G650 ICE & RAIN PROTECTION SYSTEM
The ICE x RAIN PROTECTION system is about detection, prevention, or removal of ice formation on:

- **Bleed Air Heat**
  - Engine cowls inlets
  - Wing leading edges

- **Electrical Heat**
  - Air data probes
  - Total air temperature probes
  - Windshields/cabin windows
  - EVS windshield
Icing Conditions

- Icing conditions exist when the Static Air Temperature (SAT) on the ground or inflight is between +10°C and -40°C and visible moisture in any form is present, such as:
  - Rain
  - Snow
  - Clouds
  - fog w/visibility < 1SM
  - Sleet
  - Ice crystals

- Icing conditions also exist when the SAT on the ground and for takeoff is +10°C or below when operating on ramps, taxiways or runways where:
  - Surface snow
  - Ice
  - Standing water
  - Slush

May be ingested by the engines, or freeze on the engines, nacelles or engine probes.
Ice Detection System

- The Ice Detection System consists of two (2) exterior probes located on both sides of the fuselage just below the pilot's and copilot's windows.

![Diagram of an airplane with probes]

- Ice detector probes vibrate at a frequency of \(40,000\) Hz. Ice thickness affects the resonate properties of the probes. Activation of the system occurs when probes accumulate \(>0.020\) inches of ice formation. This decreases the probe's frequency by approximately \(130\) Hz.

- When this happens, the crew is notified of the presence of ice via a CAS message:

  ICE DETECTED
- If the wing and cowl anti-ice system are in AUTO, the wing and cowl anti-ice valves open automatically and allow HOT engine bleed air to heat the wing leading edges and engine cowl inlets.

![Diagram showing wing anti-ice valves and cowl anti-ice valves with auto mode options.](Diagram Image)
- The crew is then notified via CAS messages:

- L-R Wing Anti-ice ON
- L-R Cowl Anti-ice ON

- The probes are then heated to melt the ice formation and allow its vibration frequency to return to normal speed - ready to continue detecting more icing. The process continues until there is no more icing.

- When ice is no longer detected by

1. ICE DETECTED extinguishes > ONE (1) minute
2. Cowl Anti-ice valves close > THREE (3) minutes and L-R Cowl Anti-ice ON extinguishes
3. Wing Anti-ice valves close > FIVE (5) minutes and L-R Wing Anti-ice ON extinguishes

- Left = L MAIN AC
- Right = R MAIN AC
Prior to entering icing conditions, or when icing is detected by the ice detection system, the crew should select wing and cowl anti-ice systems **ON**.

- **L Wing**
- **L Cowl**
- **R Cowl**
- **R Wing**

**Holding in icing conditions:**

1. **180 KCAS Minimum**
2. **flaps 0° (UP)**

Use of flaps in icing conditions restricted to:

- **Takeoff**
- **Approach**
- **Landing**
**Wing Anti-Ice System (WAIS)**

- Protects wing leading edges from ice accumulation

- Uses **hot** engine bleed air to heat up its onside wing leading edge

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- The two (2) bleed air controllers (BAC) control and regulate the use of hot engine bleed air

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[Diagram showing the WAIS system with engine bleed air and bleed air controllers (BAC) for left and right wings.]
In case of engine failure, a crossover duct allows bleed air from the operating engine to heat the inoperative side's wing leading edges.

Bleed air supply for WAIS is extracted from:

- Mid stage bleed port
- High stage bleed valve

During climb and cruise, the 5th stage provides adequate bleed air pressure and temperature for wing anti-ice.
At low power settings, such as on descent, bleed air is extracted from the 8th stage.

- The wing anti-ice valves are spring-loaded close, pneumatically actuated variable pressure regulator and shut-off valves.

- The WAIS heats the leading edges to $130^\circ F \pm 10^\circ$ by modulating the anti-ice valves.

- Wing anti-ice valves fail **CLOSED**.

- The WAIS, when required, should be selected on at least two (2) minutes before takeoff. That's how long it takes for a fault to be announced via a CAS message.

  **Wing Temp Low**  **Wing Overheat**
When the WAIS is selected on the command:

1️⃣ Fan air valves to modulate **OPEN**

![Diagram of fan air valves and temperature settings]

**Outlet Temperature**

- **1st**
  - **Outlet Temperature**: 400°F
  - **Outlet Temperature**: 500°F
  - Single bleed/wing anti-ice

**Inlet Temperature**: 630°F

2️⃣ High-stage valves (8th) to **OPEN** if Mid-stage (5th) is insufficient

- Wing anti-ice usage is limited to **41,000′** during single ECS pack operations

- Wing anti-ice usage above **41,000′** requires a minimum speed of **M0.85** in order to prevent an ECS pack over temperature condition
WAIS SELECTED ON

> 2 minutes; Temperature < 100°F

WAIS SELECTED ON AND
Temperature ≥ 180°F

94°F

Wing Temp Low

105°F

OR

Wing Overheat

OFF AUTO ON

OFF AUTO ON

L-R Wing Anti-ice ON

L-R Cowl Anti-ice ON

130°F

130°F
Cowl Anti-ice System (CAIS)

- Protects engine cowl inlets from ice accumulation
- Uses hot engine bleed air to heat up its inside engine cowl inlet

Engine cowl inlets
CAIS selected on

- Bleed air supply for CAIS is extracted from:

Mid stage bleed port
5th stage HP

HP compressor section
- Cowl anti-ice valves are electropneumatic. They require power and pneumatic pressure to close.

- Cowl anti-ice valves fail in the OPEN position.

- Cowl anti-ice status is indicated in pressure (PSI) instead of temperature because engine bleed air is not modulated by the cowl anti-ice valves. Pressure varies based on engine power.

- Diagram showing the cowl anti-ice valve in the open and closed position.
ECS/PRESSURIZATION synoptic page

CAIS selected OFF

Normal pressure is between 1.6 - 33 psi

CAIS selected ON

L-R Cowl Anti-ice ON

OR
- Abnormal pressure is: < 1.6 → > 33 psi

- Miscompare between L and R pressures

- Engine spinner = passive de-icing
  Tip is made of rubber which distorts and sheds ice
The WAIS and CAIS can be activated:

1. Manually by the crew (no altitude restriction)
   - L Wing
   - L Cowl
   - R Cowl
   - R Wing

2. Automatically when ice is detected by the ice detection system from the ground up to 35,000'
   - L Wing
   - L Cowl
   - R Cowl
   - R Wing

   Ice Detected
   - L-R Wing Anti-ice ON
   - L-R Cowl Anti-ice ON
- **Automatic activation of the WAIS is inhibited above 35,000**, but if WAIS and CAIS are already activated they remain on.

- **ICE DETECTED** CAS is inhibited on the ground because all **AMBER** CAS messages are considered "No Go" messages.

- BR-715 Engine: if OAT < 10°C the use of WAIS and CAIS will not result in a decrease in takeoff thrust. FADEC maintains EPR even if automatic activation of anti-ice systems occur during takeoff and takeoff climb segments.

- Cowl and wing anti-ice switches must remain off during engine start. The AUTO function does not inhibit activation on the ground and, if activated during engine start, it would divert bleed air away and result in a hot start.

![Switches Diagram](image-url)
Air Data Probes
and
Total Air Temperature (TAT) Probes

- Probes are electrically-heated to prevent ice formation

- Probe heaters are turned on after engine start

- Below 60Kts Air Data Probes are heated to 150°C
- Above 60Kts Air Data Probes are heated to 300°C

- TAT probes are only heated above 60Kts or when both throttles are advanced above 30°
Air Data Probes

and

flight controls

After selecting **anti-ice heaters to ON** wait five (5) seconds before moving the flight control surfaces to prevent **FCC1**  **FCC2** from reverting to **FCC DIRECT** mode.

+ 5 seconds =

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Windshield and Windows

- Windshield HEAT cycles ON and OFF to ensure a window temperature between 104° to 114° F
- Cabin windows are heated with WOW-Air mode

- EVS windshield heat
  - Manual: Two (2) minutes on
  - Automatic:
    - WOW Air and CAIS on:
      - L Cowl
      - R Cowl
    - One (1) minute on
    - Seven (7) minutes off
- Gear down:
  - Continuously on
Questions, comments or errors?

ivan.luciani@gmail.com

Thank you!