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Environmental Aspects of Aircraft and Airfield Deicing – An Air Force Perspective



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The Air Force (AF) uses many deicing/anti-icing compounds on its aircraft and airfields. And several new compounds have been proposed for future use because they are said to be more environmentally friendly or less corrosive to aircraft parts and pavements. A comparison of the oxygen demands of various de-icing and anti-icing compounds is presented in an effort to determine their relative environmental impacts. A theoretical approach and various manufacturers' data were used to place the compounds on an even footing. For valid comparisons, the AF must request that BOD/COD tests be run on all compounds at equivalent concentrations using the same units. Then this data, along with application rates for the same temperature range, can be used to make comparisons on which deicing compounds have the least environmental impact. The EPA suggests that COD, rather than BOD, is the best test for deicing compounds because it captures total oxygen demand, is not affected by additives, is simple to conduct, can be measured in real time, and is not temperature dependent. Other environmental aspects of aircraft and airfield deicing, such as storm water and wastewater permitting requirements affecting deicing activities, are discussed. A partial summary of the 2008 Air Force survey of deicing practices at its installations for deicing seasons 2005 through 2008 is provided. The survey shows the number of aircraft deiced versus the number of sorties flown during a deicing season. The amounts of aircraft and airfield deicing compounds used by the AF are compared to those used at commercial airports. The AF deicing footprint on the environment is much lower than that of commercial airports.

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ENVIRONMENTAL ASPECTS OF AIRCRAFT AND AIRFIELD DEICING: AN AIR FORCE PERSPECTIVE

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The Air Force (AF) uses many deicing/anti-icing compounds on its aircraft and airfields. And several new compounds have been proposed for future use because they are said to be more environmentally friendly or less corrosive to aircraft parts and pavements. A comparison of the oxygen demands of various de-icing and anti-icing compounds is presented in an effort to determine their relative environmental impacts. A theoretical approach and various manufacturers' data were used to place the compounds on an even footing. For valid comparisons, the AF must request that BOD/COD tests be run on all compounds at equivalent concentrations using the same units. Then this data, along with application rates for the same temperature range, can be used to make comparisons on which deicing compounds have the least environmental impact. The EPA suggests that COD, rather than BOD, is the best test for deicing compounds because it captures total oxygen demand, is not affected by additives, is simple to conduct, can be measured in real time, and is not temperature dependent. Other environmental aspects of aircraft and airfield deicing, such as storm water and wastewater permitting requirements affecting deicing activities, are discussed. A partial summary of the 2008 Air Force survey of deicing practices at its installations for deicing seasons 2005 through 2008 is provided. The survey shows the number of aircraft deiced versus the number of sorties flown during a deicing season. The amounts of aircraft and airfield deicing compounds used by the AF are compared to those used at commercial airports. The AF deicing footprint on the environment is much lower than that of commercial airports.



- **EPA Proposed Effluent Limitation Guidelines (ELGs)**
- **AF 2008 Deicing Data Call Results**
- **Air Force Deicing Chemicals**
- **Comparisons of Current and Proposed Deicers**
- **Summary**



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USEPA Proposed Effluent Limitation Guidelines - ELGs

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USEPA Proposed ELGs

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- **The USEPA has proposed Effluent Limitation Guidelines (ELGs) for the Airport Deicing Category under 40 CFR Part 449.**
 - **Federal Register, August 28, 2009, Proposed Rule, pgs 44675-44718.**
- **The proposed rule and ELGs are based on the results of the EPA Airport Questionnaire, sent to 153 commercial airports in April 2006.**



USEPA Proposed ELGs

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- **ELGs are discharge limits that are economically feasible and can be achieved by using pollution prevention and the Best Available Technology (BAT).**
 - **ELGs will be incorporated into NPDES permits and enforceable by regulatory agencies.**
- **At this time, it appears that most USAF Bases will not be affected by the USEPA rules.**
 - **The effect on AFBs co-located at commercial airports is unclear at this time, and**
 - **States can have more stringent rules, which may be incorporated into their permits.**



Proposed ELGs for Aircraft Deicing

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- **USEPA Questionnaire results showed that commercial airports use about 25 million gallons of Aircraft Deicing Fluid (ADF) annually, of which 22.1 M (88%) is Propylene Glycol (PG).**
- **20% / 60% of spent ADF will need to be collected.**
- **All collected ADF must be treated onsite or offsite.**
- **Offsite treatments include discharge to a POTW, collection by a recycler, or commercial disposal to an offsite industrial WWTP.**



Proposed ELGs for Airfield Deicing

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- **Results of the Questionnaire also showed that commercial airports use about 71 million pounds of chemical deicers on airfield pavement.**
- **Potassium acetate usage is 64% of the total.**
- **The best available technology (BAT) for airfield deicers is to eliminate the use of urea.**
 - **If urea usage is not completely eliminated, then airfield discharges must meet ammonia limits.**
- **Collection of airfield deicing runoff was deemed prohibitively expensive, so is not required at this time.**



Deicing ELGs - BOD₅ versus COD

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- **The EPA determined that COD, rather than BOD₅, is the best indicator pollutant for deicing compounds because:**
 - **it captures the oxygen demand from both nitrogenous, organic, and inorganic compounds,**
 - **it is not affected by additives in ADF,**
 - **is simple to conduct,**
 - **can be measured in real time, and**
 - **is not temperature dependent.**
- **A maximum daily COD of 271 mg/L and weekly average of 154 mg/L from treatment systems are proposed, along with a long term target value of 41 mg/L.**



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2008 Air Force Deicing Data Call – Selected Results

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AF 2008 DEICING DATA CALL

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- **In anticipation of the USEPA proposed ELGs for airport deicing activities, the DoD Clean Water Act Services Steering Committee requested all services to provide input on their use of deicing chemicals to:**
 - **Quantify DoD usage rates and types for deicing seasons (2005/6, 2006/7, 2007/8)**
 - **Demonstrate to EPA that DoD is fundamentally a small user compared to the airlines industry**
 - **Prepare comments and recommendations to EPA on how to regulate DoD to mitigate impacts**
- **The AF sent an extensive questionnaire to its bases**
 - **152 bases responded**



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Survey Results – AFCEE Deicing Database

INFOCON 3 UNCLASSIFIED FFCON: Alpha

US_Air_Force_Deicing_2008

Home Create External Data Database Tools

frm_MAIN_SWITCHBOARD

U.S. Air Force 2008 Deicing Report

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For Official Use Only All Reports are based on Deicing Seasons 2005, 06, and 07 Data Collected July 2008

Data Management

Quit

| | |
|-----------------------------|------------|
| POCs | Table POCs |
| Aircraft Deicing Usage_BMPs | Table A/C |
| Runway Deicing Usage BMPs | Table RWY |
| Run-Off Management | Table MGT |

Type 1 Reports

- Usage by MAJCOM and Base
- Usage by State and City near AF Base
- Usage by State and City with Base Name
- Amount to Deice Aircraft by Type
- Bases that exceed Deminimus Amount
- Percent Bases Deice Aircraft by MAJCOM
- Bases Reporting Aircraft Deicing Activity

BMP Reports

- BMPs for A/C deicing with Percent Used
- BMPs for A/C deicing with Additional Comments
- BMPs for RWY deicing with Percent Used
- BMPs RWY deicing with Additional Comments

Analysis

- Potentially Inconsistent Responses

Misc. Reports

- Type 4 Usage by MAJCOM and Base
- Percentage of aircraft deiced vs. sorties flown
- Potassium Application Rate on Runway Pavement
- Bases that Deice with 303d Listed Waters Nearby
- Pollutant Discharge Limits
- Deicing Points of Contact by Installation

Available for download to any dod mil computer at:
<https://afkm.wpafb.af.mil/ASPs/CoP/OpenCoP.asp?Filter=OO-MS-CE-37>



Qualifications on Data

- **Some data inconsistencies were apparent. For example:**
 - **Base reported deicing aircraft, but reported no use of runway deicing chemicals, and *vice versa***
 - **Some MAJCOMs did not report all their bases**
 - **Some quantities appeared very high or very low compared to others**
 - **There was no rigorous QA/QC on installation data at base, MAJCOM or AF level**
 - **Deicing records at some installations were incomplete**



AF Aircraft Deicing Overview

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- **70% (107) of bases reported using aircraft deicers**
- **Propylene Glycol (PG), AMS 1424, Type I**
- **AF-wide average use = 616,000 gal/year, as supplied**
- **47 Bases used 98.5% of the AF total PG/Yr**
- **2 bases used 31% of all PG fluid**
- **Nineteen installations reported using > 10,000 gallons PG/Yr**
- **60 Bases used <1000 gallons PG/Yr (1.5% of AF Total)**
- **Only 5% of sorties were deiced**
- **Just 5 installations reported using Propylene Glycol, Type IV, anti-icing chemical**



Aircraft Deicing BMPs

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For the 47 Bases using >1000 Gallons PG/Yr or 98.5% of the AF total. % of Bases using these BMPs:

| | |
|--------------------------------------|--------------|
| ■ Hangar Aircraft | 85.1% |
| ■ Mechanical removal | 61.7 |
| ■ Enclosed cab deicing trucks | 61.7 |
| ■ Operator training | 59.6 |
| ■ Solar radiation | 46.8 |



Aircraft Deicing BMPs

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For the 47 Bases using >1000 Gallons PG/Yr or 98.5% of the AF total. % of Bases using these BMPs:

| | |
|--------------------------------|-------|
| ■ Run off discharge blocks | 31.9% |
| ■ Weather forecast -anti-icing | 27.7 |
| ■ Vary PG mixtures | 25.5 |
| ■ Single ramp location deicing | 17.0 |
| ■ Aircraft covers | 12.8 |
| ■ Additional BMPs | Most |



AF Airfield Deicing Overview

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- **57% (87) of installations reported the use of potassium acetate (KAc).**
 - **AF-wide average use = 608,000 gal/year**
 - **41 Bases used 99% of the KAc/Yr**
 - **5 installations used 62% of the KAc**
 - **46 Bases use <1000 Gallons KAc/Yr or 1.0% of KAc**
 - **Average reported application rate = 1.9 gal /1,000 square feet**
 - **Number of applications of KAc per season ranged from 0 to 81 times, depending on the base**
- **Minor amts of sodium formate were used**



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Airfield Deicing BMPs

For the 41 Bases using >1000 Gallons KAc/Yr or 99% of the AF total. % of Bases using these BMPs:

| | |
|---------------------------------------|------|
| ■ Mechanical snow removal | 100% |
| ■ Controlled app equipment | 87.8 |
| ■ Operator training | 68.3 |
| ■ Vary app rate by ambient conditions | 56.1 |
| ■ Weather forecast -anti-icing | 43.9 |



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Airfield Deicing BMPs

For the 41 Bases using >1000 Gallons KAc/Yr or 99% of the AF total. % of Bases using these BMPs:

| | |
|-------------------------------|-------|
| ■ Runway ice detect (RIDS) | 26.8% |
| ■ Mobile pavement temp sensor | 24.4 |
| ■ Pre-wet dry chemicals | 22.0 |
| ■ Block run-off | 22.0 |
| ■ Additional BMPs | Most |



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Comparison of AF and Commercial Airports

- Commercial airports used 22.1 million gallons of PG or 35 times more than the AF did (0.62 M gallons).
- Commercial airports used 45 million pounds of potassium acetate or 13 times more than the AF did (3.47 M pounds).
- AF use of sodium formate was 860, 541, and 80 tons for years 2008, 2007, and 2006, respectively, as compared to commercial airports at 1065 tons for one deicing season.
- **So the AF deicing footprint on the environment is much lower than that of commercial airports.**



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***Air Force Deicing Chemicals
and
Comparisons to Deicers
Proposed for AF Use***

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AF Deicing Chemicals

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- **Deicing and anti-icing compounds used on AF aircraft and airfields must meet strict approval requirements.**



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Current AF Aircraft Deicers

- **Must be petroleum-based, propylene glycol; FAA approved; certified to SAE AMS 1424; AND meet requirements in AF TO 42C-1-2 & Holdover Tables**
- **Must be DLA supplied (these are currently used, but can change)**
 - **Octaflo EF**
 - **Kilfrost**
 - **Safetemp ES, Safetemp ES Plus**



BOD₅ / COD of PG Used by the USAF

- **Propylene Glycol, Currently used by AF**
 - **Average BOD₅ as supplied: 0.74 Kg O₂/Kg PG**
 - **Average COD, as supplied: 1.45 Kg O₂/Kg PG**
- **The application rate of currently used PG depends on LOUT (Lowest Operational Use Temperature) & conditions**
 - **For a LOUT of ~ 3° F (-16 °C):**
 - **50-50 Mixture of PG as supplied and water is used**
 - **Has a BOD₅ of 0.39 M mg/L (3.23 lbs/gallon)**
 - **Has a COD of 0.76 M mg/L (6.34 lbs/gallon)**



Comparison to Wastewater

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- **Each gallon of 50-50 Mixture of PG has a BOD₅ load of ~ 3.2 lbs.**
- **The “average” BOD₅ load of 1 gallon of domestic wastewater coming into a treatment plant is 0.0025 lbs.**
- **This means that the strength of PG is ~ 1300 times greater than domestic wastewater!**
 - **So dilution of PG with water and snow can only do so much.**



Current AF Airfield Deicers

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- **Certified to SAE AMS 1431/1435 AND must meet requirements in AFI 32-1002**
 - **Sodium Formate**
 - **Sodium Acetate**
 - **Potassium Acetate**
- **Local supply permitted**

- **Application Rate depends on ice thickness and pavement temperature.**



Comparison of Oxygen Demands

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- **Many new deicing compounds have been proposed for future use on AF aircraft and airfields because they are said to be more environmentally friendly or less corrosive to aircraft parts and pavements.**
- **Application data for some proposed deicers are needed to compare “apples with apples.”**
- **A comparison of the oxygen demands of currently used and proposed deicing compounds was made to determine their relative environmental impacts.**



Comparison of Oxygen Demands

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- **Theoretical calculations were used to place deicing compounds on an even footing.**
- **Then current data from various manufacturers were used in an effort to compare currently used compounds to those proposed for future use.**
- **Please note that the COD data are the best estimations that can be made from existing data and cannot be used as absolute values.**



COD of Aircraft Deicers

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| ADF | Kg O2/Kg compd |
|-----------------------------|-----------------------|
| ■ Ethylene glycol | 1.14 T |
| ■ Propylene glycol | 1.47 T |
| ■ Isopropyl alcohol | 2.11 T |
| ■ Neopentyl glycol | 1.89 T |
| ■ Pentaerythritol | 1.23 T |
| ■ Sorbitol | 1.01 T |
| ■ PG/Non-glycol mix | 1.20 M |
| ■ PG –Currently used | 1.45 M |

T = theoretical; M = manufacturers' data



COD of Airfield Deicers

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| Airfield Compd | Kg O₂/Kg compd* |
|--------------------------------------|-----------------------------------|
| ■ Sodium Formate | 0.12 |
| ■ Potassium Acetate | 0.32 |
| ■ Sodium Acetate | 0.78 |
| ■ Urea | 1.85 |
| ■ KAc - propanediol mix | 0.60 |
| ■ NaAc - propanediol mix | 0.94 |
| ■ Polyol - Organic Salts mix1 | 0.50 |
| ■ Polyol - Organic Salts mix2 | 0.52 |

***Average of manufacturers' data**

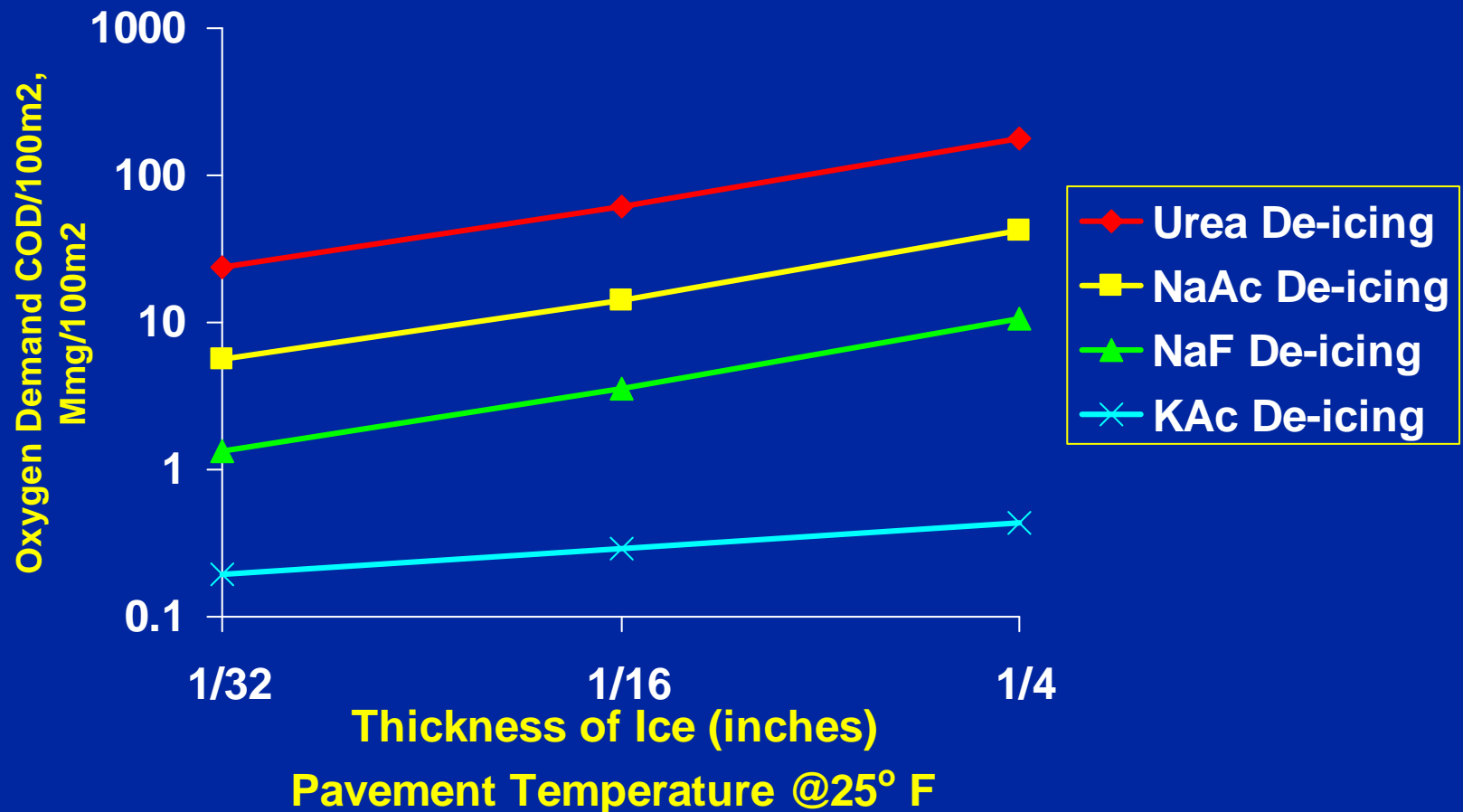


Comparison of Environmental Impacts

- **The same COD and BOD tests need to be run on all compounds at equivalent conditions and concentrations using the same units.**
- **These data, along with application rates for the same weather conditions, can then be used to make valid comparisons on which deicing compounds have the least environmental impact.**
- **This is crucial for valid environmental comparisons, like those shown in the following graphs of currently used airfield deicers (urea for comparison only).**

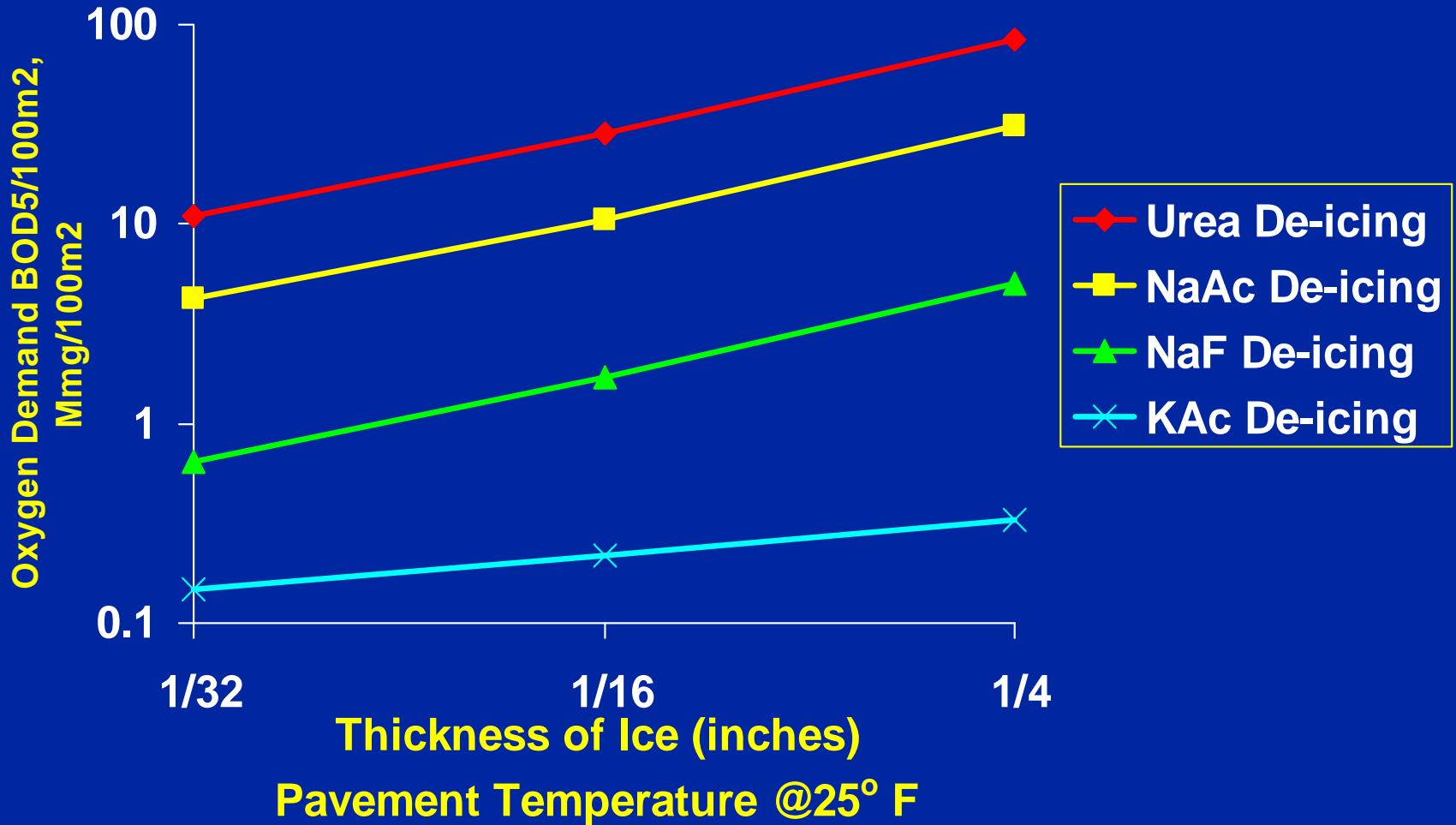
COD Load of AF Pavement Deicers

Log Scale



BOD₅ Load of AF Pavement Deicers

Log Scale





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Proposed Aircraft and Airfield Deicers –Approval Process

- **Manufacturer/developer is responsible for all testing and costs to show proof of meeting specifications**
- **Deicer must be approved by AF Weapon and Aircraft Single Manager (ASM)**
- **Aircraft deicers must be certified by FAA and to SAE AMS 1424**
- **Airfield deicers must be certified to SAE AMS 1431/1435**
- **Must have equivalent performance and cost**



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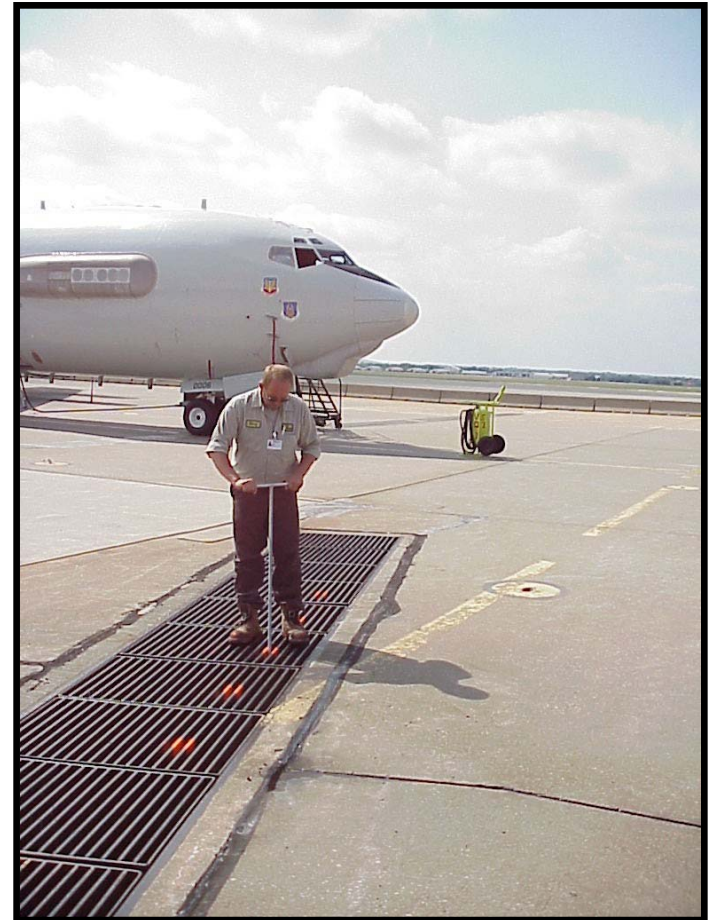
Summary Highlights

- USEPA ELGs should have minor effects on the AF.
- ELGs call for COD measurements rather than BOD₅
- Few AFBs use >10,000 gallons of PG/year.
- Just 5 AFBs use 62% of the KAc.
- The AF has many effective deicing BMPs in place.
- Valid environmental comparisons of deicing compds must be based on equivalent conditions and tests.
- Manufacturers/developers of proposed deicing compounds for AF use are responsible for testing and costs, and gaining AF ASM approval.
- **The AF deicing footprint on the environment is much lower than that of commercial airports.**



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Questions?



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Mike Sanders, HQ AFPET/PTPT, Aircraft**

**Manufacturers/Others Literature:
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