angle (ρ) and failure limit angle (φ) remaining nearly unchanged after cycling.
- Overall, freeze–thaw cycling had little to no effect on the EK35®-treated aggregate's mechanical performance, supporting its use in cold regions where thaw weakening is a concern.

**TRANSPORTATION GEOTECHNICS FIGURE 10:**
*Trends of resilient moduli MR for SF-1 specimens tested before and after 10 FT cycles (w = 0%)*




**TRANSPORTATION GEOTECHNICS FIGURE 5:**
*Illustration of the main steps to perform FT cycles.*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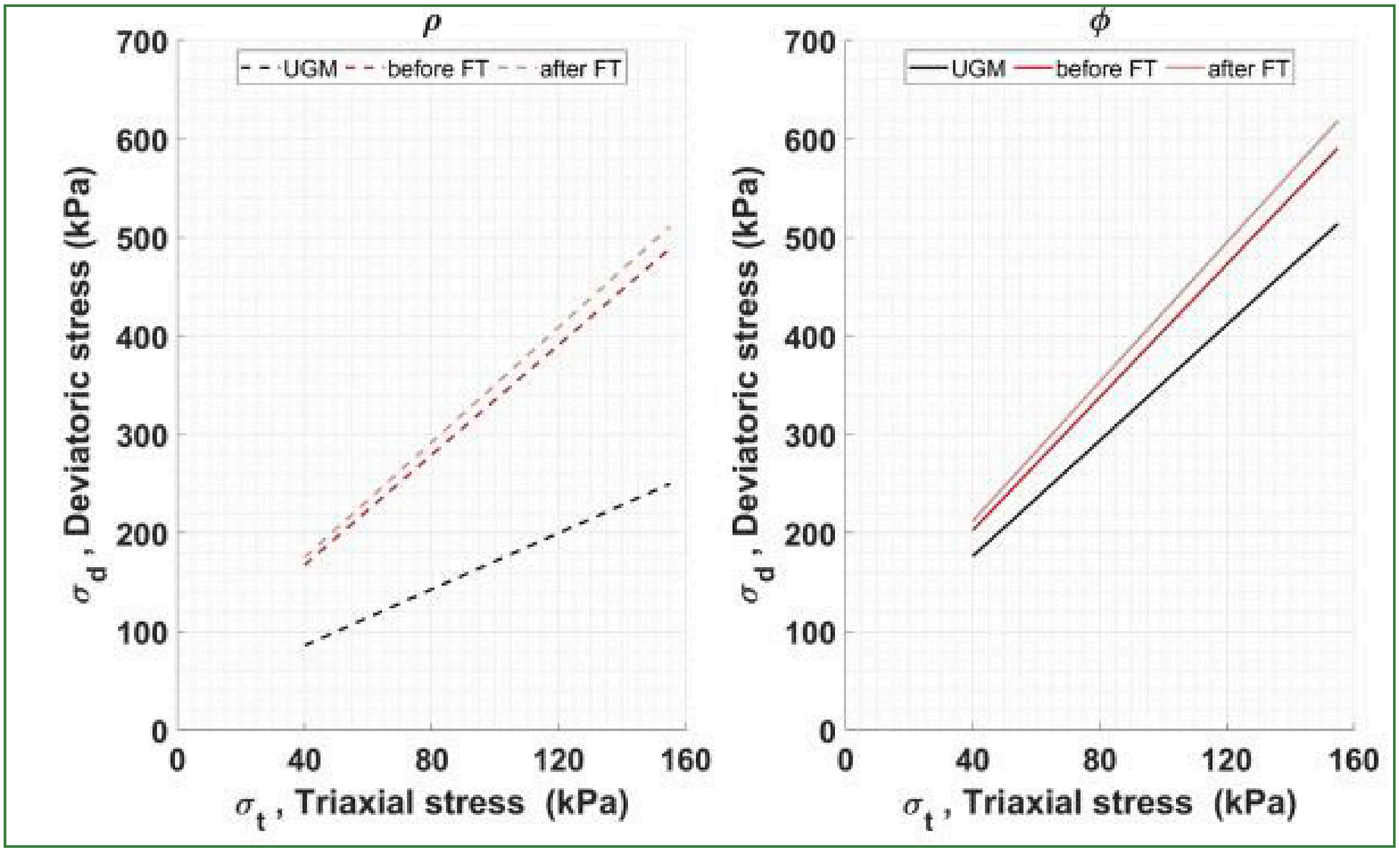
**TRANSPORTATION GEOTECHNICS FIGURE 12:**

*Elastic limit angle ρ and failure limit angle φ for SF-1 specimens before and after 10 FT cycles (w = 0%).*




# EK35® INDEPENDENT PERFORMANCE SUMMARY

## ROLLING BOTTLE TESTING (RBT) FOR AGGREGATE ADHERENCE AND LEACHING POTENTIAL

*Based on "Mechanical properties of roads unbound treated with synthetic fluid based on isoalkane and tall oil" (Transportation Geotechnics 32)*


### ABSTRACT

This report summarizes independent laboratory testing by the Norwegian University of Science and Technology (NTNU) evaluating EK35® (a synthetic fluid based on isoalkane and tall oil pitch) for use in unbound road layers, with emphasis on Rolling Bottle Test (RBT) performance under sustained water exposure and mechanical agitation. In a modified RBT procedure, loose aggregates (8–11.2 mm fraction) were coated with 3% EK35® by mass, conditioned for 30 days, then rolled in distilled water at 60 rpm with a glass rod to induce stirring for intervals from 1 to 24 hours; integrity was quantified objectively as percent mass loss after drying. Across all time intervals, EK35®-coated aggregates exhibited very low stripping and substantially lower mass loss than uncoated aggregates, indicating strong adhesion and a water-resistant coating that was sustained even after 24 hours of rolling. Microscopy observations confirmed the quantitative results, showing the aggregate surface remained largely covered with EK35® after testing with only minor localized exposure. These findings demonstrate EK35®'s ability to maintain coating integrity in wet, abrasive conditions—an important performance attribute for unbound road courses where resistance to moisture-driven stripping directly supports durability and performance longevity.


### BACKGROUND

Unbound granular layers (surface, base and subbase) are fundamental to pavement performance in both gravel roads and gravel runways, where the aggregate structure must resist traffic-induced abrasion and moisture-driven weakening. In wet conditions, water can reduce interparticle friction, remove fine particles, and contribute to surface deterioration and material loss—especially when aggregates are exposed directly to tire action and precipitation. For stabilizing agents such as EK35®, a key performance indicator is not only whether the treatment alters stiffness, but whether it forms a durable coating that remains adhered to aggregate particles when subjected to water and mechanical agitation. Loss of coating (stripping) can increase susceptibility to erosion and degrade long-term efficacy, leading to more frequent maintenance (e.g., grading and reapplication) and reduced structural reliability. Rolling Bottle Testing (RBT), originally developed to assess binder–aggregate affinity in asphalt systems, provides a practical laboratory method for evaluating EK35®'s coating adherence under sustained immersion and repeated agitation. In the NTNU study, a modified RBT procedure was used to quantify stripping objectively via mass loss, enabling direct comparison of untreated and EK35®-coated aggregates and supporting assessment of EK35®'s water resistance and adhesion durability for gravel road and runway applications.

### ROLLING BOTTLE TEST (RBT)

The Rolling Bottle Test (RBT) is a laboratory method used to evaluate how well a coating or binder stays attached to aggregate particles when exposed to water and repeated agitation—conditions that can drive stripping, abrasion, and material loss in the field. Loose aggregates coated with bitumen are rotated in water and then visually rated for retained coverage. The modified RBT method used in the NTNU study replaced subjective visual ratings with objective measurements (e.g., mass loss of coated aggregates after rolling and drying) and added internal stirring to better represent mechanical disturbance. Because the test combines prolonged moisture exposure with continuous movement, it provides a practical indicator of coating integrity and water resistance under aggressive, repeatable conditions.

## TEST PROCEDURE

In the test, 150 g of aggregates are mixed with 3% EK35®, conditioned for 30 days, then submerged in distilled water inside glass bottles with a stirring rod and rotated at 60 rpm. All the specimens rotated and were assessed after fourteen different time intervals: 1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16, 20 and 24 hours.

After testing, the aggregates are dried and the mass loss (MLRBT) is calculated by comparing the initial and final dry mass, providing an objective measure of coating stripping and integrity. Unlike the standard RBT, this modified approach uses quantitative mass loss to directly evaluate resistance to stripping, making it a more repeatable and defensible indicator of wet durability and erosion resistance. Upon completion, the samples were examined with a microscope to better understand the extent of the coated surface and the corresponding degradation process.

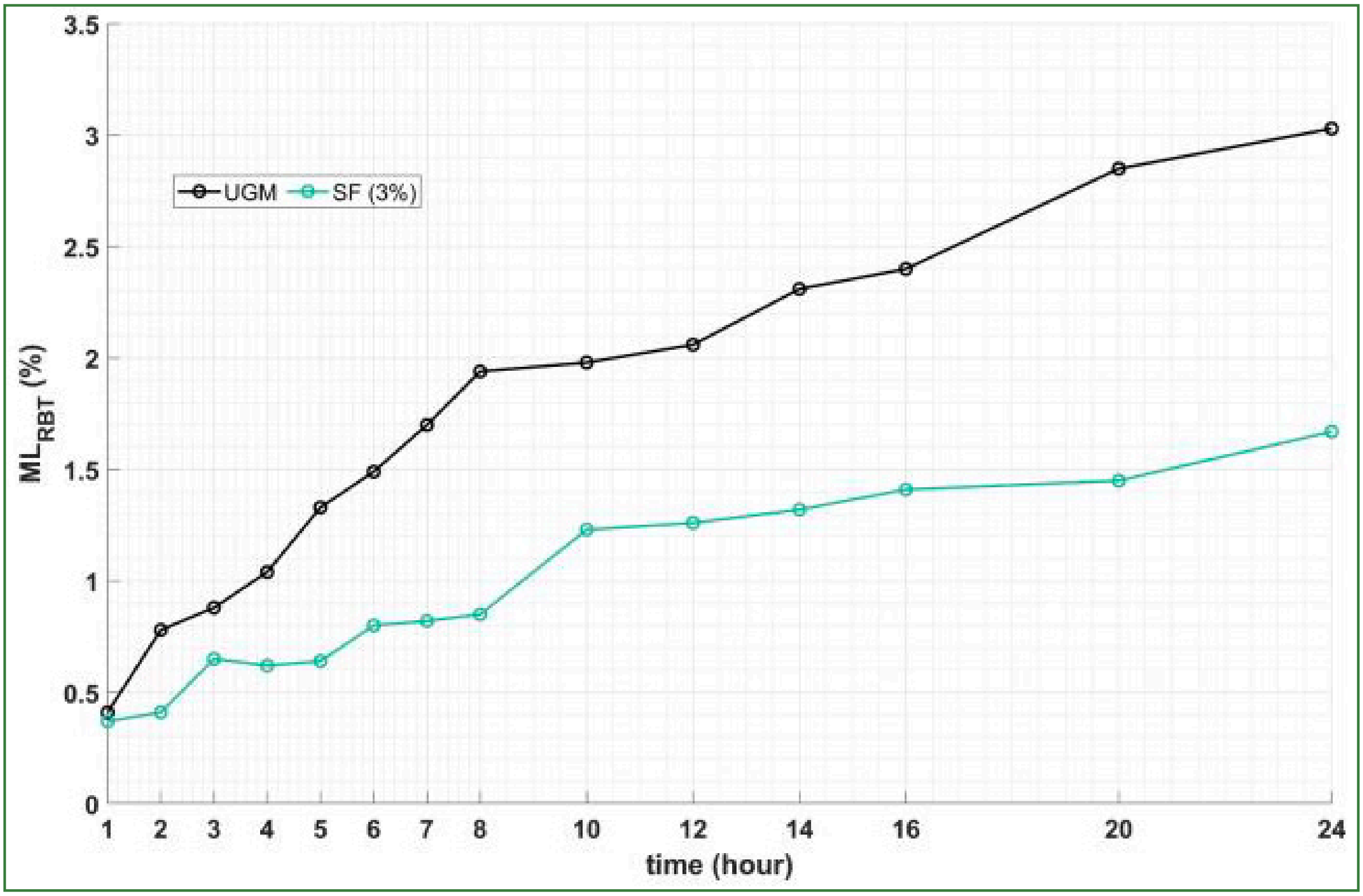

**TRANSPORTATION GEOTECHNICS FIGURE 6:**
*Rolling machine setup with test bottles*

## TEST OBJECTIVES

The purpose of the Rolling Bottle Test (RBT) was to measure how well the EK35® coating adheres to aggregates and resists stripping when exposed to water and agitation, simulating harsh real-world conditions. The test provided a quantitative assessment of coating durability and leaching potential during prolonged water immersion and agitation.

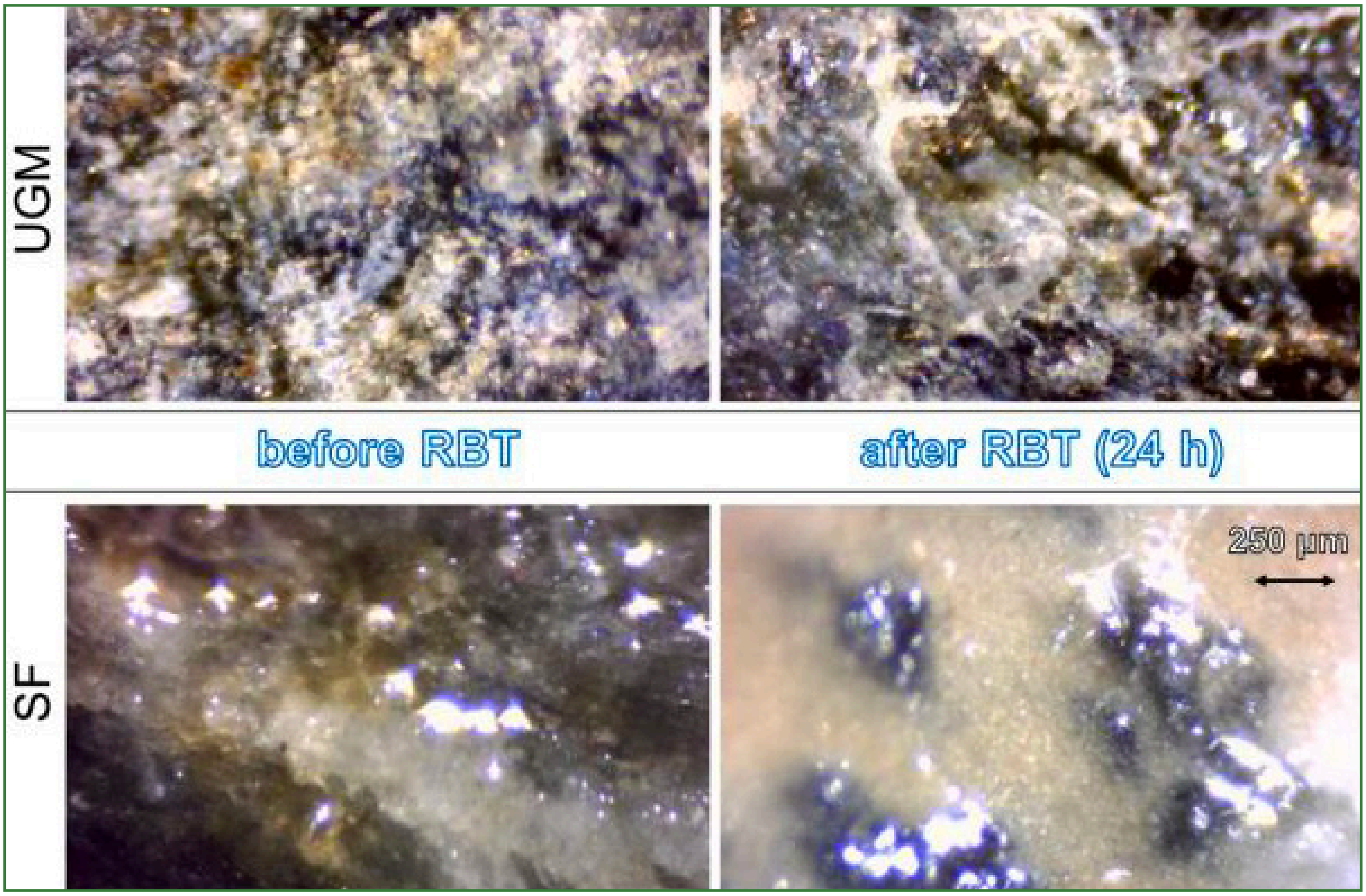
## FINDINGS

- Before testing, microscopic analysis confirmed the treated aggregates exhibited a continuous, uniform coating covering the particle surface.
- After 24 hours of RBT, the EK35® coating was still largely intact and covering the aggregates with minimal exposure of the underlying aggregate surfaces observed.
- Significantly lower mass loss was observed for EK35®-treated aggregates compared to untreated material, indicating that EK35® created a durable, water-resistant coating.
- The treated aggregates showed minimal stripping even after extended rotation (up to 24 hours), demonstrating strong resistance to prolonged saturation and mechanical agitation.
- Overall, the results confirm that the additive provides good adhesion and low leaching potential, even under severe wet conditions.

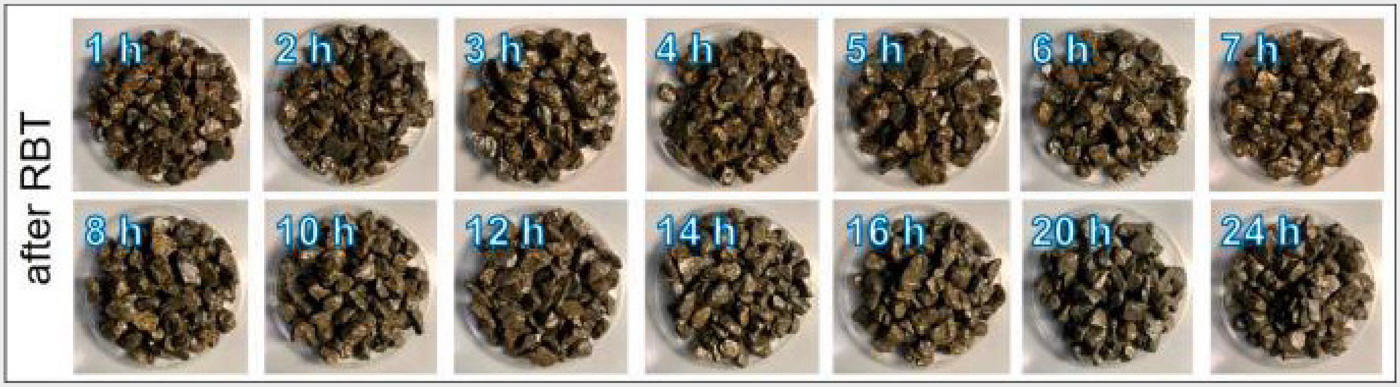



**TRANSPORTATION GEOTECHNICS FIGURE 13:**
*Mass loss (MLRBT) for each tested time interval for uncoated aggregates and aggregates coated with EK35®.*

**TRANSPORTATION GEOTECHNICS FIGURE 14:**
*Appearance of fourteen RBT samples before and after testing according to as many rotating time intervals.*




**TRANSPORTATION GEOTECHNICS FIGURE 15:**
*Surface appearance probed with microscope before RBT and after RBT (24 h).*



# II. CORROSION AND PERFORMANCE OF DUST PALLIATIVES: LABORATORY AND FIELD STUDIES

*U.S. Army Corps of Engineers Engineer Research and Development Center (ERDC/GSL TR-21-31)*

Link: Corrosion and performance of dust palliatives : laboratory and field studies

ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

# EK35® INDEPENDENT PERFORMANCE SUMMARY

## AIR IMPINGEMENT TESTING – EVALUATION OF DUST CONTROL AND SURFACE DURABILITY

*Based on ERDC/GSL TR-21-31 (U.S. Army Engineer Research and Development Center)*


### ABSTRACT

This report summarizes the independent evaluation of EK35®, with a focus on its performance in controlling dust emissions and surface erosion under severe wind conditions. Using laboratory-based Air Impingement testing, developed by the U.S. Army Engineer Research and Development Center (ERDC), EK35®-treated silty sand specimens were subjected to high-velocity air jets and abrasive sand to replicate worst-case scenarios such as helicopter downwash and aircraft operations. Results demonstrated that EK35® consistently achieved substantial reductions in both airborne dust concentration and surface mass loss, outperforming traditional water treatments and meeting stringent thresholds for effective dust control. EK35®-treated surfaces maintained their integrity and exhibited minimal erosion, as confirmed by quantitative measurements and visual inspections. The testing validated EK35®'s ability to provide durable, long-lasting dust suppression and erosion resistance, making it a top-performing solution for demanding military and aviation environments.


### BACKGROUND

Traditional dust monitoring methods often rely on vehicle traffic or visual observations, which can be highly variable and difficult to reproduce. To address this limitation, the U.S. Army Engineer Research and Development Center (ERDC) developed and incorporated the Air Impingement testing into its dust palliative evaluation program. Air Impingement testing provides a controlled, repeatable, and measurable laboratory method for assessing a surface's susceptibility to wind-generated dust and erosion. This approach provides a quantitative and comparative basis for screening dust palliatives prior to field deployment, particularly for military aviation, airfield, and high-exposure applications.

### AIR IMPINGEMENT TESTING

The Air Impingement test is a laboratory method developed to simulate extreme wind conditions, such as helicopter downwash and aircraft movements, for evaluating dust palliatives. It uses a high-velocity air jet directed at the surface of a compacted and treated soil specimen within an enclosed chamber. During testing, the soil specimen is simultaneously exposed to both high speed wind forces and particle abrasion. Overall, the test represents a severe, repeatable "worst-case" condition that identifies a product's ability to form a cohesive, erosion-resistant surface and prevent fine particle loss, making it a critical screening tool for selecting the best products for high-demand environments.

## TEST PROCEDURE

Compacted silty sand specimens were treated with dust suppressants—including EK35®—at precisely controlled application rates (0.8gsy). These samples were then subjected to a high-velocity (~150 mph) angled air jet within a test chamber, while sand particles were injected to simulate abrasive saltation. During testing, airborne dust concentrations were continuously monitored in real time using a Haz-Dust TM EPAM-5000 Environmental Particulate Air Monitor. Data was logged at one-second intervals throughout the 30-second air impingement period and the subsequent 120-second wait time to track the settling rate of dust within the chamber. Upon completion, specimens were visually inspected, assessed, and weighed to determine mass loss. The mass of soil displaced from each specimen served as a quantitative indicator of its dust mitigation capability and resistance to erosion.

This test evaluates two critical metrics: surface erosion (measured as mass loss) and airborne dust concentration (mg/m$^3$), indicating the specimen's durability and dust suppression performance.

Results are compared against established thresholds—typically less than 40 g mass loss and less than 12 mg/m$^3$ dust concentration—for effective dust control and erosion resistance.

## TEST OBJECTIVES

The objective of this testing was to replicate a worst-case wind and abrasion scenario in a controlled setting and generate quantitative metrics (erosion and dust emissions) that could be used to reliably screen, rank, and select dust control products for military applications. More specifically, the test was intended to:

- Simulate extreme wind conditions in a controlled lab setting.
- Evaluate surface durability by measuring resistance to erosion.
- Quantify dust generation under high wind shear and abrasive conditions.
- Compare performance across products and application.

**ERDC/GSL TR-21-31 FIGURE 5:**
*Air Impingement Chamber & Sample Setup*

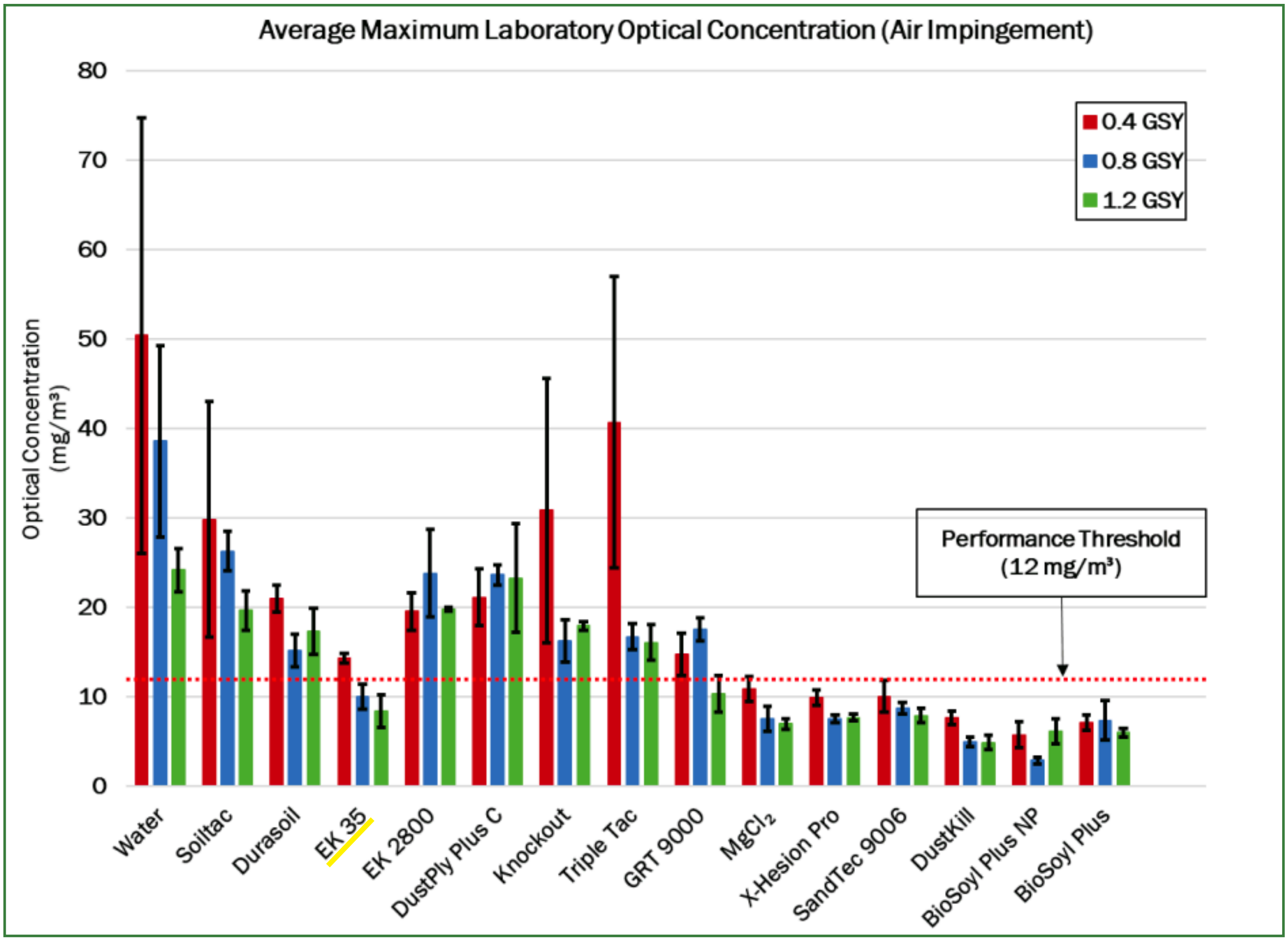
## RESULTS

- EK35® reduced mass lost by approximately 97%, 95% and 90% compared to water at 0.4, 0.8 and 1.2 gsy, respectively.
- EK35® reduced dust levels by approximately 72%, 74% and 68% compared to water only at 0.4, 0.8 and 1.2 gsy, respectively.
- EK35® exceeded all the ERDC performance thresholds for dust concentration and mass loss.
- EK35® was selected for field testing based on its excellent air impingement performance.

## FINDINGS

- EK35® demonstrated exceptional surface durability and dust suppression during severe wind and particle abrasion.
- Testing confirmed EK35®'s suitability for use in extreme wind environments, such as airfields and helipads.
- EK35® outperformed the binderless synthetic fluid product (Durasoil®) in air impingement testing.

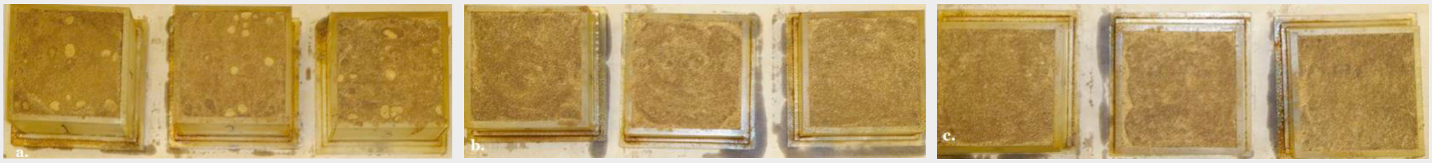
## TEST RESULTS



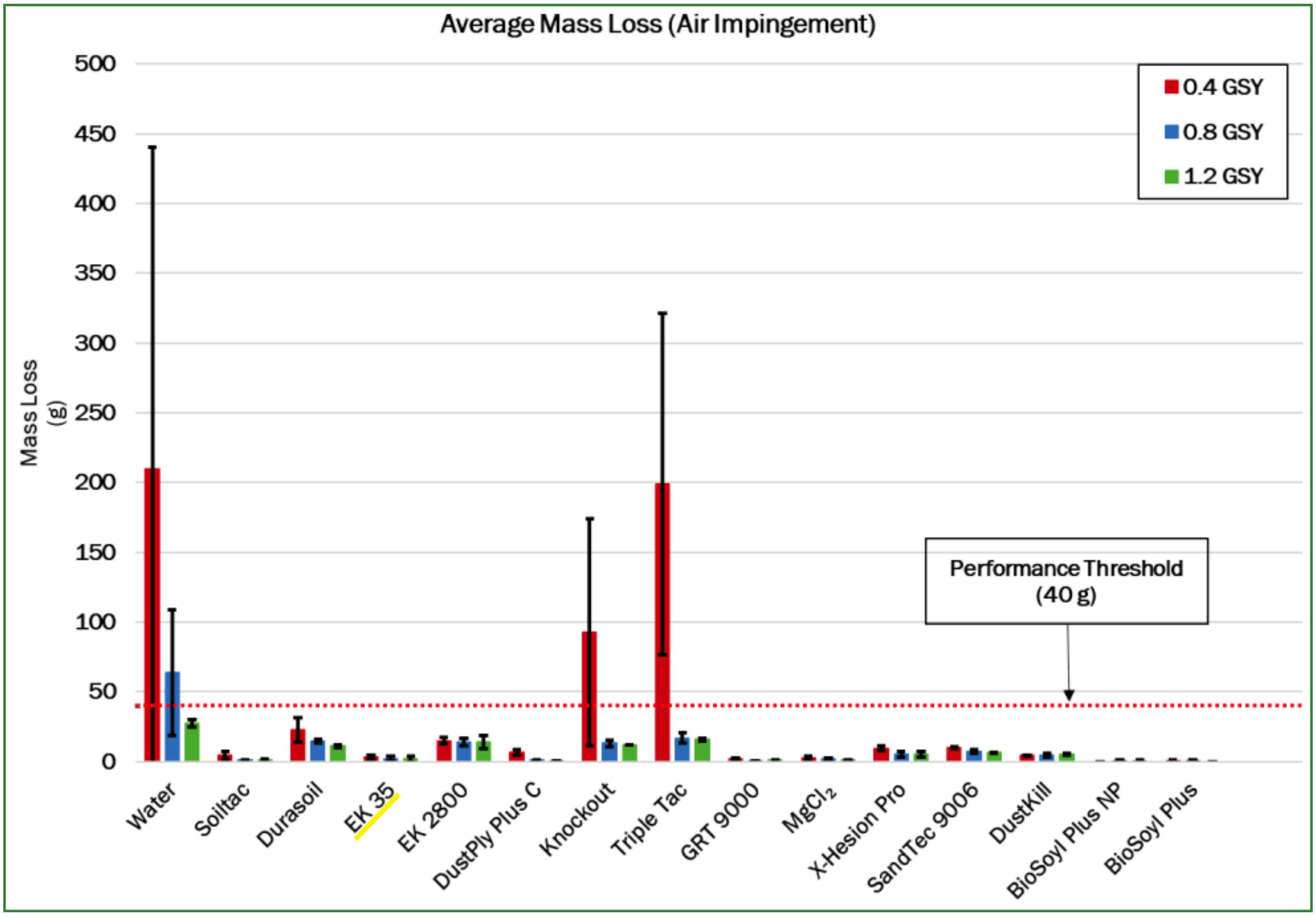

**ERDC/GSL TR-21-31 FIGURE 8:**
*Optical Concentration Results from the testing chamber using the Haz-Dust EPAM-5000*

*Note: The Y-axes in these figures use different scales and measurement units; therefore, visual comparisons of magnitude between graphs are not directly representative of relative performance.*

**ERDC/GSL TR-21-31 FIGURE A8:**
*Test specimens treated with EK35® after air impingement testing, at application rates of (a) 0.4 gsy, (b) 0.8 gsy, and (c) 1.2 gsy.*



## TEST RESULTS




**ERDC/GSL TR-21-31 FIGURE 7:**
*Mass loss of laboratory samples, indicating erosion potential.*

*Note: The Y-axes in these figures use different scales and measurement units; therefore, visual comparisons of magnitude between graphs are not directly representative of relative performance.*

# EK35® INDEPENDENT PERFORMANCE SUMMARY

## PORTABLE IN-SITU WIND EROSION LABORATORY (PI-SWERL) TESTING

*Based on ERDC/GSL TR-21-31 (U.S. Army Engineer Research and Development Center)*


### ABSTRACT

This report summarizes the independent performance evaluation of EK35® through Portable In-Situ Wind Erosion Laboratory (PI-SWERL) testing, conducted by the U.S. Army Engineer Research and Development Center (ERDC). The PI-SWERL device provides controlled, repeatable measurements of dust emissions from treated and untreated surfaces under simulated high-energy wind shear conditions. Laboratory results demonstrated that EK35® significantly reduced dust emissions compared to water at all tested shear levels (wind speeds), consistently maintaining low suspended dust mass even at rotational speeds simulating helicopter downwash and other aviation scenarios. Field tests further confirmed EK35®'s effectiveness, with treated sections exhibiting substantial dust reduction immediately after application and sustaining lower emission levels over 30, 60, and 90 days, despite exposure to traffic and rainfall. EK35®-treated surfaces remained cohesive and visually distinguishable throughout the duration of the test. PI-SWERL field measurements closely matched visual observations, confirming the durability and persistence of EK35®. Some variability in laboratory results were noted and attributed to specimen preparation rather than diminished dust control. Overall, EK35® ranked among the top-performing treatments for dust suppression in both laboratory and field evaluations, offering reliable, long-lasting dust control.


### BACKGROUND

Traditional dust monitoring methods often rely on vehicle traffic or visual observations, which can be highly variable and difficult to reproduce. To address this limitation, the U.S. Army Engineer Research and Development Center (ERDC) incorporated the Portable In-Situ Wind Erosion Laboratory (PI-SWERL) into its dust palliative evaluation program. PI-SWERL testing provides a controlled, repeatable, and quantitative method for assessing a surface's susceptibility to wind-driven dust generation under simulated field-relevant shear stresses. The PI-SWERL device has been widely used by ERDC and other research institutions to evaluate and compare wind erosion potential, dust emission rates, and surface stability, particularly for military aviation, airfield, and expeditionary applications.

### PI-SWERL TESTING

The Portable In-Situ Wind Erosion Laboratory (PI-SWERL), developed by the U.S. Department of Defense (DoD), provides a consistent, quantitative way to measure wind-driven dust emissions from unpaved surfaces. The U.S. Army Engineer Research and Development Center (ERDC) utilizes PI-SWERL to recreate high-shear scenarios like helicopter downwash, fast-moving vehicles, and aircraft operations, particularly where standard visual and/or traffic-based measurements are often unreliable.

### TEST PROCEDURE

A rotating ring inside a sealed chamber positioned on the soil creates controlled near-surface wind shear. Tests were conducted at progressively higher speeds: approximately 107, 143, and 179 mph equivalents. During each test phase, the total suspended dust mass (measured in micrograms) was continuously recorded. Evaluations took place on both. laboratory-prepared soil samples and field test plots before and 1, 30, 60, and 90 days after they received treatments.

## TEST OBJECTIVES

PI-SWERL testing was conducted by the ERDC to:

1. Quantify the dust emission potential of treated and untreated soils at different shear speeds.
2. Simulate high-energy wind shear typical of aviation and industrial conditions
3. Objectively compare dust palliatives using a controlled method
4. Correlate laboratory testing and product screening with field performance.

**ERDC/GSL TR-21-31 FIGURE 12:**
*PI-SWERL Laboratory Test Setup*

## FINDINGS-OVERALL

- EK35® significantly reduced dust emissions relative to untreated soil under both laboratory and field PI-SWERL testing.
- EK35® delivers superior performance under high-shear conditions, which are most representative of helicopter downwash, aircraft operations, and high-speed traffic.
- The combination of laboratory and field PI-SWERL findings indicates that EK35® provides reliable, quantifiable, and durable dust control for unpaved roads, runways, helipads, and high-trafficked surfaces.

## FINDINGS-LAB TESTING

- EK35® achieved a significant reduction in dust emissions compared to water alone, at all tested shear levels (107, 143, and 179 mph).
- EK35® maintained low total suspended dust mass, indicating strong resistance to wind-induced particle entrainment, even under increasing rotational speeds.
- EK35® performed among the top products tested in the lab.
- The variability in the EK35®laboratory test results was due to specimen preparation, rather than loss of dust control capability.

## FINDINGS- FIELD TESTING

- The EK35® treated field section exhibited substantial reductions in dust emissions immediately after application compared to control (water only) measurements.
- PI-SWERL measurements at 30, 60, and 90 days showed that EK35® maintained lower dust emission levels over time, even after traffic and rainfall events.
- EK35®-treated surfaces remained clearly identifiable in the field, with sustained surface cohesion and reduced dust re-entrainment.
- Field PI-SWERL results aligned closely with visual field observations, confirming the durability and persistence of EK35®.

# EK35® INDEPENDENT PERFORMANCE SUMMARY

## CORROSION TESTING ON FOUR CRITICAL METALS

*Based on ERDC/GSL TR-21-31 (U.S. Army Engineer Research and Development Center)*


### ABSTRACT

The corrosion testing conducted by the U.S. Army Corps of Engineers Research and Development Center (ERDC) evaluated EK35®'s compatibility with critical aircraft and equipment metals (magnesium ZE41A, aluminum 2024-T3, aluminum 7075-T6, and steel 4340) by embedding pre-weighed metal coupons in EK35®-treated silty sand (1.2 gsy) for 360 days and tracking mass change as an indicator of corrosion activity. Across all metals, EK35® exhibited minimal mass change, indicating very limited chemical interaction and no measurable acceleration of corrosion on aircraft aluminum alloys. Performance remained stable over the full one-year exposure, demonstrating long-term corrosion resistance rather than short-term compatibility. Relative to other dust palliative chemistries (including chlorides and several non-chloride alternatives), EK35® showed the most favorable corrosion profile. These results support EK35® as a low-corrosion dust suppressant suitable for corrosion-sensitive environments such as military airfields and helipads, helping reduce critical equipment damage while enabling effective dust control.


### BACKGROUND

Fugitive dust control for military roads and airfields has historically relied on chlorides, which are effective at retaining moisture but introduce significant corrosion risk to metals—particularly aluminum used in aircraft and lightweight vehicles. These chemistries can accelerate equipment degradation, increase maintenance costs, and are therefore restricted in environments where corrosion is critical, such as airfields. While non-corrosive alternatives – (including polymers, synthetic fluids, and bio-based products) have been developed to mitigate these issues, their long-term interaction with common structural metals is not well documented. As a result, controlled laboratory corrosion testing is necessary to evaluate the compatibility of dust palliatives with metals and to support selection of dust suppressants that provide effective dust suppression without compromising structural integrity.

### AIR IMPINGEMENT TESTING

ERDC conducted controlled laboratory corrosion studies using metal coupons embedded in treated soil to simulate exposure conditions encountered on unpaved roads, airfields, and helipads. Four metals representative of aircraft and military equipment were tested:

| Material | Aircraft Relevance |
|---|---|
| Magnesium ZE41A | Transmission Housing |
| Aluminum 2024-T3 | Outer Skin |
| Aluminum 7075-T6 | Structural Frames |
| Steel 4340 | Landing Gear |

The metal couples remained in the treated soil for 360 days with periodic measurements taken to evaluate the change in mass over time. The mass loss or gain indicates a chemical interaction and potential corrosion activity.

## TEST PROCEDURE

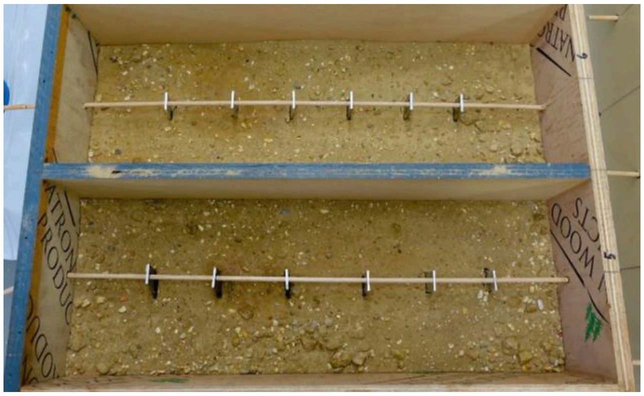
The corrosion testing embedded pre-weighed metal coupons (four different metals) into silty sand soil treated with EK35® applied at an application rate of 1.2 gsy, then kept the samples in a controlled laboratory environment for up to one year. The treated soils were prepared by applying the product in multiple passes, allowing absorption between applications, and curing for 24 hours before exposure. Coupons were suspended at a consistent depth in the treated soil and removed at scheduled intervals for evaluation, during which they were cleaned, dried, and reweighed. Corrosion behavior was assessed by tracking the change in mass over time relative to the initial weight, with results compared across products and metals to identify relative reactivity and corrosion potential.

## TEST OBJECTIVES

The corrosion testing was performed to evaluate and compare how different dust suppressants chemically interact with and degrade critical metals under realistic soil exposure conditions, with the goal of identifying low-corrosion products suitable for military airfields and roads.

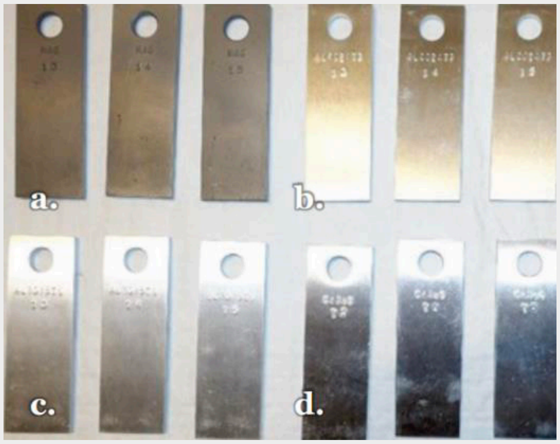
**ERDC/GSL TR-21-31 FIGURE 17:**
*Metal Coupon Placement*

**ERDC/GSL TR-21-31 FIGURE 18:**
*Metal Coupons in the Testing Container (Top View)*

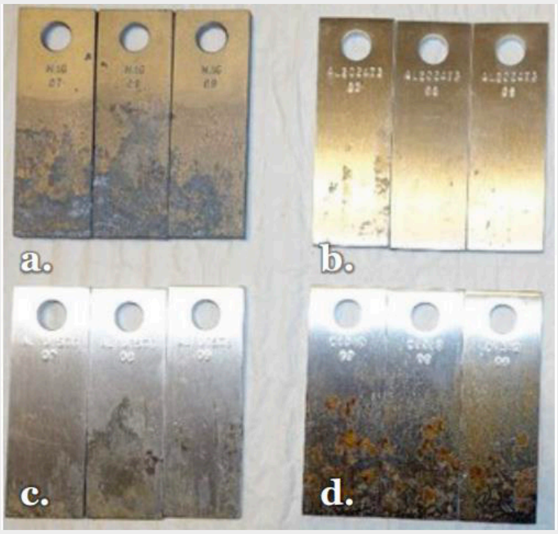


## FINDINGS

- EK35® exhibited very minimal chemical interaction (mass change) across all tested metals.
- EK35® demonstrated no adverse behavior or acceleration in corrosion on aircraft alloys.
- EK35® demonstrated long-term corrosion stability, not just short term compatibility.
- EK35® performed better than other dust palliative chemistries (water, chlorides, soy-based, aliphatic alcohol, guar gum, and organic polymers).

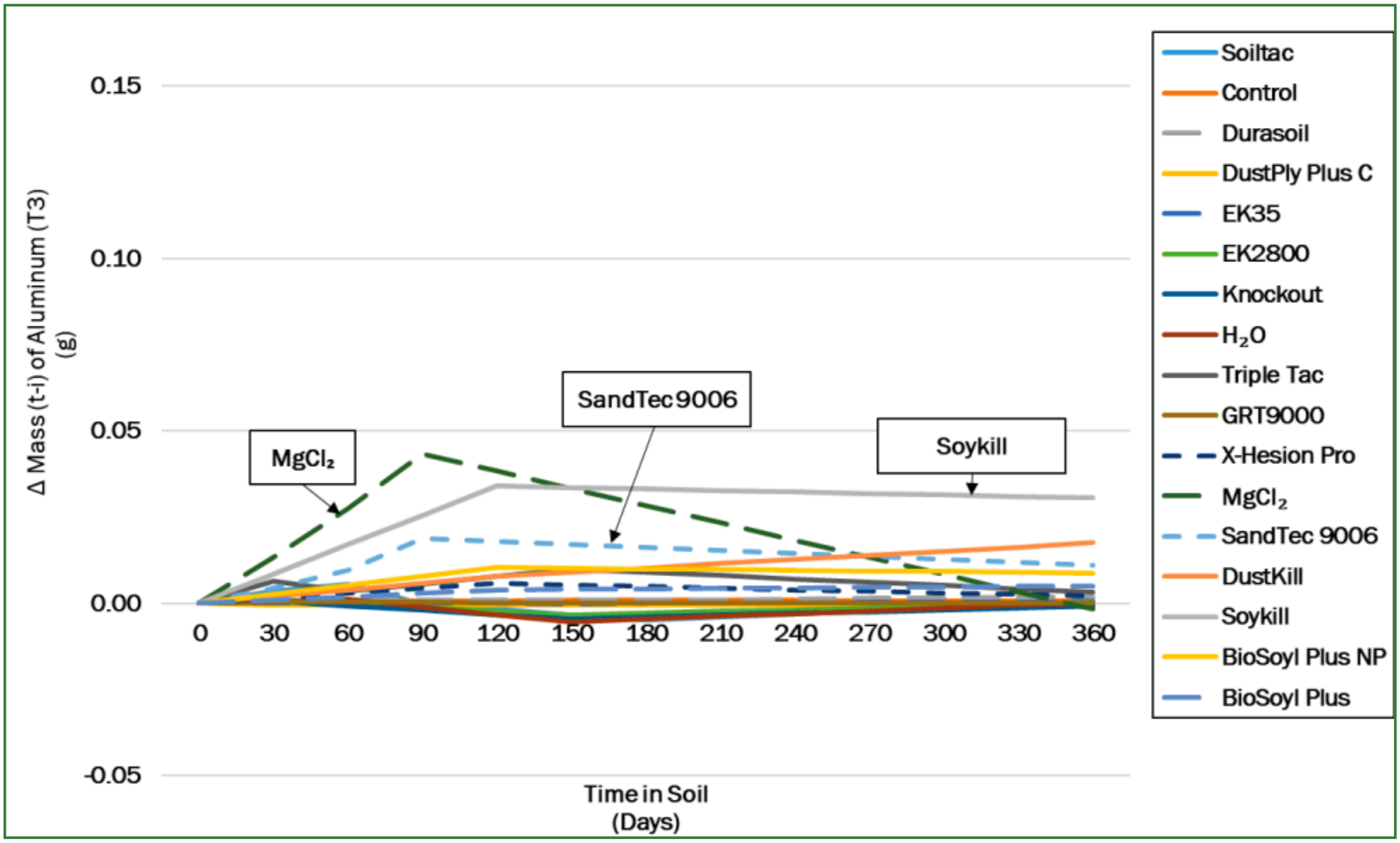



**ERDC/GSL TR-21-31 FIGURE 47:**
*Metal Coupons After 360 Days in Soil Treated with EK35®*



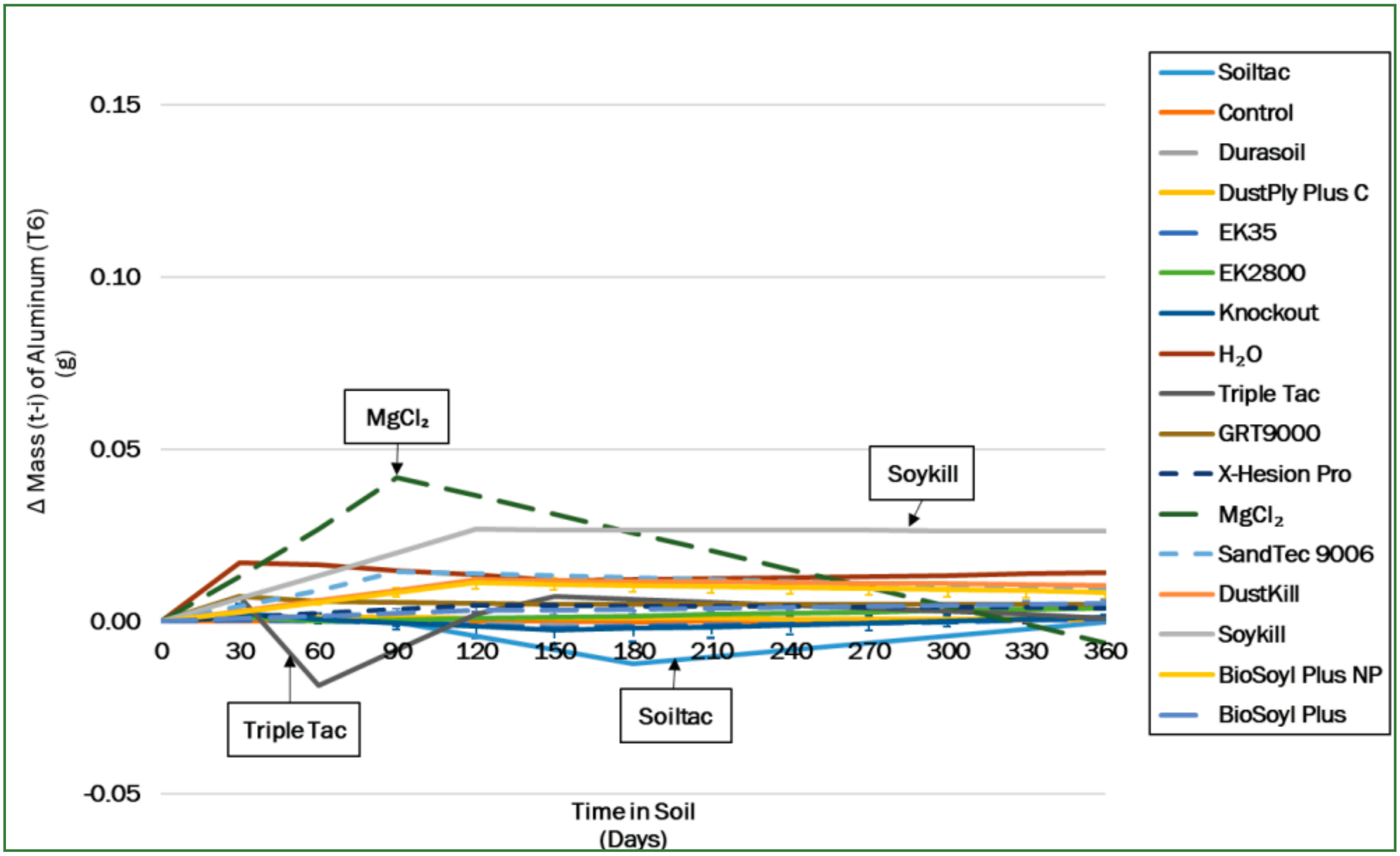

**ERDC/GSL TR-21-31 FIGURE A32:**
*Metal Coupons After 360 Days in Soil Treated with Water*

## TEST RESULTS



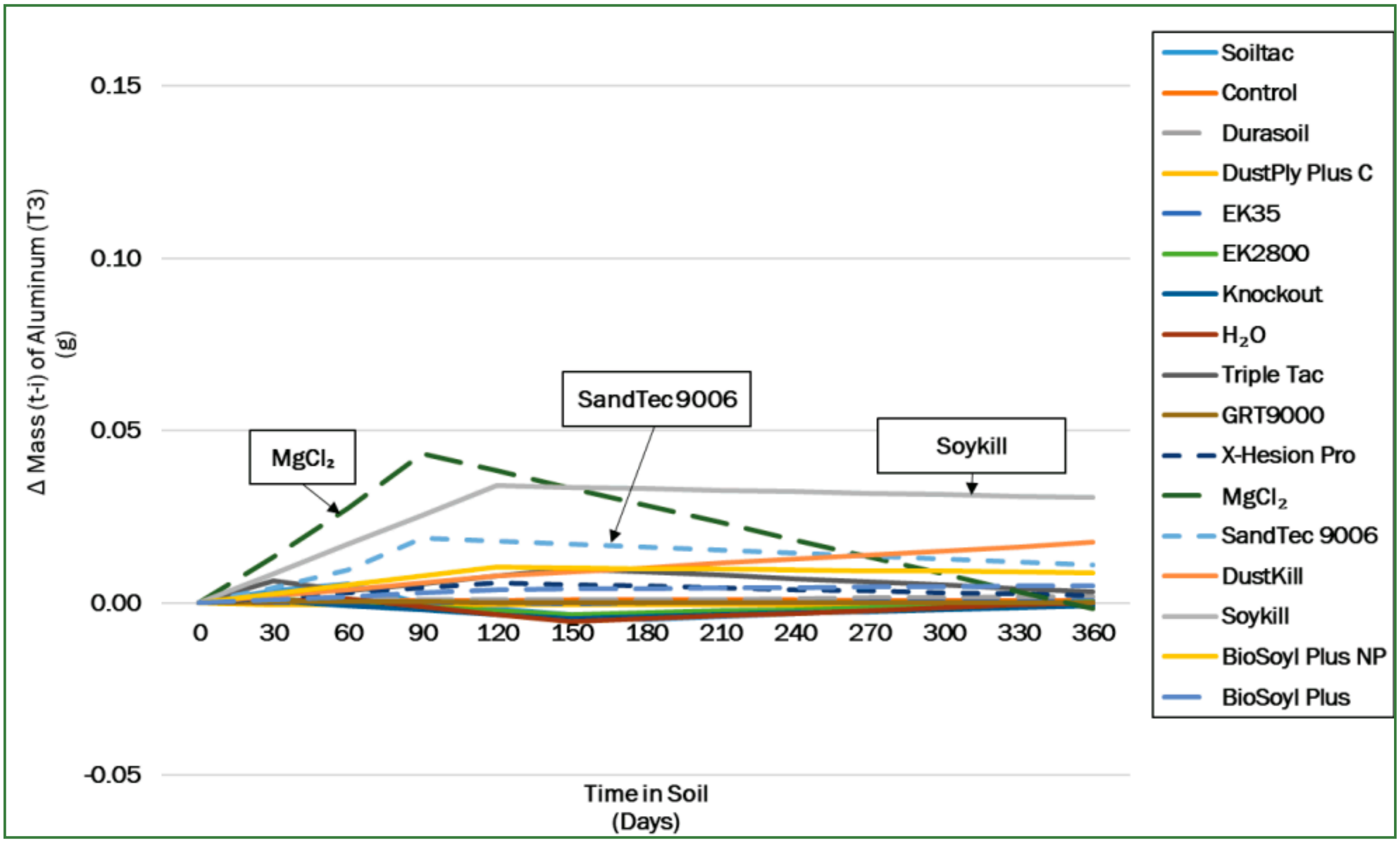

**ERDC/GSL TR-21-31 FIGURE 20:**
*Changes in mass of aluminum (2024-T3) coupons after exposure to soil/product as a function of time.*

## TEST RESULTS



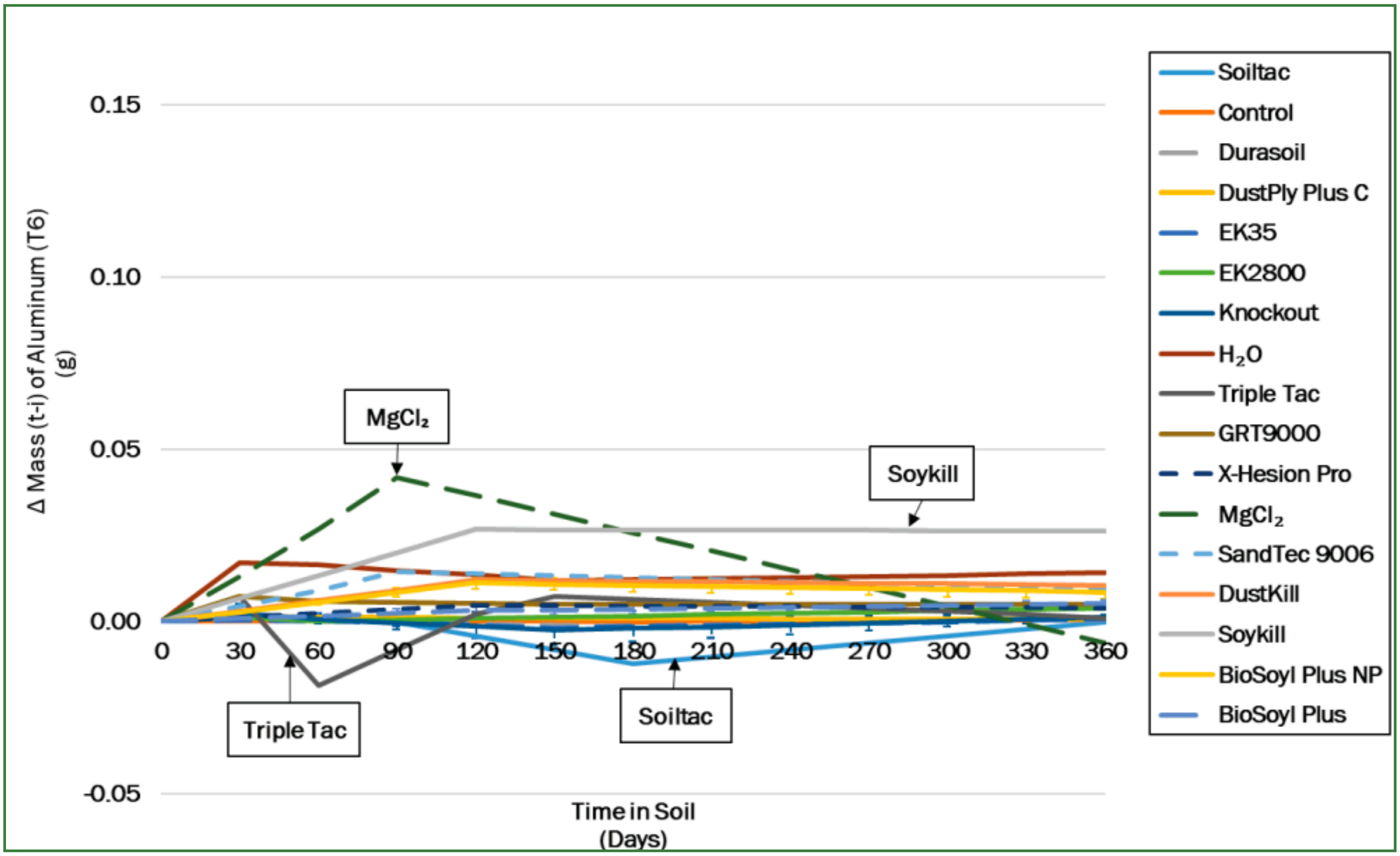

**ERDC/GSL TR-21-31 FIGURE 21:**
*Changes in mass of aluminum (7075-T6) coupons after exposure to soil/product as a function of time.*

## TEST RESULTS

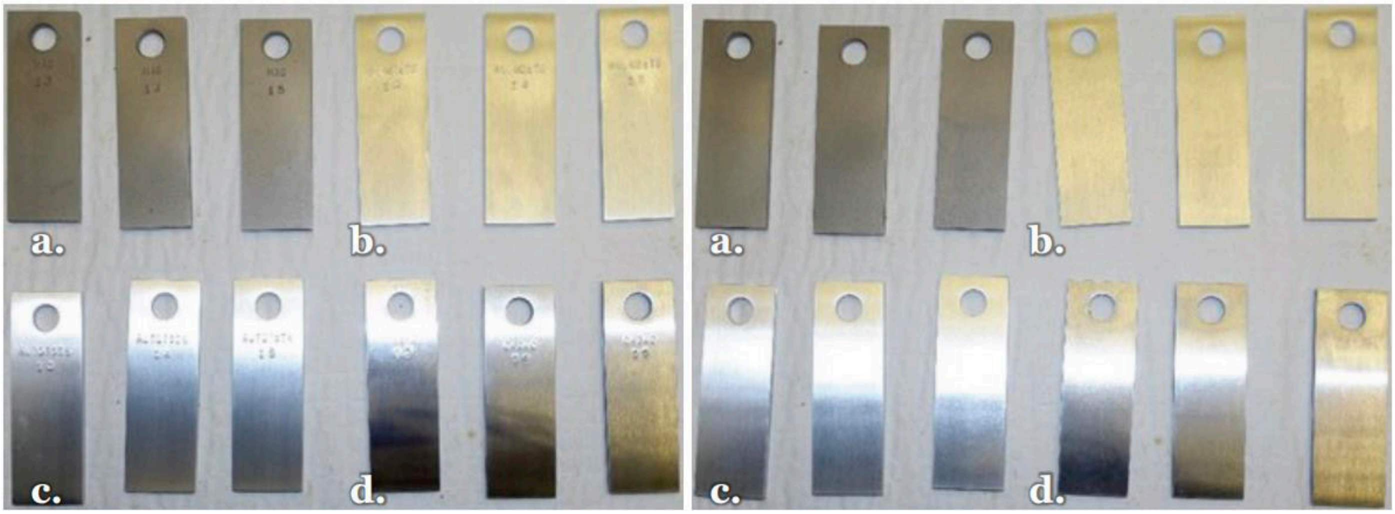



**ERDC/GSL TR-21-31 FIGURE 20:**
*Changes in mass of aluminum (2024-T3) coupons after exposure to soil/product as a function of time.*

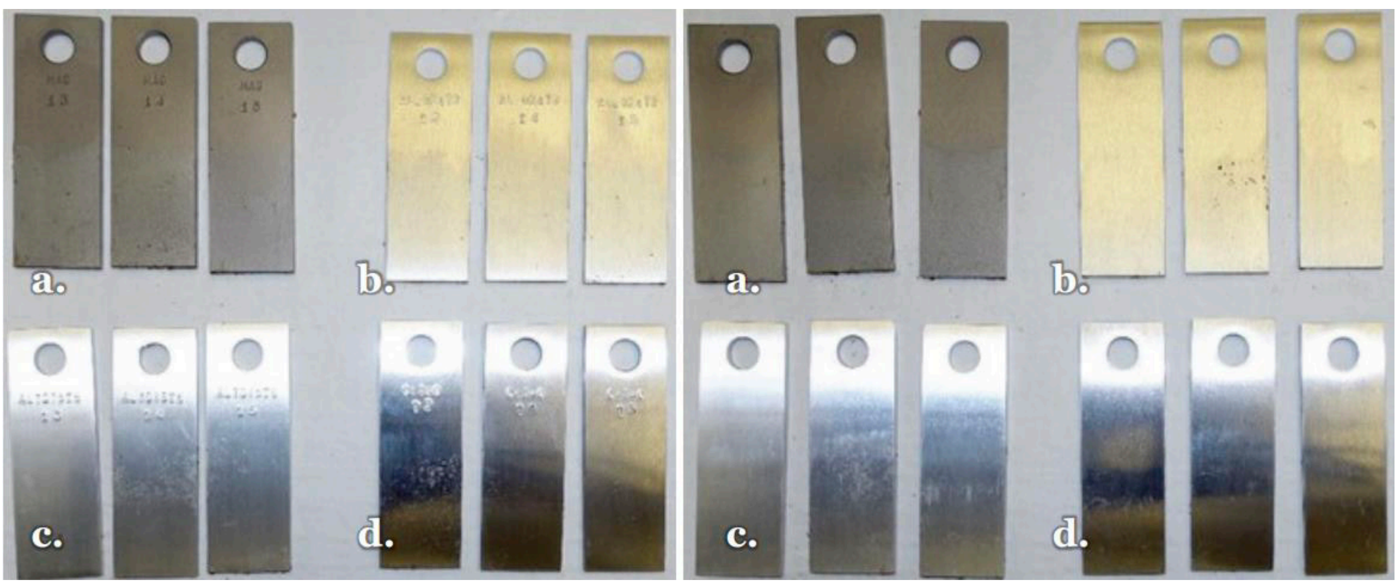
## TEST RESULTS



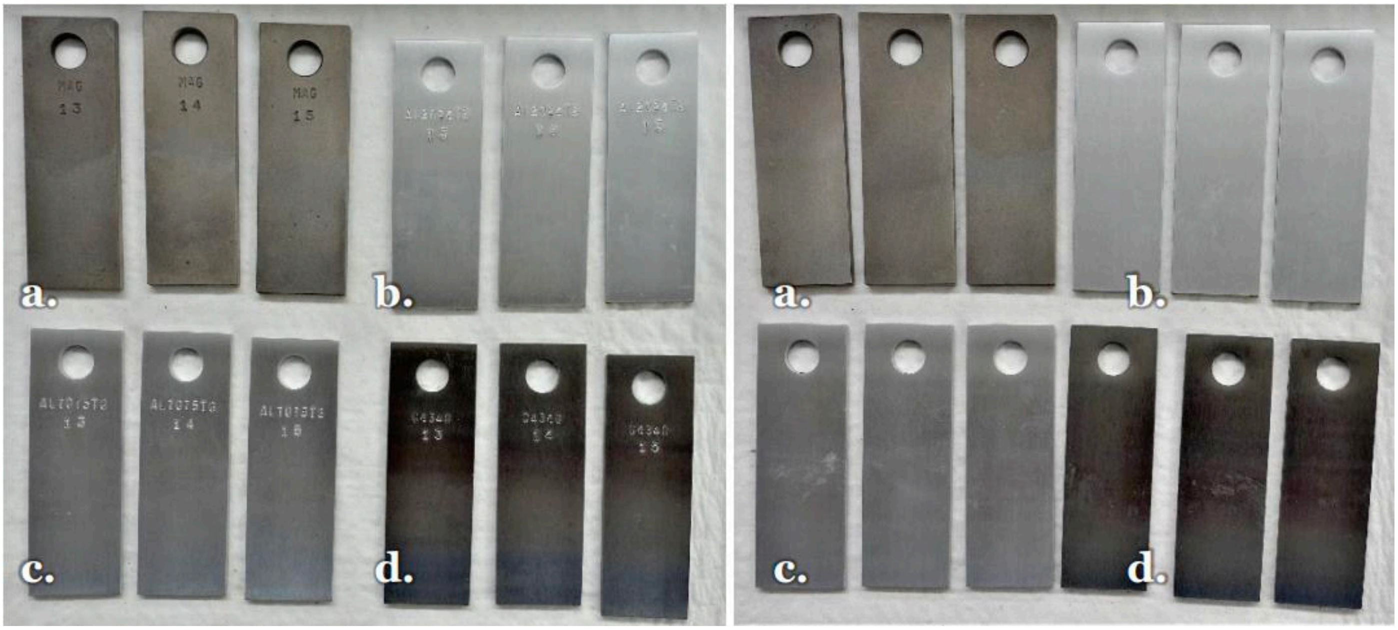

**ERDC/GSL TR-21-31 FIGURE 21:**
*Changes in mass of aluminum (7075-T6) coupons after exposure to soil/product as a function of time.*



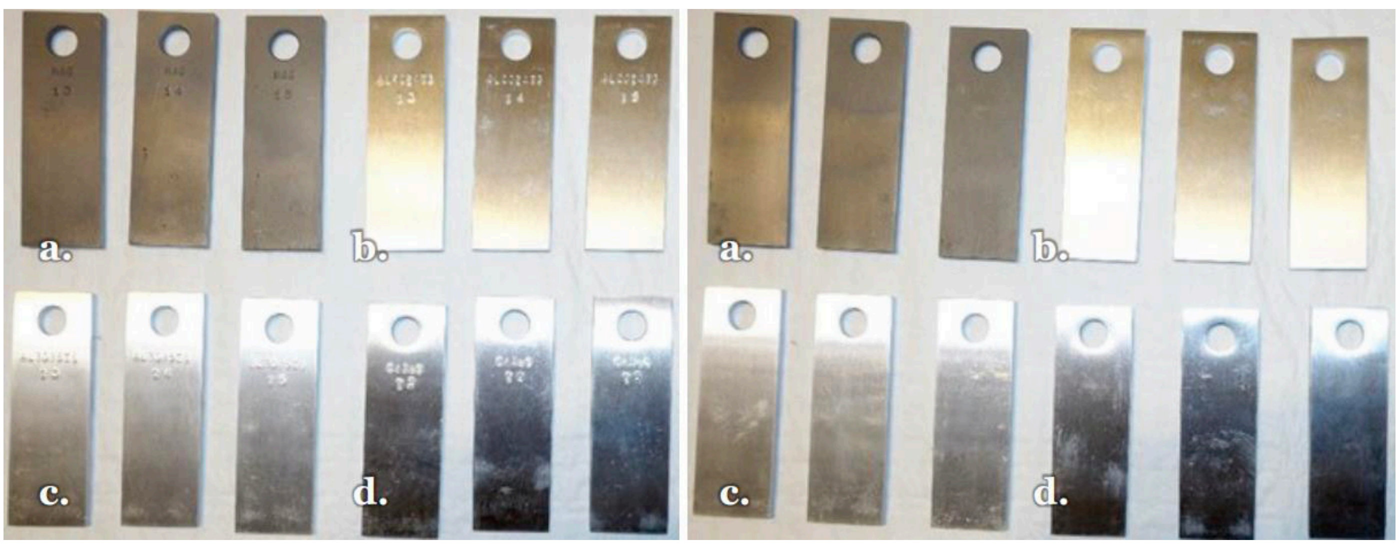

**ERDC/GSL TR-21-31 FIGURE A44:**
*Metal coupons after **30 days** in soil treated with EK35®: (left) fronts and (right) backs. Metals are (a) magnesium, (b) aluminum T3, (c) aluminum T6, and (d) steel.*




**ERDC/GSL TR-21-31 FIGURE A45:**
*Metal coupons after **90 days** in soil treated with EK35®: (left) fronts and (right) backs. Metals are (a) magnesium, (b) aluminum T3, (c) aluminum T6, and (d) steel.*




**ERDC/GSL TR-21-31 FIGURE A46:**
*Metal coupons after **120 days** in soil treated with EK35®: (left) fronts and (right) backs. Metals are (a) magnesium, (b) aluminum T3, (c) aluminum T6, and (d) steel.*




**ERDC/GSL TR-21-31 FIGURE A47:**
*Metal coupons after **360 days** in soil treated with EK35®: (left) fronts and (right) backs. Metals are (a) magnesium, (b) aluminum T3, (c) aluminum T6, and (d) steel.*

# III. ENVIRONMENTAL TECHNOLOGY VERIFICATION: MIDWEST INDUSTRIAL SUPPLY, INC'S EK35®

*Based on U.S. EPA's Environmental Technology Verification Report: Dust Suppressant Product EK35®*

Link: DOCUMENT DISPLAY | NEPIS | US EPA

U.S. EPA Environmental Technology Verification Program

# EK35® INDEPENDENT PERFORMANCE SUMMARY

## DUST CONTROL EVALUATION OVER TIME

*Based on U.S. EPA's Environmental Technology Verification Report: Dust Suppressant Product EK35®*


### ABSTRACT

This report summarizes the independent U.S. Environmental Protection Agency (EPA) Environmental Technology Verification (ETV) evaluation of EK35® as a dust suppressant for unpaved roads under real-world field conditions. Performance was measured by comparing treated and untreated road sections at two contrasting sites using a mobile dust sampling system and quantifying control efficiency for total particulate, PM10, and PM2.5. Results showed that EK35® delivered sustained dust suppression over time, including PM10 reductions of 90% at 70 days in Maricopa County and 86% at 77 days and 84% at 119 days at Fort Leonard Wood, with strong performance also observed for total particulate and fine particulate fractions. These findings demonstrate that EK35® can provide durable, field-verified dust control across different climates, traffic conditions, and road materials. The value of this performance lies in offering reliable, independently verified data to support product selection, engineering evaluation, and long-term dust management decisions.


### BACKGROUND

The U.S. Environmental Protection Agency (EPA), through its Environmental Technology Verification (ETV) Program, conducted an independent, peer-reviewed evaluation of dust suppressant technologies to provide defensible performance data for real-world applications. As part of this program, EK35® was evaluated to quantify its effectiveness in reducing particulate emissions from unpaved roads. Field testing was performed at two sites with differing climate, soil, and traffic conditions—Fort Leonard Wood, Missouri, and Maricopa County, Arizona—to ensure representative and accurate performance characterization. Performance was assessed by comparing treated road sections to untreated control sections using a mobile dust sampling system designed to measure airborne particulate emissions within the vehicle-generated dust plume. The primary metric was control efficiency (CE), expressed as the percent reduction in emissions for total particulate (TP), PM10, and PM2.5. Testing was structured to monitor performance over time and under varying environmental conditions, providing a robust, field-based assessment of dust suppression effectiveness and its dependence on factors such as application history, weather, and site conditions.

### MOBILE DUST EMISSIONS TESTING

The performance of EK35® was evaluated using a mobile dust sampling system designed to quantify particulate emissions generated by vehicle traffic on unpaved road surfaces under field conditions. The system was configured to measure airborne particulate matter directly within the dust plume produced by a test vehicle, providing a realistic assessment of fugitive dust emissions during normal road use. Field testing was planned quarterly over a 1-year period; however, some logistical difficulties related to the weather and maintenance activities on the roads required the test plan to be modified.

## MOBILE DUST EMISSIONS TEST PROCEDURE

Dust emission measurements were conducted on both treated (EK35®) and untreated (control) road sections following a standardized and repeatable process.

- Each test consisted of five replicate measurements for both treated and untreated conditions.
- Each replicate included multiple vehicle passes (typically 12 passes) over a defined road segment (approx. 500 ft).
- Total sampling distance per replicate was approximately 6,000 ft.

The sampler was activated only while the vehicle traversed the designated test section, ensuring that collected particulate mass corresponded directly to emissions generated from the surface being evaluated. The data collected quantified particulate emissions as mass collected per unit distance traveled, reported as mg of dust per 1,000 ft. Performance was expressed as control efficiency (CE), calculated by comparing emissions from treated and untreated sections.

## TEST OBJECTIVES

The objective of this EPA ETV report was to independently verify the field performance of EK35® in controlling dust emissions from unpaved roads using standardized testing protocols. Performance testing focused on quantifying control efficiency (CE)—the percent reduction in particulate emissions relative to untreated control sections—across total particulate (TP), PM10, and PM2.5 fractions. The overall goal was to provide reliable, independent data to inform engineering evaluations and product selection.

## TEST ROADS

Field testing was conducted at two distinctively different unpaved road sites: Fort Leonard Wood, Missouri, (FLW) and Maricopa County, Arizona (MC). The FLW site was a military training road subjected to heavy-duty, variable traffic dominated by truck convoys (2.5- and 5-ton vehicles) with additional construction truck traffic and light vehicles. The region experiences a temperate climate with seasonal variability, including significant precipitation and cold-weather periods, resulting in variable moisture conditions over time. The road material had relatively low silt content (~1–5%).

In contrast, the Maricopa County site was a low- to moderate-volume county road (~150–200 vehicles/day) carrying primarily light-duty commuter traffic. The climate is arid to semi-arid, characterized by very high temperatures and minimal precipitation , creating persistently dry surface conditions. The roadway consisted of shale-based material with finer, dust-prone soils.

## TEST RESULTS

- At Maricopa County, 70 days since application (with no road maintenance), EK35® maintained control efficiencies of:
  - Total Particulate = 87%
  - PM10 = 90%
  - PM2.5 = >94%
- At Fort Leonard Wood, 77 days since application (with no road maintenance), EK35® maintained control efficiencies of:
  - Total Particulate = 74%
  - PM10 = 86%
  - PM2.5 = 56%
- At Fort Leonard Wood, 119 days since application (with no road maintenance), EK35® maintained control efficiencies of:
  - Total Particulate = 63%
  - PM10 = 84%

## TEST RESULTS

- EK35® is effective at binding fines and preventing traffic-generated fugitive dust for extended periods of time.
- EK35® was effective in all climates tested, therefore, it's performance is not climate dependent.
- EK35® achieved and maintained a high level of dust suppression (typically 80–90% PM10 reduction) across varied climates and several months after application.

## TEST RESULTS

| Test period | Uncontrolled emissions, mg/1,000 ft *(RSD, %)* | | | Time since last application, days | Controlled emissions, mg/1,000 ft *(RSD, %)* | | | Control efficiency, % | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | TP | $PM_{10}$ | $PM_{2.5}$ | | TP | $PM_{10}$ | $PM_{2.5}$ | TP | $PM_{10}$ | $PM_{2.5}$ |
| **FLW** | | | | | | | | | | |
| October 2003[a] | 7.9 | 0.68 | 1.5 | 119 | 2.9 | 0.11 | 1.6 | 63 | 84 | [b] |
| | *(59)* | *(78)* | *(27)* | | *(30)* | *(53)* | *(10)* | | | |
| May 2003[c] | 9.1 | 1.2 | 0.71 | 77 | 2.4 | 0.13 | 0.31 | 74 | 86 | 56 |
| | *(14)* | *(21)* | *(29)* | | *(54)* | *(78)* | *(41)* | | | |
| **MC** | | | | | | | | | | |
| May 2003 | 50 | 14 | 3.7 | 70 | 6.5 | 1.4 | <0.24[d] | 87 | 90 | >94 |
| | *(76)* | *(84)* | *(65)* | | *(32)* | *(45)* | *(0.0)* | | | |

[a] All test sections were wet from rain the previous day. The uncontrolled section was heavily potholed and another section was used for the test. MRI used traffic to dry the road before testing.
[b] No emissions reduction was observed.
[c] Rainfall in the morning meant that the uncontrolled section of the road was wet and another section was used for the test.
[d] All values were below the detection limit.

**Environmental Technology Verification Report Dust Suppressant Products: EK35® - Table #1:**
*Summary of Test Results for EK35® (No Road Maintenance)*

## TEST RESULTS

| Test section | Date | Moisture content, % | Silt content, % |
|---|---|---|---|
| **FLW** | | | |
| Uncontrolled | 10/12/02[a] | 0.4 | 1.6 |
| | 10/13/02[a] | 0.63 | 1.5 |
| | 10/14/02[a] | 0.75 | 1.7 |
| | 5/24/03 | 1.8 | 4.3 |
| | 5/26/03 | 0.01 | 1.6 |
| | 10/12/03 | 1.4 | 3.0 |
| | 10/13/03 | 1.5 | 5.4 |
| | 10/13/03 | 0.62 | 1.7 |
| EK35 | 10/14/02[a] | 1.1 | 6.6 |
| | 5/24/03 | 0.31 | 2.3 |
| | 10/11/03 | 0.71 | 1.1 |
| | 10/11/03 | 1.0 | 1.7 |
| **MC** | | | |
| Uncontrolled | 5/14/03 | 0.22 | 4.7 |
| | 8/6/03[b] | 0.32 | 8.8 |
| | 8/6/03[b] | 0.32 | 9.2 |
| EK35 | 5/14/03 | 0.17 | 1.7 |
| | 8/6/03[b] | 0.33 | 2.9 |

[a] Unexpected road maintenance activity occurred at FLW in September 2002 prior to the October 2002 test period.
[b] Unexpected road maintenance activity appeared to have occurred at MC after the time of the May 2003 visit and prior to the August 2003 test period.

**Environmental Technology Verification Report Dust Suppressant Products: EK35® - Table #14:**
*Road Surface Properties*

# IV. DUST-M AIRPORT DUST SUPPRESSION TESTING

*Alaska DOT&PF, University of Alaska Fairbanks (UAF), Alaska University Transportation Center (AUTC)*

# EK35® INDEPENDENT PERFORMANCE SUMMARY

## DUST CONTROL EFFICACY AND LONGEVITY ASSESSMENT

*Based on a four year study at 21 Alaskan unpaved runways conducted by the Alaska DOT&PF and the University of Alaska Fairbanks (2009-2012)*


### ABSTRACT

This independent performance summary reports a four-year field evaluation (2009–2012) of dust control treatments on 21 unpaved Alaskan airport runways using the University of Alaska Fairbanks UAF-DUSTM protocol. Based on best-fit performance trends from 35 individual tests, EK35® produced and maintained high levels of PM10 reduction—approximately 87% after one year and remained above 80% through year four (≈82%). In contrast, Durasoil® exhibited comparable first-year suppression but a markedly shorter service life, with efficacy declining substantially between years one and two. Several EK35®-treated sites maintained >90% suppression three to four years after application, demonstrating robust long-term control under real-world weather and traffic. These findings provide quantitative, independent evidence that EK35® can deliver multi-year dust suppression, supporting improved air quality and visibility, reduced runway maintenance demand, and extended life-cycle performance for remote and cold-region airfield operators.


### BACKGROUND

Fugitive dust from gravel surfaces—including unpaved roads and airport runways—is a significant source of particulate pollution. These emissions can affect public health, reduce visibility, and accelerate surface degradation. Although chemical dust suppressants are widely used, their long-term effectiveness is not well documented, and standardized methods to quantify dust reduction were not available when this study was conducted. To address this gap, the University of Alaska Fairbanks developed the UAF-DUSTM device and a repeatable field protocol to measure dust palliative efficacy and longevity. Using this method, 35 tests were performed from 2009 to 2012 at 21 different unpaved Alaskan runways treated with EK35® or Durasoil. The results were compiled to compare performance over time.

### UAF-DUSTM TESTING

The UAF-DUSTM, developed by the University of Alaska Fairbanks, provides a quantitative, field-deployable method for measuring fugitive dust emissions from unpaved surfaces and evaluating dust suppressant performance in the field. Its portable, user-friendly design enables use in remote locations. The device uses a TSI DustTrak Aerosol Monitor to measure PM10 mass concentration (mg/m3) in the dust plume generated behind an all-terrain vehicle (ATV). Measurements are recorded at 1-second intervals. The DUSTM enables direct comparison between treated and untreated surfaces to assess dust control effectiveness and longevity. Performance is assessed based on PM10 reduction and the duration over which the treatment remains effective.

## MOBILE DUST EMISSIONS

The UAF DUSTM protocol collects data by mounting a DustTrak aerosol monitor on an ATV to measure real-time $PM_{10}$ concentrations in the dust plume generated by the vehicle as it travels over a test surface. During each run, the ATV accelerates to and maintains a constant speed (approximately 20 mph) across a defined test section, while the instrument continuously records $PM_{10}$ concentrations at roughly one-second intervals through an intake positioned behind the tire where dust generation is most representative. Only the data collected during the steady-state travel portion of the section (excluding acceleration and braking) is used, and multiple runs are performed in both directions to account for variability such as wind effects. The resulting dataset consists of time-series $PM_{10}$ concentration measurements that are compared between treated and untreated sections to evaluate dust suppression performance and how it changes over time.

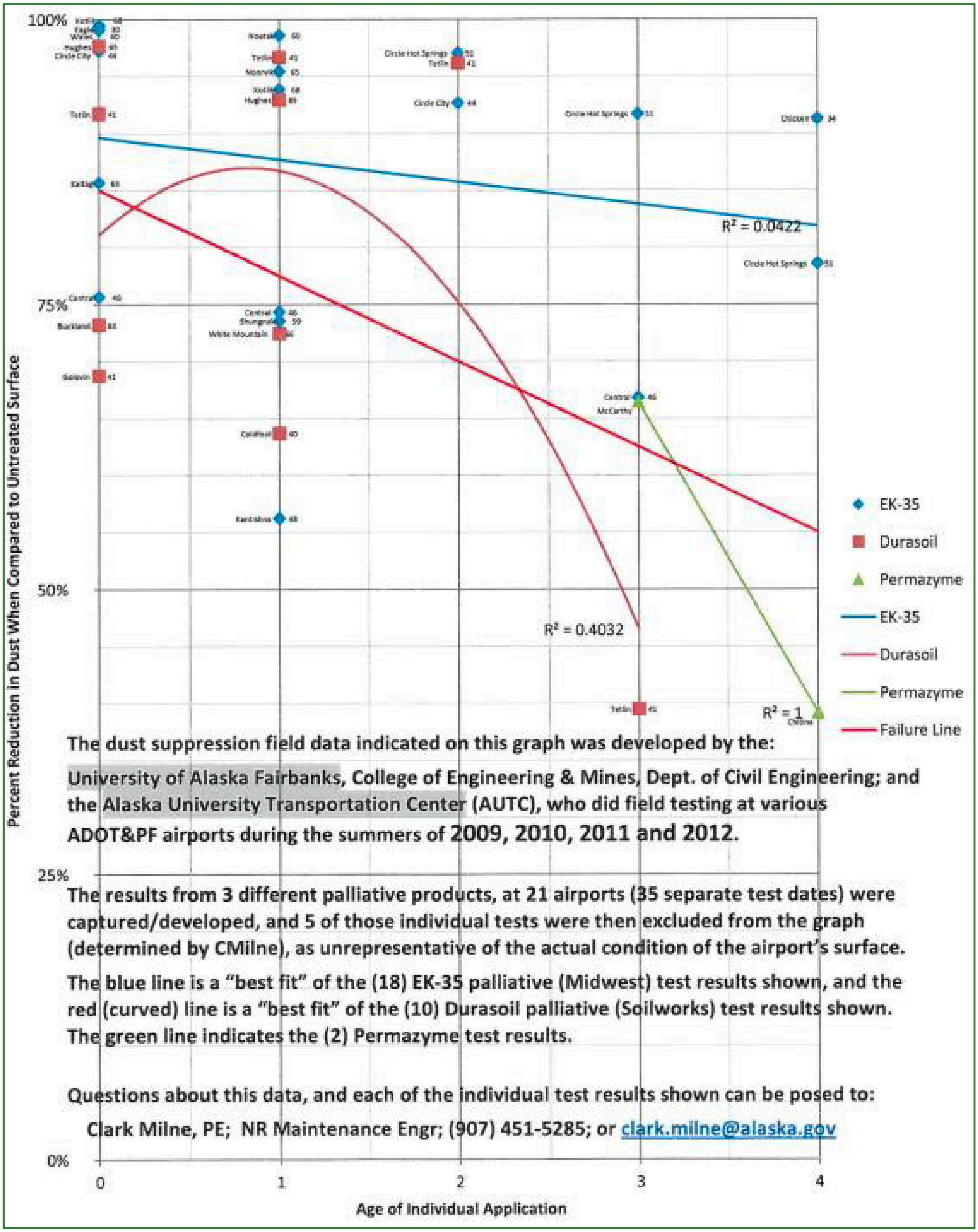
**EVALUATING DUST PALLIATIVE PERFORMANCE AND LONGEVITY USING THE UAF-DUSTM FIGURE 1:**
*UAF-DUSTM mounted on an ATV for data collection*

## TEST OBJECTIVES

The primary purpose of this four year study was to measure, quantify, and compare the reduction of dust achieved and maintained with EK35® and Durasoil over an extended period of time using a standardized and repeatable method. Rather than relying on qualitative observations or manufacturers' claims, this study directly and independently measured the dust emissions relative to untreated conditions and quantified the performance changes over time under real-world conditions, weather, and traffic.

## TEST RESULTS

- Using the best-fit trend line, EK35®-treated runways achieved an average dust reduction of:
  - 87% one year after application
  - 85% two years after application
  - 84% three years after application
  - 82% four years after application
- For comparison, using the best-fit trend line, Durasoil-treated runways achieved an average dust reduction of:
  - 86% one year after application
  - 75% two years after application
  - 47% three years after application
- EK35®'s performance undergoes a gradual decline over time, whereas Durasoil's performance abruptly declines.
- Several EK35®-treated runways (Circle Hot Springs and Chicken) maintained above 90% dust suppression three and four years after application.
- Overall, EK35® delivers and maintains effective dust control for three to four years after application compared to Durasoil which has a substantial decline in efficacy between one and two years after application.




The dust suppression field data indicated on this graph was developed by the:
University of Alaska Fairbanks, College of Engineering & Mines, Dept. of Civil Engineering; and the Alaska University Transportation Center (AUTC), who did field testing at various ADOT&PF airports during the summers of 2009, 2010, 2011 and 2012.

The results from 3 different palliative products, at 21 airports (35 separate test dates) were captured/developed, and 5 of those individual tests were then excluded from the graph (determined by CMilne), as unrepresentative of the actual condition of the airport's surface.

The blue line is a "best fit" of the (18) EK-35 palliative (Midwest) test results shown, and the red (curved) line is a "best fit" of the (10) Durasoil palliative (Soilworks) test results shown. The green line indicates the (2) Permazyme test results.

Questions about this data, and each of the individual test results shown can be posed to:

Clark Milne, PE; NR Maintenance Engr; (907) 451-5285; or clark.milne@alaska.gov

**UAF/AUTC DUST-M Airport Dust Suppression Test Data; 2009-2012:**
*Performance of Various Dust Palliative Performance Over Four Year Period At 21 Different Unpaved Runways*