Aircraft Anti-Icing Systems

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Negative Effects of Ice Buildup

- Destroys smooth flow of air over wing, leading to severe decrease in lift and increase in drag forces
- Can change pitching moment
- As angle of attack is increased to compensate for decreased lift, more accumulation can occur on lower wing surface
- Causes damage to external equipment such as antennae and can clog inlets, and cause impact damage to fuselage and engines
- Considered a cumulative hazard because as ice builds up on the wing, it increasingly changes the flight characteristics

http://www.aopa.org/asf/publications/sa11.pdf#search=%22anti-icing%20systems%20aircraft%22
Types of Ice

- Rime: “has a rough milky white appearance and generally follows the surface closely”

- Clear/Glaze: “sometimes clear and smooth but usually contain some air pockets that result in a lumpy translucent appearance, denser, harder and more difficult to break than rime ice”

- Mixed
Ice Detection

- Electronic ice detection common, but can give false readings
- GM is developing a mass based ice detection system where ice builds up on external probe
- After mass of probe has increased due to additional ice, anti-icing systems are alerted and turned on
- This increases fuel efficiency and system life as de-icing systems are only turned on as required by conditions
Types of Ice Removal

• **Anti-Icing**
  - Preemptive, turned on before the flight enters icing conditions
  - Includes: thermal heat, prop heat, pitot heat, fuel vent heat, windshield heat, and fluid surface de-icers

• **De-Icing**
  - Reactive, used after there has been significant ice build up
  - Includes surface de-ice equipment such as boots, weeping wing systems, and heated wings
Propeller Anti-Icers

- Ice usually appears on propeller before it forms on the wing
- Can be treated with chemicals from slinger rings on the prop hub
- Graphite electric resistance heaters on leading edges of blades can also be used

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Windshield Anti-Icers

- Usually uses resistance heat to clear windshield or chemical sprays while on the ground
- Liquids used include: ethylene glycol, propylene glycol, Grade B Isopropyl alcohol, urea, sodium acetate, potassium acetate, sodium formate, and chloride salts
- Chemicals are often bad for the environment

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Thermal Heat

- **Air Heated**
  - Bleed air from engine heats inlet cowls to keep ice from forming
  - Bleed air can be ducted to wings to heat wing surface as well
  - Ice can also build up within engine, so shutoff valves need to be incorporated in design
  - Usually used to protect leading edge slat, and engine inlet cowls

- **Resistance heater**
  - Used to prevent ice from forming on pitot tubes, stall vanes, temperature probes, and drain masts
Boots

• Inflatable rubber strips that run along the leading edge of wing and tail surfaces
• When inflated, they expand knocking ice off of wing surface
• After ice has been removed, suction is applied to boots, returning them to the original shape for normal flight
• Usually used on smaller planes

• http://www.aopa.org/asf/publications/sa11.pdf#search=%22anti-icing%20systems%20aircraft%22
Weeping Wing

• Fluid is pumped through mesh screen on leading edge of wing and tail
• Chemical is distributed over wing surface, melting ice
• Can also be used on propeller blades and windshields

•http://www.aopa.org/asf/publications/sa11.pdf#search=%22anti-icing%20systems%20aircraft%22
Electro-impulse Deicing

- Electromagnetic coil under the skin induces strong eddy currents on surface
- Delivers mechanical impulses to the surface on which ice has formed
- Strong opposing forces formed between coil and skin
- Resulting acceleration sheds ice from the surface
- Can shed ice as thin as 0.05”

http://www.idiny.com/eidi.html
Typical Anti-Icing

- **C-130:**
  - Engine bleed air used for anti-icing wing and empennage leading edges, radome, and engine inlet air ducts.
  - Electrical heat provides anti-icing for propellers, windshield, and pitot tubes.

- **777:**
  - Engine bleed air used to heat engine cowl inlets. If leak is detected in Anti-Ice duct, affected engine Anti-Ice valves close.
  - Wing Anti-Ice System provides bleed air to three leading edge slats on each wing. Wing Anti-Ice is only available in flight.
References

- “Airplane Design, Pt 4.” Roskam
- www.p2pays.org/ref/07/06047.pdf
- Ice Pictures