Battelle
The Business of Innovation

Development of Environmentally Benign and Reduced Corrosion Runway Deicing Fluid Paper # 07ICE-54

Dr. Satya P. Chauhan

26 September 2007

SAE Aircraft & Engine Icing International Conference
Seville, Spain

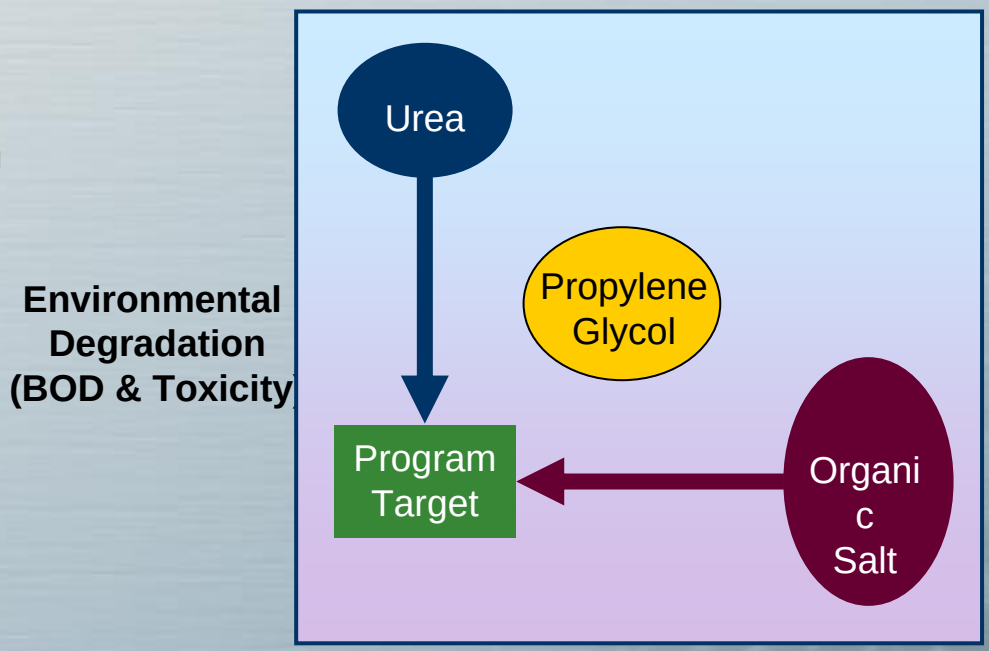
SAE®

Contents

- Need for improved Runway Deicing Fluids (RDFs)
- Battelle's RDF-development background
- Objectives of Strategic Environmental R&D Program (SERDP)
- Results
- Future Test Plans

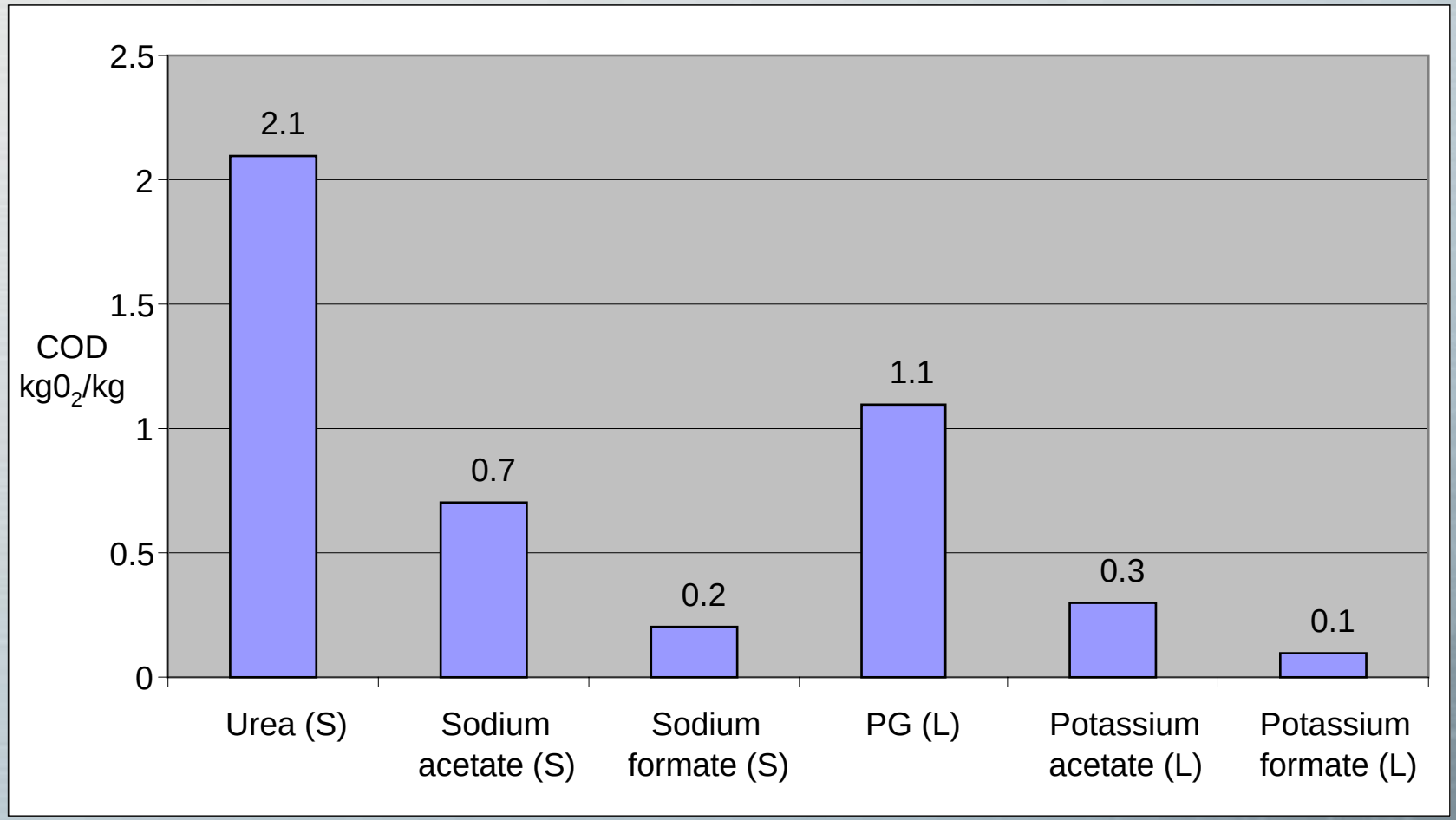
Problem Statement

- Airports switched from urea to organic salt deicers to reduce biological/chemical oxygen demand (BOD/COD), but salts are too corrosive
  - Concerns over corrosion of cadmium (Cd)-plated landing gear parts
  - >50% increase in cost of maintaining carbon brakes
  - Runway concrete and lighting structures damage
- Alternatives have shortcomings
  - Adding more corrosion inhibitor increases toxicity and cost
  - The price and BOD of propylene glycol (PG) deicers is more than two times the target level



Rate of Corrosion of Aerospace Materials

Organic Salts have lower BOD and COD



(S)-Solid; (L)-Liquid

Battelle's RDF-Development Background

- R&D on bio-based deicing fluids for last 10 years
- Patented processes for deicing/anti-icing for aircrafts, runways, pavements/bridges
- Battelle-RDF is nearly ready for testing at military and commercial airports
  - Currently undergoing R&D under a government-funded SERDP program

Technical Objectives

- Develop and evaluate novel chemistry to formulate RDF from inexpensive, bio-based raw materials
- Demonstrate that the new RDF will meet multiple requirements
  - Environmental friendliness
  - Reduced corrosion of Cd-plated parts and carbon brakes
  - Improved material compatibility with advanced aircraft materials
  - Cost effectiveness

Battelle Team for SERDP Program

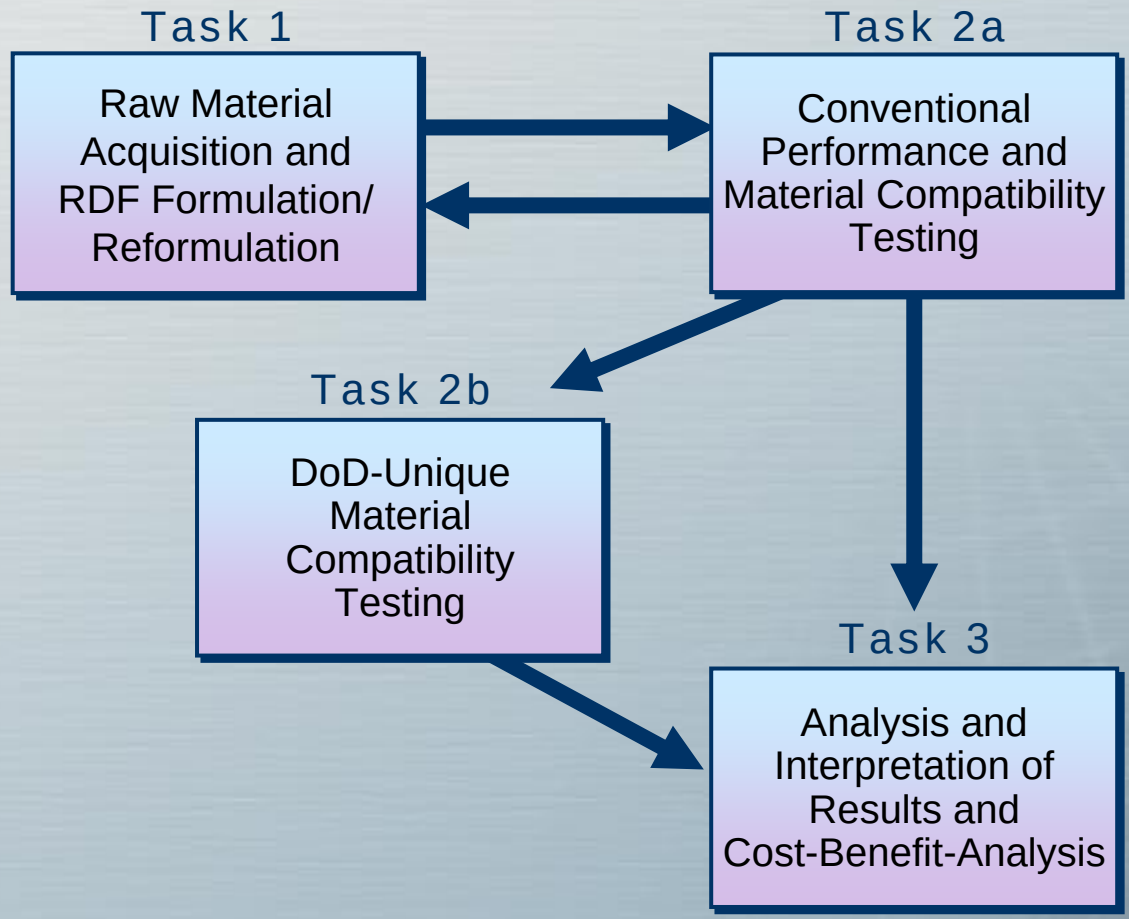
R&D Performers

- Battelle
- Pacific Northwest National Laboratory (PNNL)
- Air Force Research Laboratory (AFRL)

Advisors/Collaborators

- Airport operators
- Industrial firms/vendors
- Testing Laboratories

Technical Approach – Research Tasks



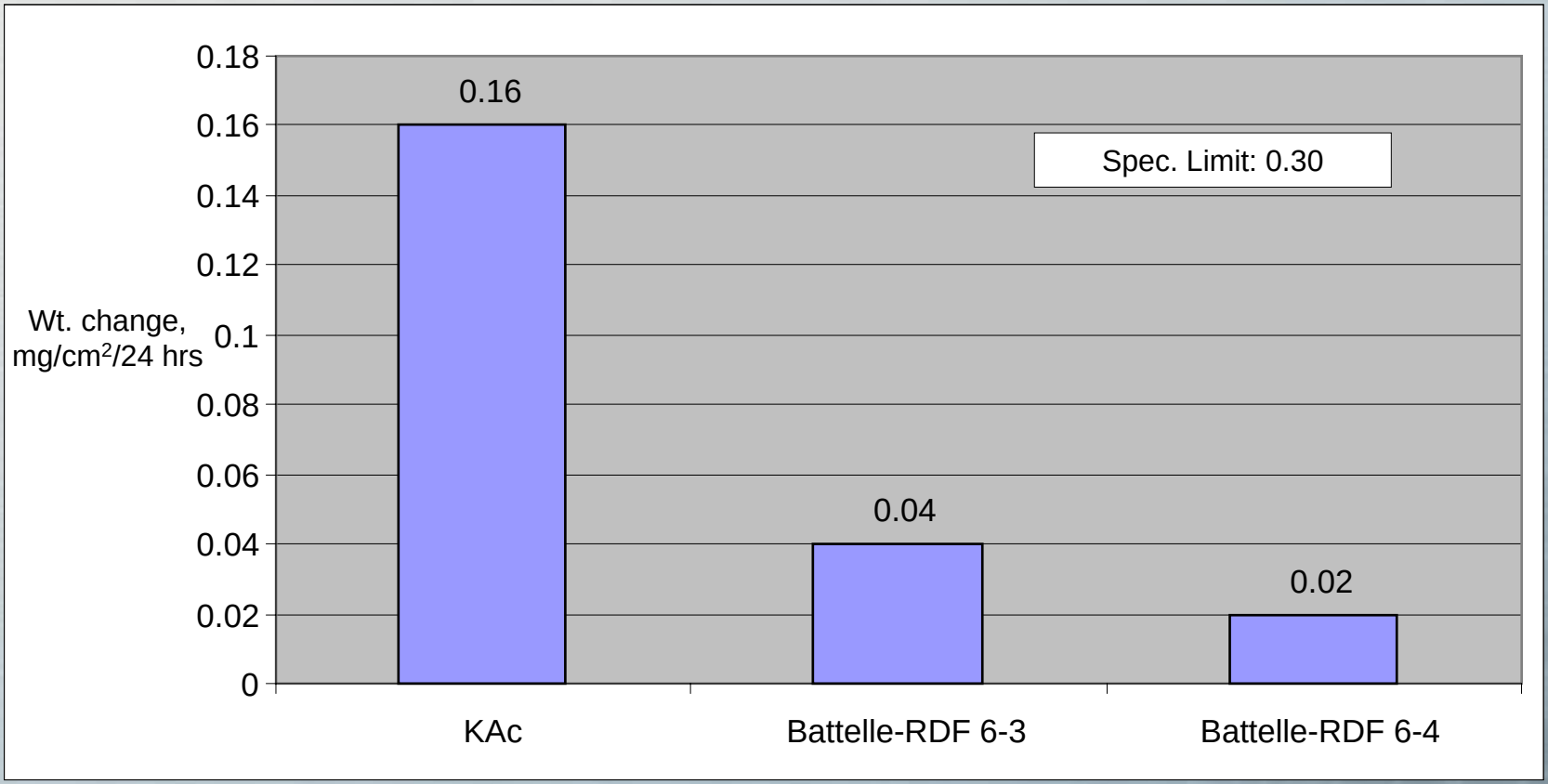
Testing for Two Formulations

- AMS 1435 A *(successfully completed)*
  - Environmental
    - Biodegradability
    - Ecological behavior
  - Physical Properties and Materials Compatibility
    - FPt, specific gravity, pH
    - Effects on aircraft metals
    - Effects on plastics, painted surfaces, cement
- Deicing Performance
  - Ice cutting, penetration, and undercutting
  - Friction coefficient
- Specialty Materials Testing
  - Carbon brake pad oxidation
  - Long-term Cd corrosion
  - Military aircraft materials compatibility

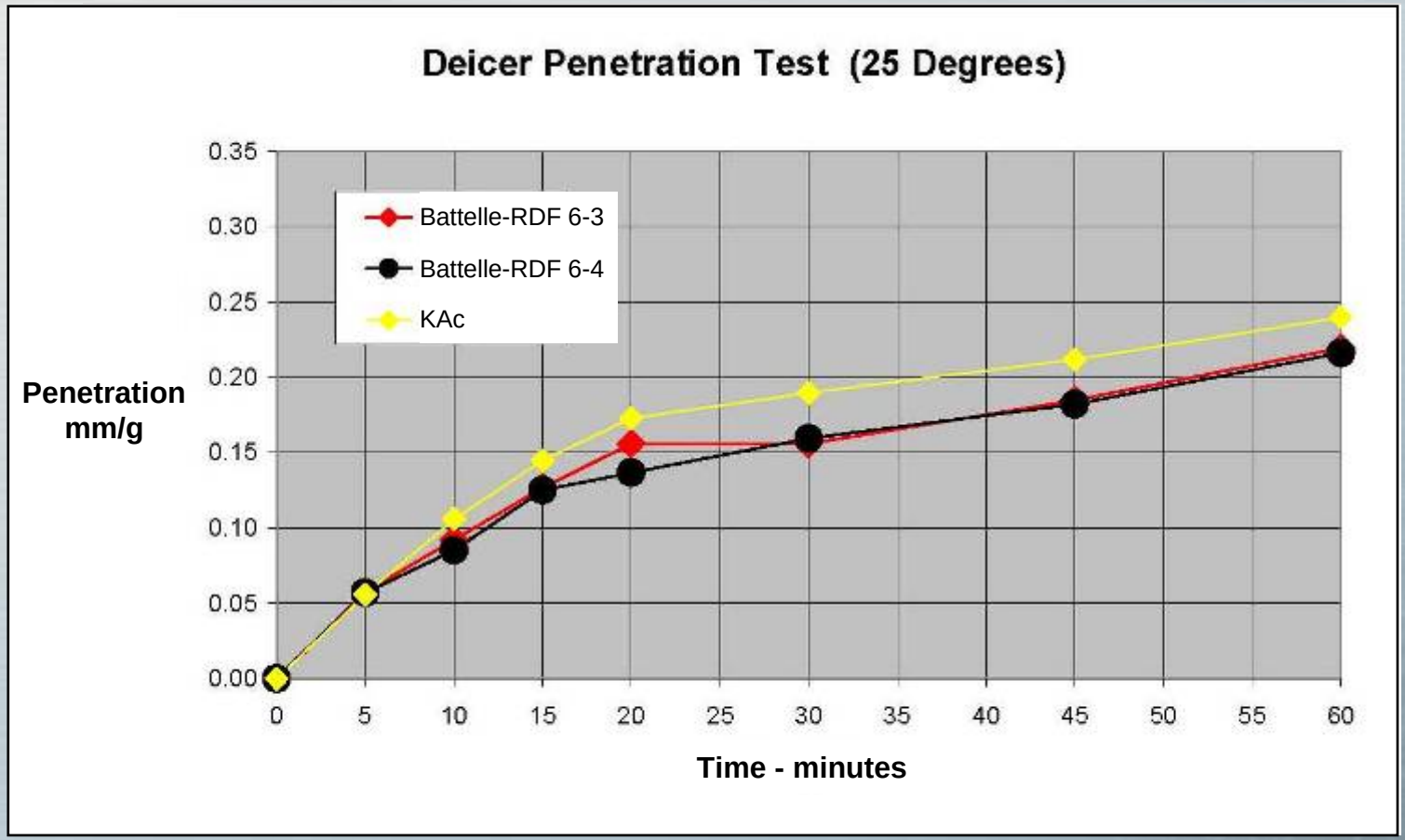
Environmental Testing Results

BOD_5 @ 20°C kg 0_2/kg	Battelle – RDF 6-3: 0.30 Battelle – RDF 6-4: 0.30
COD, kg 0_2/kg	Battelle – RDF 6-3: 0.52 Battelle – RDF 6-4: 0.62
Daphnia magna 48-hr LC_{50}, mg/L	Battelle – RDF 6-3: 4,025 Battelle – RDF 6-4: 4,275
Pimephales promelas *(fathead minnow)* 96-hr LC_{50}, mg/L	Battelle – RDF 6-3: 4,425 Battelle – RDF 6-4: 4,525

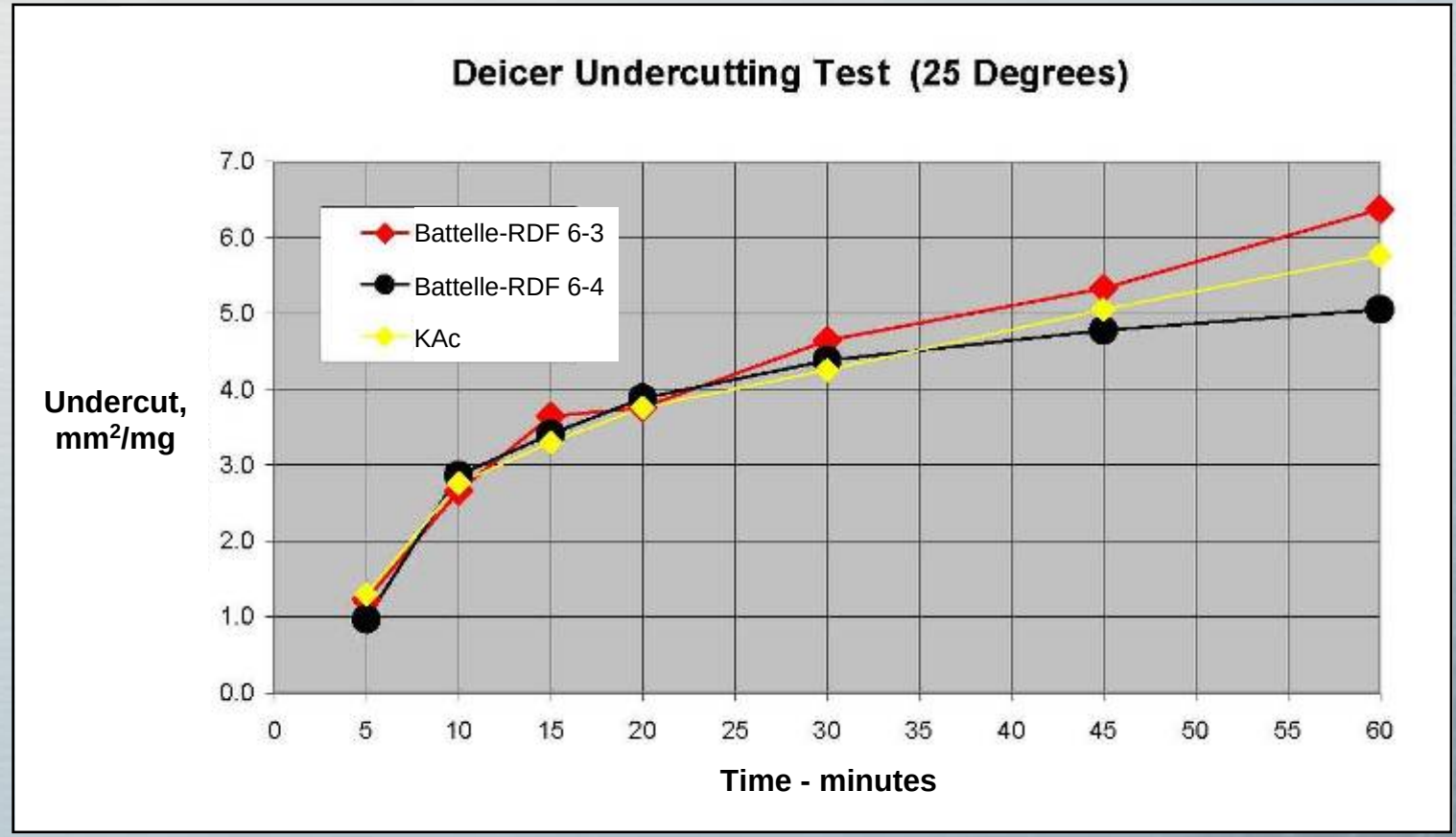
Low-Embrittling Cd Corrosion Reduced



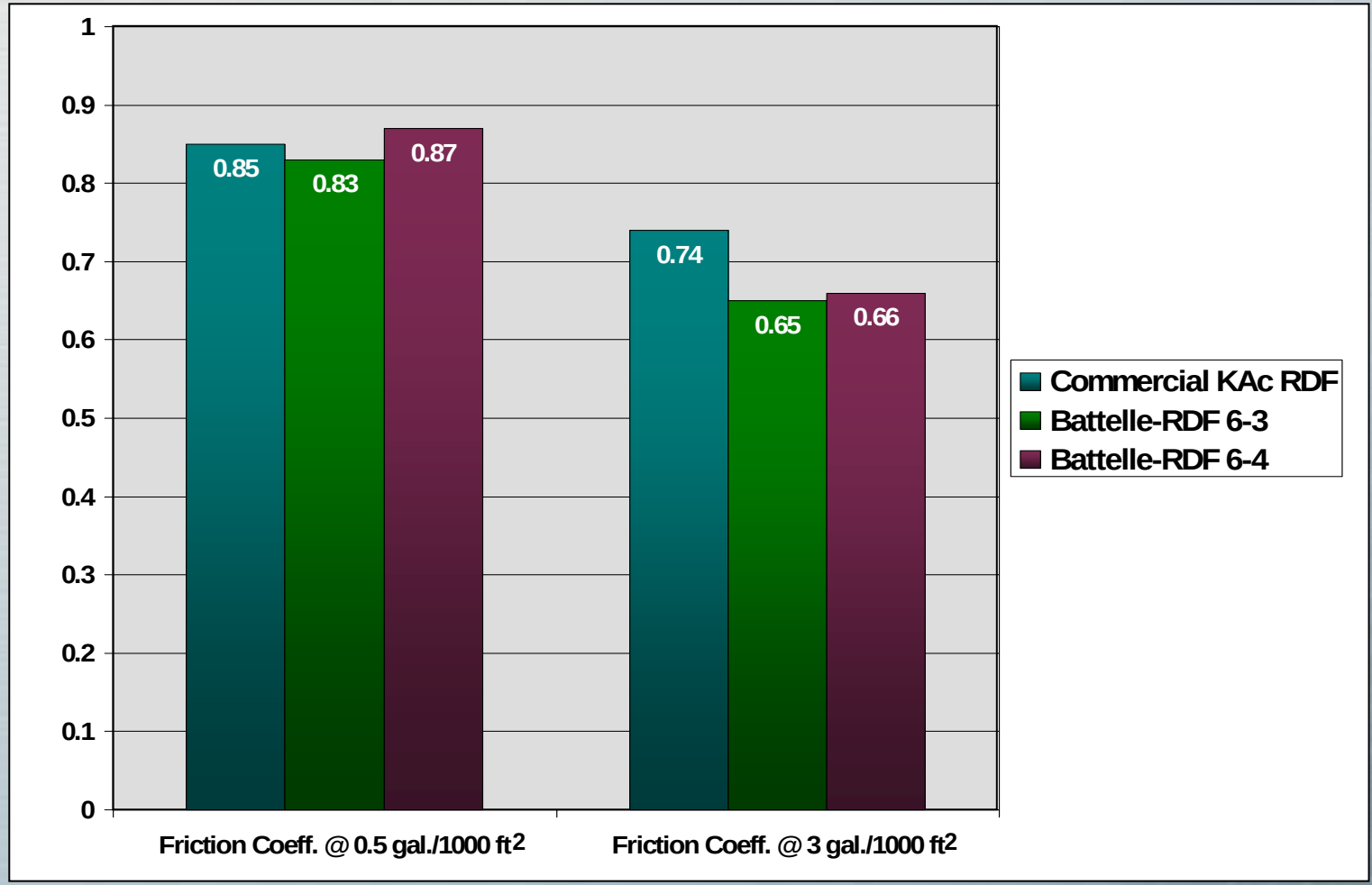
Ice Penetration Results



Ice Undercutting Results



SAAB Friction Test Results



Reduced Electrical Conductivity

- **Typical KAC RDFs: >100 mS**
- **Battelle – RDFs: <35 mS**

Catalytic Oxidation of Carbon-Carbon Brakes

- Honeywell's standard method
- Carbenix® 2300 coupons coated with P-13 antioxidant system
- Soaked in RDF and then dried at 80°C
- Oxidized in flowing air for 24 hours at 650°C
- Weight loss recorded after cooling coupons

Reduced Oxidation of Carbon-Carbon Brakes

No RDF	**3% Weight Loss**
Commercial KAc RDF	**71% Weight Loss Base Case**
Battelle-RDF 6-3	**22% Weight Loss 69% Reduction in Catalytic Activity**
Battelle-RDF 6-4	**15% Weight Loss 79% Reduction in Catalytic Activity**

Future Testing Plans

- Carbon-carbon brake pad oxidation – *continued*
- Multi-cycle Cd corrosion testing – *planned*
- Military Test Method Standard (U.S. DoD-specific) testing – *underway*
- Airport demonstration
  - Seeking airport cooperation to demonstrate next winter

Battelle RDF Advantages over Potassium Acetate Deicers

Results to Date Show:

- Reduced rate of carbon brake oxidation
- Reduced rates of metal corrosion
- Lower toxicity
  - No triazoles or other nitrogen compounds
- Reduced conductivity

Acknowledgements

- **Co-Authors**
  - Battelle: Nick Conkle and Melissa S. Roshon
  - PNNL: Williams D. Samuels
  - U.S. Air Force: Elizabeth Berman and Mary T. Wyderski
- **Testing**
  - MTU: Russ Alger
  - SMI: Patricia D. Viani
  - Honeywell: Terry Walker
- **Funding by SERDP**

Contact Information

Dr. Satya P. Chauhan
Senior Program Manager
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201
USA
(614)424-4812
chauhan@battelle.org