DE-ICE AND ANTI-ICE SYSTEMS

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DEFINITIONS

• ANTI-ICE
  - PREVENTION OF THE FORMATION OF ICE

• DE-ICE
  - THE REMOVAL OF THE ICE AFTER IT HAS FORMED
TYPES OF ICE FORMATION

• **RAIN ICE**
  - Clear/glassy; severe
  i) Aircraft flying towards a shallow, sloped front. Supercooled droplets striking a sub-zero airframe
  ii) Aircraft descending from sub-zero temperatures into a rain belt

• **CLEAR ICE**
  - Translucent; moderate to severe
  Within a cloud of supercooled water droplets. Temperature 0°C to -18°C; down to -25°C if encountered in storms

• **RIME ICE**
  - Greyish-white; light to moderate
  Within a cloud of small, supercooled water droplets. Temperature 0°C to -40°C

• **HOAR FROST**
  - Small crystals; light
  Clear air when water vapour is converted to ice
EFFECT OF A BUILD-UP OF ICE

- Aerodynamic shape disrupted
- Increase in weight
- Controls/moving parts ice-up and may seize
- Loss of engine power/flame out
- Air intakes/pitot static vents blocked
- Vision obscured
PROTECTED AREAS

- Aerofoil Leading Edges
- Propellers
- Pressure (pitot) head
- Windscreens
- Engine Air Intakes
PNEUMATIC DE-ICING SYSTEM (BOOTS)

• Employed in certain types of piston-engine and turbo-prop aircraft
• System consists of;
  - Air supply
  - Air distribution system
  - Pneumatic de-icer boots
  - Controls and indications

• When switched on, pressure is admitted to the pneumatic boot (cyclically) sections to inflate the tubes. Ice breaks up and is carried away by the air flow
• Air is dumped to atmosphere via valves
• System operates on a timed cycle, with each section on for about 20 seconds, then off for about 80 seconds
• Tubes are then fully deflated by a vacuum supply
• When system off, vacuum is continually supplied and used to hold boots flat against the wing
• Susceptible to damage (made of rubber) by refuelling and bright sunlight
• **DO NOT OPERATE UNTIL AFTER ICE HAS FORMED**
TYPICAL INSTALLATION

- Electronic Cycle Timer
- Dual Vacuum/Pressure Gauge
- Group 1
- Group 2
- Solenoid Distributer Valve
Deicing system inoperative. Cells lie close to airfoil section. Ice is allowed to form.

Flexible hose

After deicer system has been put into operation; centre cell inflates, cracking ice.

When centre cell deflates, outer cells inflate. This raises the cracked ice, causing it to be blown off by air stream.
BOOTS - CROSS SECTION

- Wing skin
- Inflated tube
- Deflated tube
THERMAL ANTI-ICING SYSTEMS

• May be employed on some turbo-props, exhaust air heats ram air via a heat-exchanger and hence to ducting in skin
• Always used on modern turbo-jet civil transport aircraft
• Air from the engines is ducted through a gap formed by the outer aircraft skin and a second, inner skin
• The outer skin is heated and ice is prevented from forming
• MUST BE SWITCHED ON PRIOR TO ENTERING ICING CONDITIONS
• Air is exhausted to atmosphere through outlets in the skin
• Protected areas are leading edges and leading edge high-lift devices
• Cockpit indications of temperature, pressure and warning lights are provided
• Relies on airflow to moderate the effect of the ducted air on the skin and, therefore, should only be tested on the ground (and not actually operated)
• The airframe system is not used on take-off or landing because of the loss of engine power caused by bleed air
TURBO-PROPELLER THERMAL ANTI-ICING SYSTEM
TYPICAL HEATED LEADING EDGE

- Contour-etched outer skin
- Inner skin
- Leading edge diaphragm
- Anti-icing air duct
- Inner skin
- Front spar
- Exhaust
HEATED AREAS - TURBO-JET SYSTEM

- PI PROBE
- INLET GUIDE VANES
- INTAKE
- NOSE CAP
- INSPECTION LAMP
- TWIN-PROBE PITOT HEADS AND MASTS
- WINDSCREEN HEATING SYSTEM
- CANOPY WINDOW SYSTEM
- WINDSCREEN DEMISTING FAN
- SINGLE-PROBE PITOT HEAD
- HOT-ROD ICE DETECTOR
- AUTOMATIC ICE DETECTOR
- INCIDENT PROBES
- WINDOW HEATING SYSTEM
- WASTE WATER OUTLET (DRAIN MAST)
- BAY HEATING
- INSPECTION LAMP (L.H & R.H)
- WING FENCE LEADING EDGE
- SLATS
- STUB WING HOT AIR DUCTING
- HOT AIR DUCTING
- PERISCOPE
- FUSELAGE WINDOW SYSTEM

HEATED AREAS
FLUID DE-ICING SYSTEM
(WEEPING WING)

- Used primarily on small turbo-jets (business jet types)
- De-icing fluid (glycol) is drawn from a storage tank by electrically driven pump and fed through micro-filters to a number of porous metal distributor panels
- Panels formed to profile of the wing to which they are fitted
- As fluid escapes, it breaks the adhesion between the ice and the wing and the airflow carries it away
- Head compensating valve ensures an even distribution through all wing areas
- Limiting factor is the amount of fluid that can be carried
- OPERATE ONLY AFTER ICE HAS FORMED
WEEPING WING CUT-AWAY
Ice Detectors
ICE DETECTION DEVICES

• The following ice detection devices are in common use:
  - 'Hot rod'
  - Pressure
  - Rotary
  - Vibrating
  - Inferential
'HOT ROD' DETECTOR

- Placed in a spot on the aircraft that is visible to the pilot
- Detector represents the wing; no ice on detector = none on wing
- May incorporate a heater to remove the ice and allow further icing assessments to be made
PRESSURE DETECTOR

- Holes in leading edge of detector sense pitot pressure; those in trailing edge just static
- Leading edge holes get iced up and the pressure in the capsule changes
- As capsule expands, electrical contact puts on a light (usually blue) and maybe a case heater

- Light only goes out when pilot cancels it manually (or switches on an airframe anti-icing system)
• Rubber-mounted motor drives a rotor against a knife-edge cutter (rotating the whole flight)
• Normally a small (.05mm) gap separates them
• Ice build up blocks the gap, the cutting action of the rotor now produces a torque reaction that rotates the motor on its mounts
• This makes a micro-switch that puts on a light in the cockpit
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VIBRATING ICE DETECTOR

- Ultrasonically vibrates at a frequency of 40 kHz
- When ice forms on the probe, the frequency reduces
- Ice detector circuit detects the change in frequency and puts on a warning light (also operates a timed heater to clear the ice and return to detection mode)
- Pilot must cancel the warning light manually
INFERENTIAL ICE DETECTOR

- Two sensors; one open to the airflow and the other sheltered from the airflow
- When ice forms on the open detector, a change in temperature takes place and this change is monitored
- At a pre-set level, the detector will illuminate a light in the cockpit
- As with other systems, the pilot must cancel the light manually
PROPELLER ANTI-ICING SYSTEM

- Propeller anti-icing system is electrical
- Power usage is reduced by a cyclic timer system
- Spinner system is on all the time to prevent ice forming and entering the engine
- Propeller system breaks the adhesion of the ice and centrifugal force throws it off
- Whole system should be switched on prior to entering icing conditions
TURBO-JET (HOT AIR) ENGINE ANTI-ICING

- NOSE COWL
- INTAKE GUIDE VANES
- PRESSURE REGULATING VALVE
- NOSE CONE
- AIR INTAKE MANIFOLD
- OUTLET TO NOSE COWL
WINDSCREEN ANTI-ICING SYSTEM

- System is electrical (ac powered and dc controlled)
- Uses either gold-film or very fine heating elements between the layers of the windscreen and is permanently on whilst the aircraft is airborne (put on during taxi)
- Two settings
  - Normal uses 2φ supply
  - High uses 3φ (only used during severe icing)
- Yellow warning light (put on by overheat sensor) shows only that power has been removed by Temperature Control Unit (when up to temperature of about 40°C) and not that system has failed
- If a cb trips, beware of resetting if operating in cold ambient temperatures, as re-applying heating may shatter the windscreen
- Secondary advantage of heating the screen is to improve impact resistance as a heated screen is inherently more flexible
- There is also, normally, a blown, hot-air, windscreen demisting system fitted
WINDSCREEN ANTI-ICING SYSTEM
WINDSCREEN WIPER/WASHER SYSTEM

- Aircraft may also have a rain repellent system
- Only to be used in heavy rainfall
OTHER ANTI-ICING SYSTEMS

- Pitot heads, angle of attack indicators and domestic drains are all anti-iced by the use of electrical heaters
- Heaters are permanently on when the aircraft is airborne and may be set to reduced levels by wheels-on micro-switches
- Ice inspection lights may also be fitted to various parts of the aircraft to enable them to be inspected at night when in icing conditions
- Typically they are fitted in places that illuminate such items as engine intakes and the mainplane leading edges
ICE INSPECTION LIGHT