Aircraft Deicing and Anti-icing Fluid Qualification Testing and Research

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LIMA AMIL

Anti-icing Materials International Laboratory

What is AMIL?

- Icing research lab at the University of Quebec at Chicoutimi since 1987
- The only laboratory in the world which qualifies aircraft ground de/anti-icing fluids to international SAE standard procedures for aerodynamic acceptance and ice protection
- Accredited by le Performance Review Institute (PRI) du Society of Automotive Engineers (SAE) and ISO 9001 (2000)

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AMIL - Installations

- Two icing wind tunnels
  which can simulate aircraft take-off

- Five climatic chambers where:
  freezing rain, freezing drizzle,
  freezing fog, frost, snow, snow pellets, ice pellets and sea spray are simulated

- Fluid characterization lab: viscosity (down to –30°C),
  refractive index, surface tension, freezing point, specific mass
  heat capacity, water diffusion…

De / Anti-icing Fluids

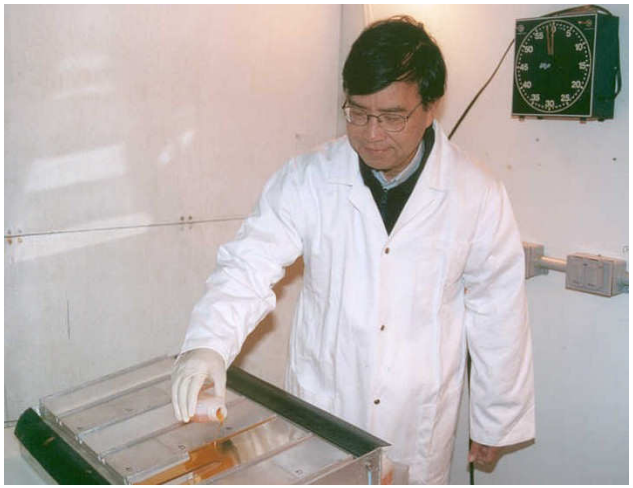
	Type I	Type II	Type III	Type IV
Main use:	De-ice	Anti-ice	Anti-ice	Anti-ice
Behavior:	Newtonian	Non-Newtonian	Non-Newtonian	Non-Newtonian
Specification:	AMS1424	AMS1428	AMS1428	AMS1428
Aircraft:	Both	Large	Commuter	Large
Icing Protection:	WSET = 3 min	WSET = 30 min	WSET = 20 min	WSET = 80 min
Color:	Orange	Pale straw	Bright yellow	Green

Fluid Qualification (AMS 1424/1428)

Performed at AMIL

- Effect on aircraft materials
- Environment
- **Fluid Performance**
  - **Anti-icing Endurance**
  - **Aerodynamic Acceptance**
- Physical Properties
- Fluid Stability

Anti-icing Endurance Tests – AS5901

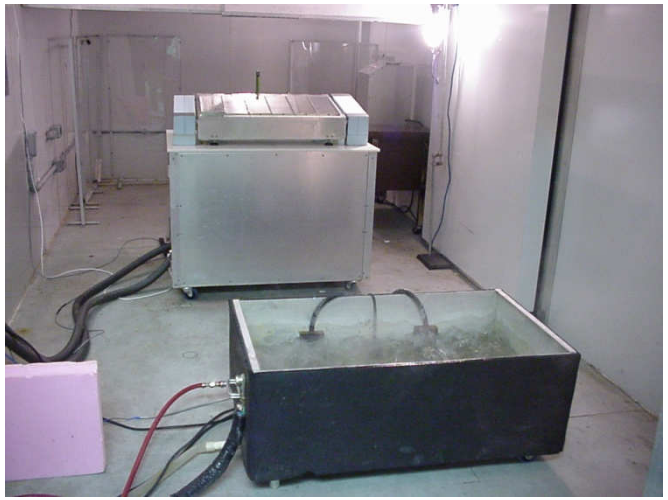


Water Spray Endurance Test:

- Fluid coated plates exposed to supercooled precipitation from a water spray over the plates (simulating freezing fog)
- Measure time before a prescribed icing

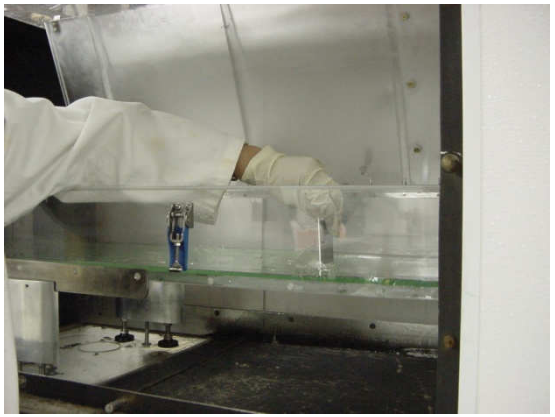
High Humidity Endurance Test:

- Fluid coated plates exposed to a humid environment below 0°C (simulating frost)
- Measure time before a prescribed icing

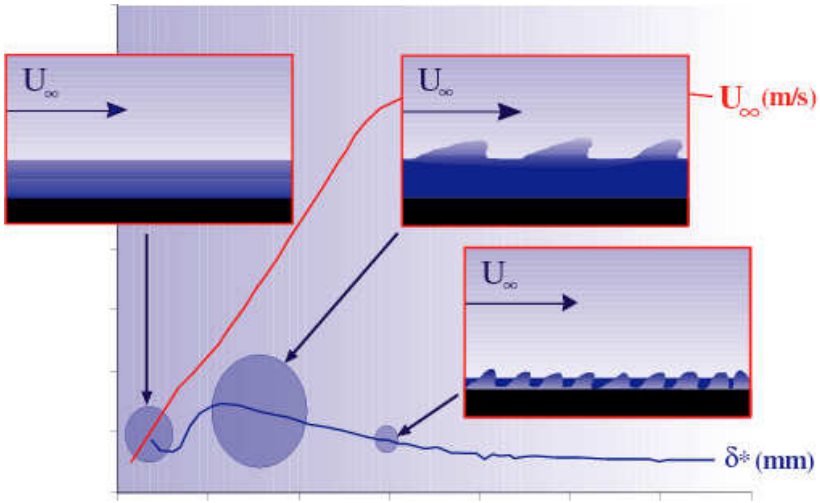


Aerodynamic Acceptance – AS5900

Tests performed in low speed wind tunnel between 0 and –50°C



Airflow simulating an aircraft ground roll:
wind acceleration of 2.6 m/s² to maximum air velocity of 65 m/s.



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Fluid Characterization and Stability

Characterization:

- Viscosity from 20 to –30°C
- pH
- Surface Tension
- Refractive Index

Stability:

Simulating

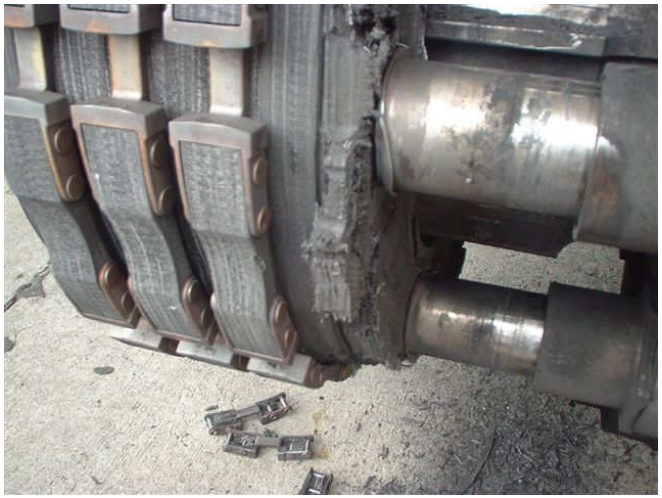
- heated leading edge
- overnight exposure
- heated storage
- shearing
- …

Newer Tests:

- Catalytic oxidation of carbon brakes
- Runway deicer performance
- Icephobic coatings

Carbon Brake Disk Catalytic Oxidation Test

Under Ballot
AMS1431
AMS1435



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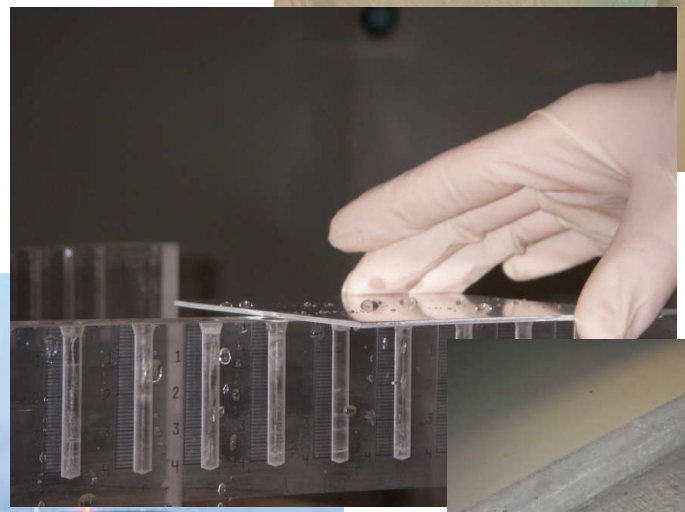
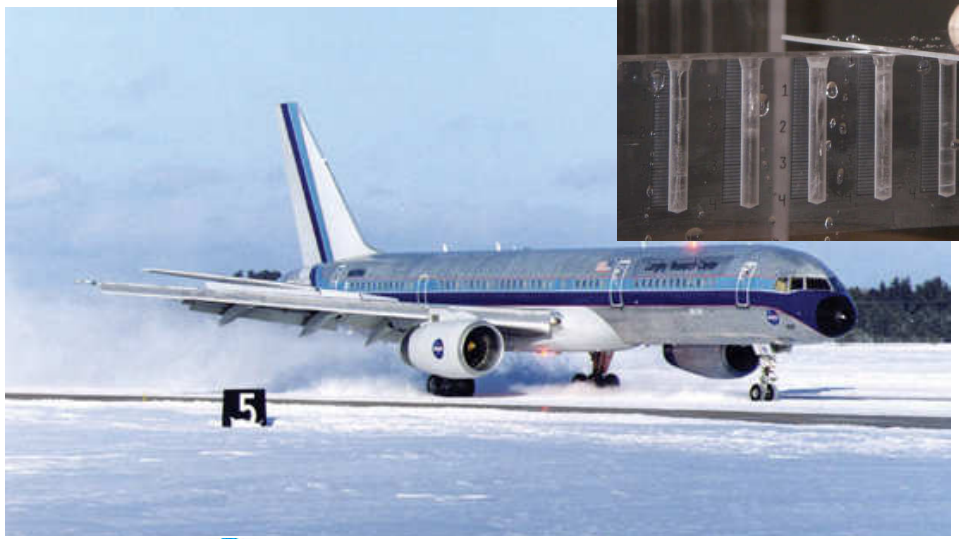
Runway Deicer Performance Testing

Modified SHRP Tests

- Ice Melting
- Ice Penetration
- Ice Undercutting





Icephobic Coating Evaluation

Ice Adhesion
- reduction thereof

Ice accumulation
- Mass
- Shape (aerodynamic forces)

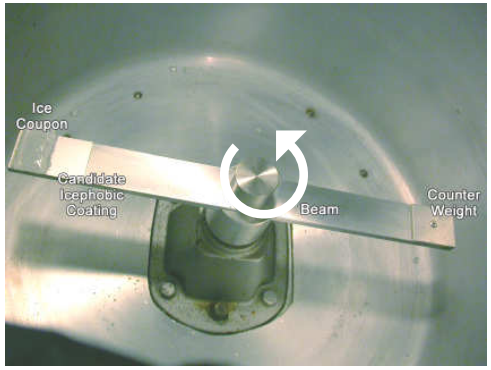
Power to deice
- Reduction thereof

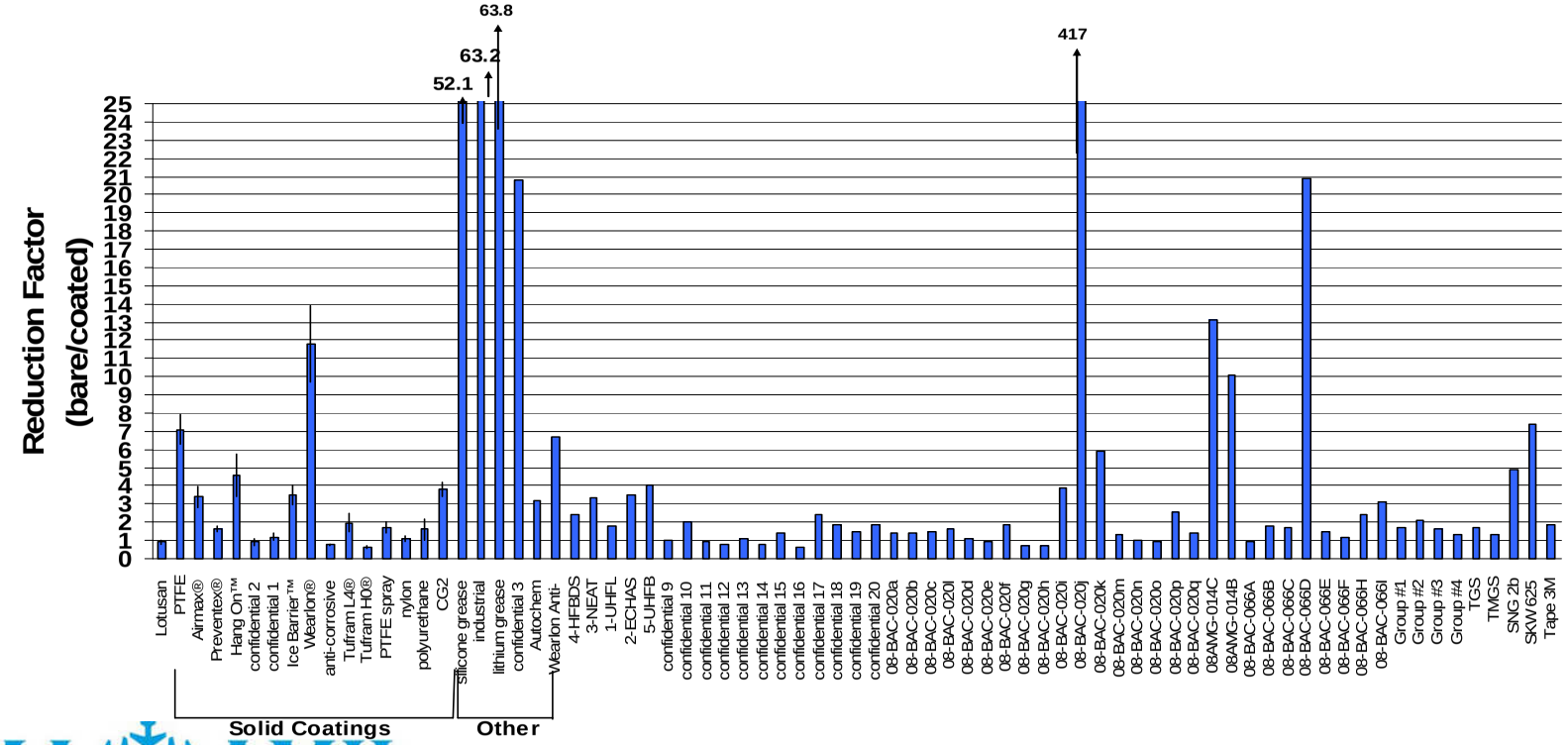
Weight (drag) of the coating itself
- Not always in icing conditions

Effect on fluids
- Since many are hydrophobic

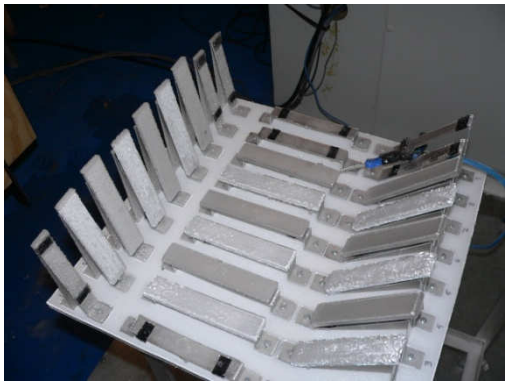
Ice Adhesion CAT

$$ARF = \frac{\tau_{bare}}{\tau_{coated}}$$

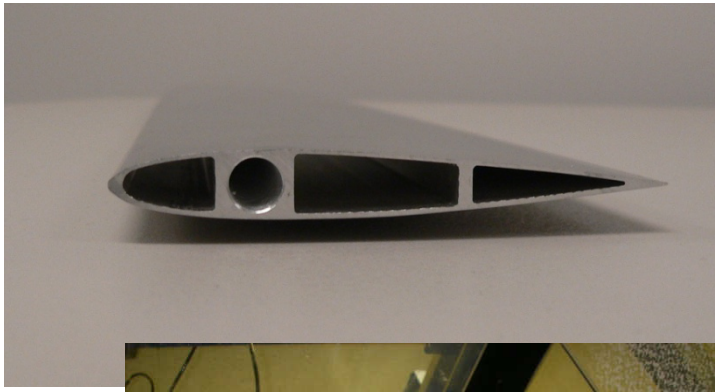


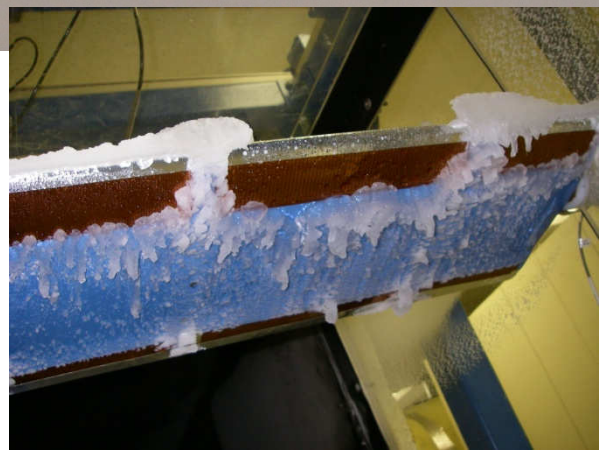


Reduction of ice Accumulation – SAT DAT



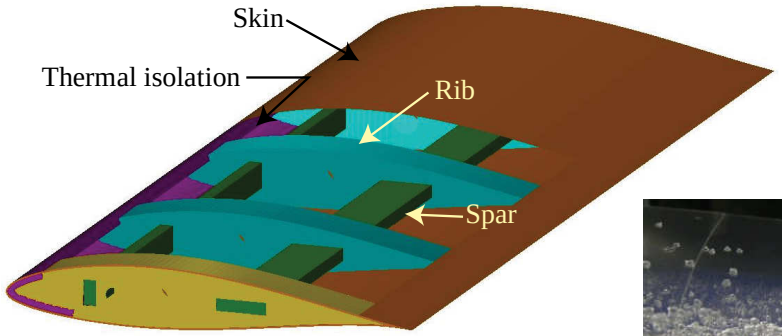
SAT:
Static icing to measure differences in ice weight





DAT: Wind tunnel icing to measure differences in lift/drag

Power to Deice



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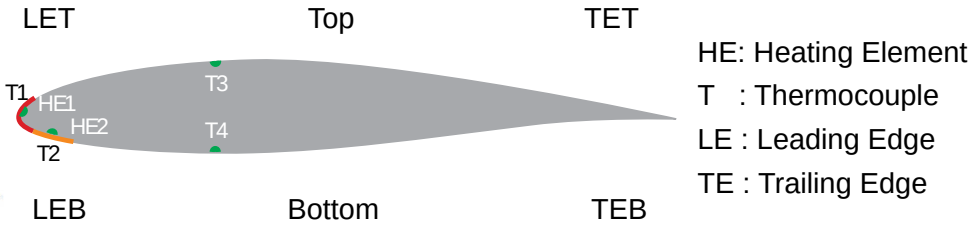
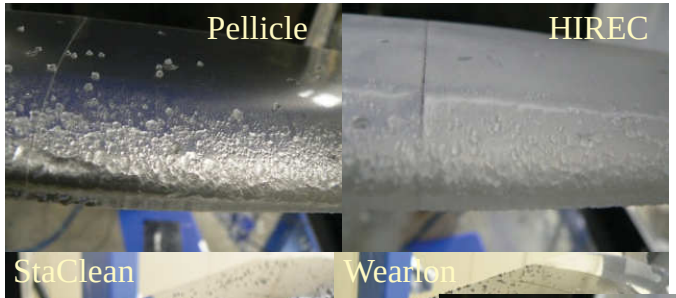
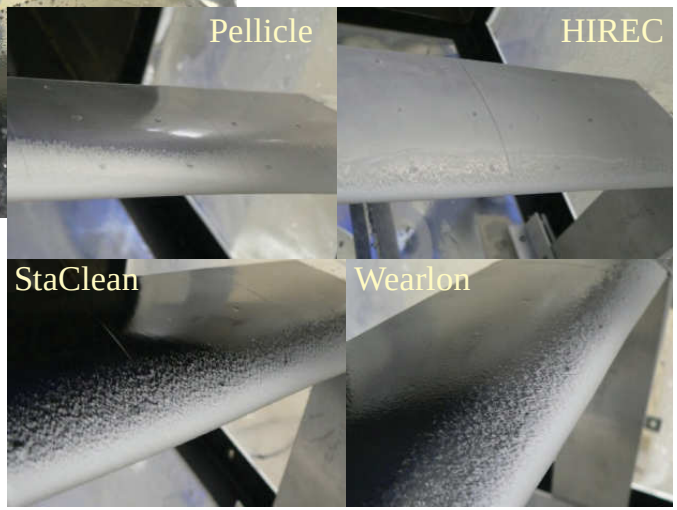




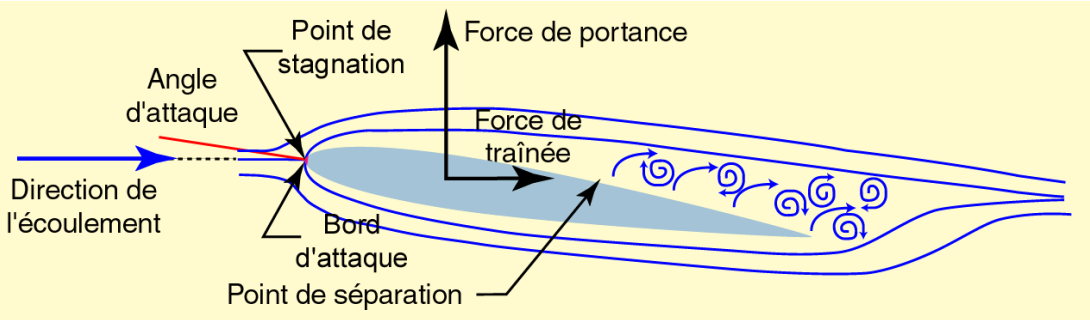
Glaze ice

Made of aluminum
or composite carbon fiber

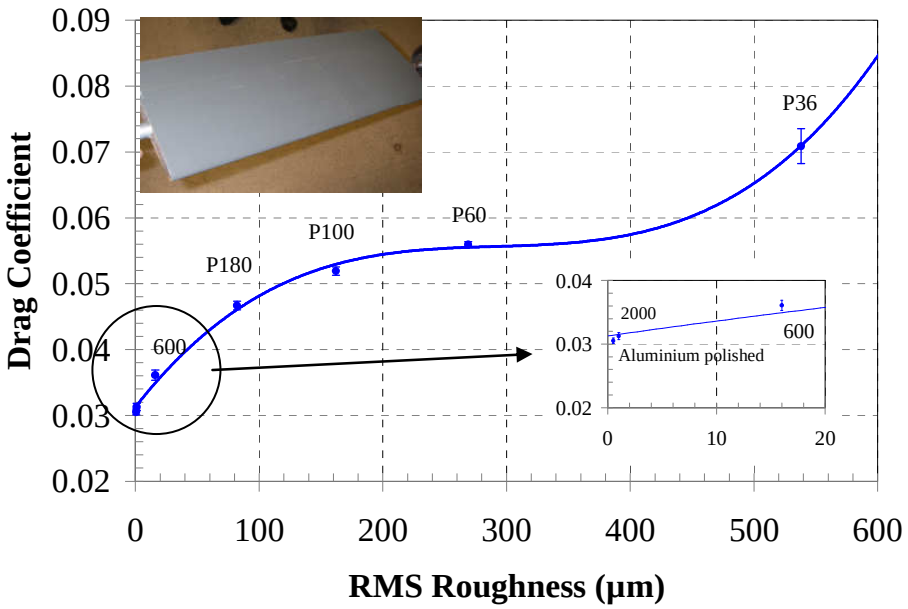


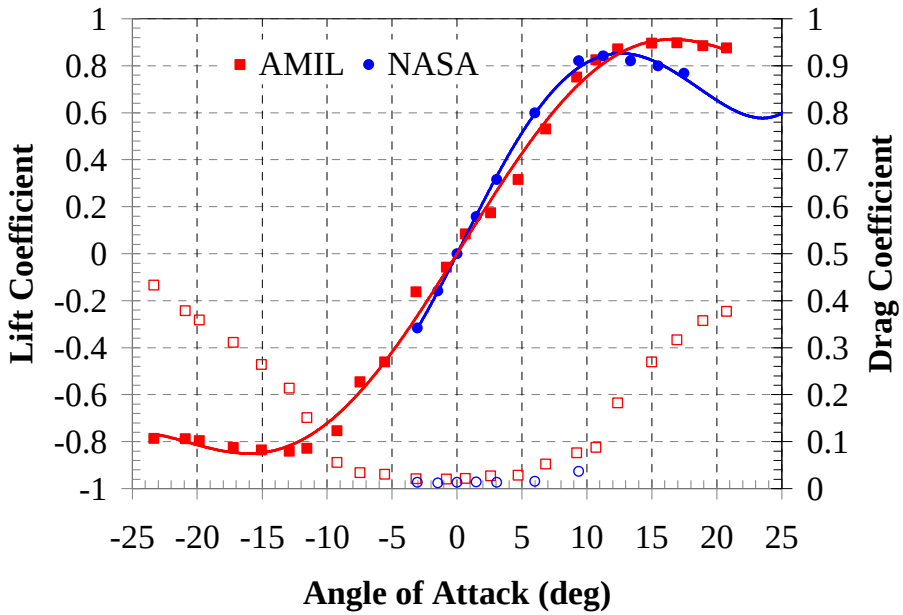
Rime ice

Effect of Coating on Drag



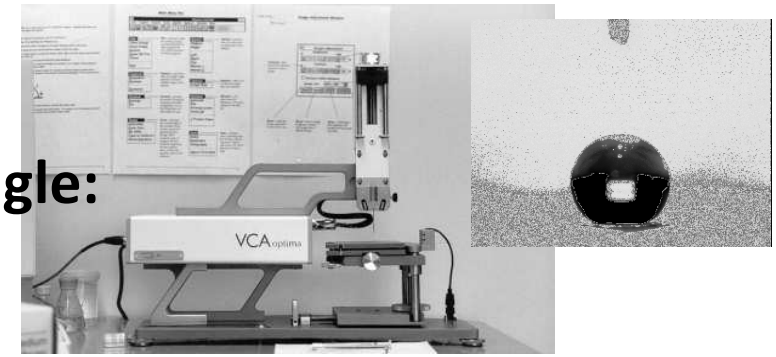
High Re = 360 000



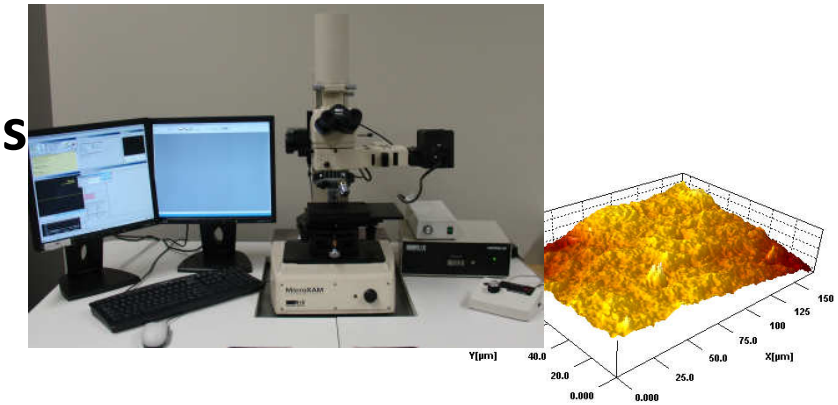


Other Tests - Characterization

Contact angle:

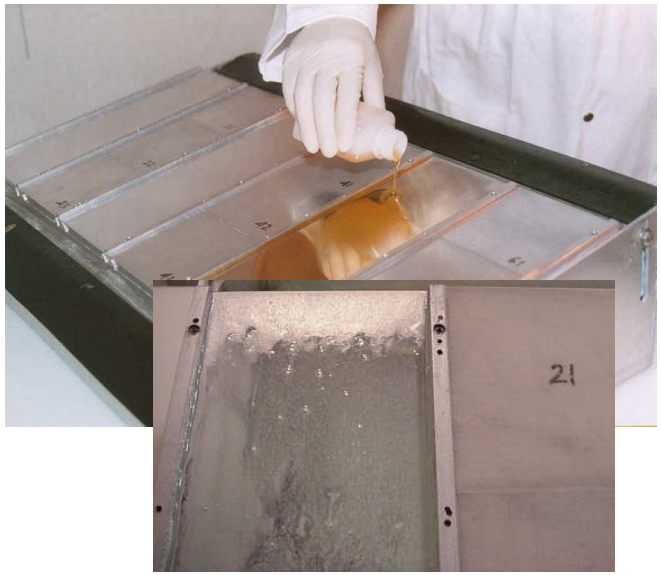


Roughness



Hardness:

Effect on fluids



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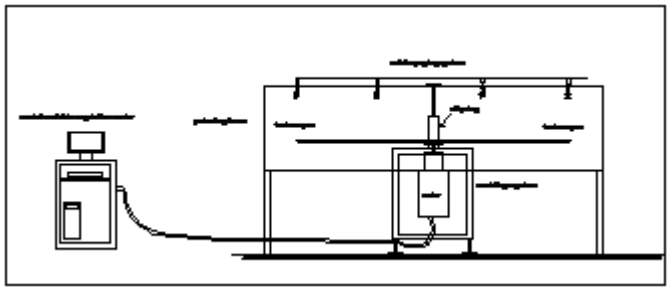
Other Tests – Will the Coating Last

Weathering and erosion testing:

(advantage of flat shape)



Summary - Icephobics

To characterize a coating:

- contact angle
- roughness
- hardness
- CAT – ice adhesion
- SAT – ice accumulation (weight)
- DAT – ice accumulation (shape)
- reduction of power to deice
- effect on lift and drag
- effect on de/anti-icing fluids

- Resistance to erosion, UV and watered environment

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