CL-350

CL-350 TRAINING MANUAL

ICE & RAIN PROTECTION | 09

AIRCRAFT SYSTEMS

TRAINING MANUAL

LOFT.AERO

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ICE AND RAIN PROTECTION

The Challenger 350 ice and rain protection system provides comprehensive protection against ice formation on critical aircraft surfaces during flight and ground operations. The system utilizes engine bleed air to heat wing leading edges and engine nacelles, while electrical heating protects air data probes, windshields, and windows, ensuring safe operation in all weather conditions.

I. INTRODUCTION

A. ICE PROTECTION SYSTEM OVERVIEW

- Wing leading edges heated with high-pressure engine bleed air
- Engine nacelle inlets protected with bleed air anti-icing
- Air data probes and sensors heated electrically
- Windshields and side windows heated with embedded electrical elements
- Two ice detectors provide automatic ice detection
- Anti-icing of tail surfaces not required
- Controlled by Integrated Air System Controllers (IASC)
- Monitored via ANTI-ICE synoptic display

Ice Protection System Specifications

Parameter	Value
Ice Detection System	Two vibrating probe detectors
Wing Anti-Ice Source	High-pressure engine bleed air
Engine Anti-Ice Source	Engine bleed air
Probe/Window Heating	28 VDC electrical power
Control System	Dual-channel IASC
Leak Detection Zones	Eight total - Four zones with dual loops, Four zones with single loops
Wing Temperature Sensors	Dual sensors per wing section
Windshield Heater Sections	Three sections per windshield

II. ICE DETECTION SYSTEM

The Challenger 350 aircraft is equipped with an ice detection system that uses two detectors, positioned on each side of the fuselage just above the nose landing gear doors. Each detector contains a vibrating probe that detects the presence of icing conditions; when ice collects on the probe, its vibration frequency decreases, prompting internal thermal heaters to de-ice it. This cycle of detection and de-icing allows the system to continuously monitor for ice.

While two detectors provide redundancy, a signal from just one is sufficient to generate a CAS message. When ice is detected and the anti-ice systems are not yet active, an **ICE DETECTED** (C) message is displayed on the EICAS, accompanied by an amber **ICE icon** on the Primary Flight Display (PFD). If the anti-ice systems are already selected on, an **ICE DETECTED** (A) message is shown.

A failure of both ice detectors results in an **ICE DETECTOR FAIL** (C), while the failure of a single detector generates an **ICE DETECTOR FAULT** (A), indicating the other detector remains operational. Pilots can also perform a test, with a successful outcome indicated by the **PROBE HEAT TEST OK** (S) status message and the momentary display of the **ICE DETECTED** (C) message with an ICE icon. In conditions where ice is detected or observed, the wing and engine anti-icing systems must be activated.

A. SYSTEM DESCRIPTION

- Two ice detectors mounted above nose landing gear doors
- Vibrating probe technology for ice detection
- System redundancy with dual detectors
- Only one detector signal needed for EICAS message
- Supplied with 28 VDC power
- Continuous internal monitoring for failure conditions

Ice Detector

B. COMPONENTS AND OPERATION

Ice Detector Operation:

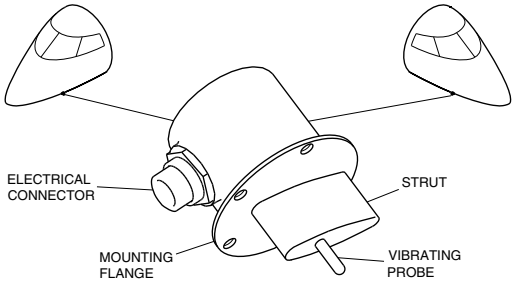
- Probes vibrate at high frequency
- Ice accumulation decreases vibration frequency
- Internal thermal heaters de-ice strut and probe
- Ice shedding restores normal vibration frequency
- Heating cycle repeats as ice accumulates
- Continuous reassessment of icing conditions

Ice Detection Indications:

- Amber ICE icon displayed on PFD (anti-ice systems off)
- **ICE DETECTED** (C) message (anti-ice systems off)
- **ICE DETECTED** (A) message (anti-ice systems on)

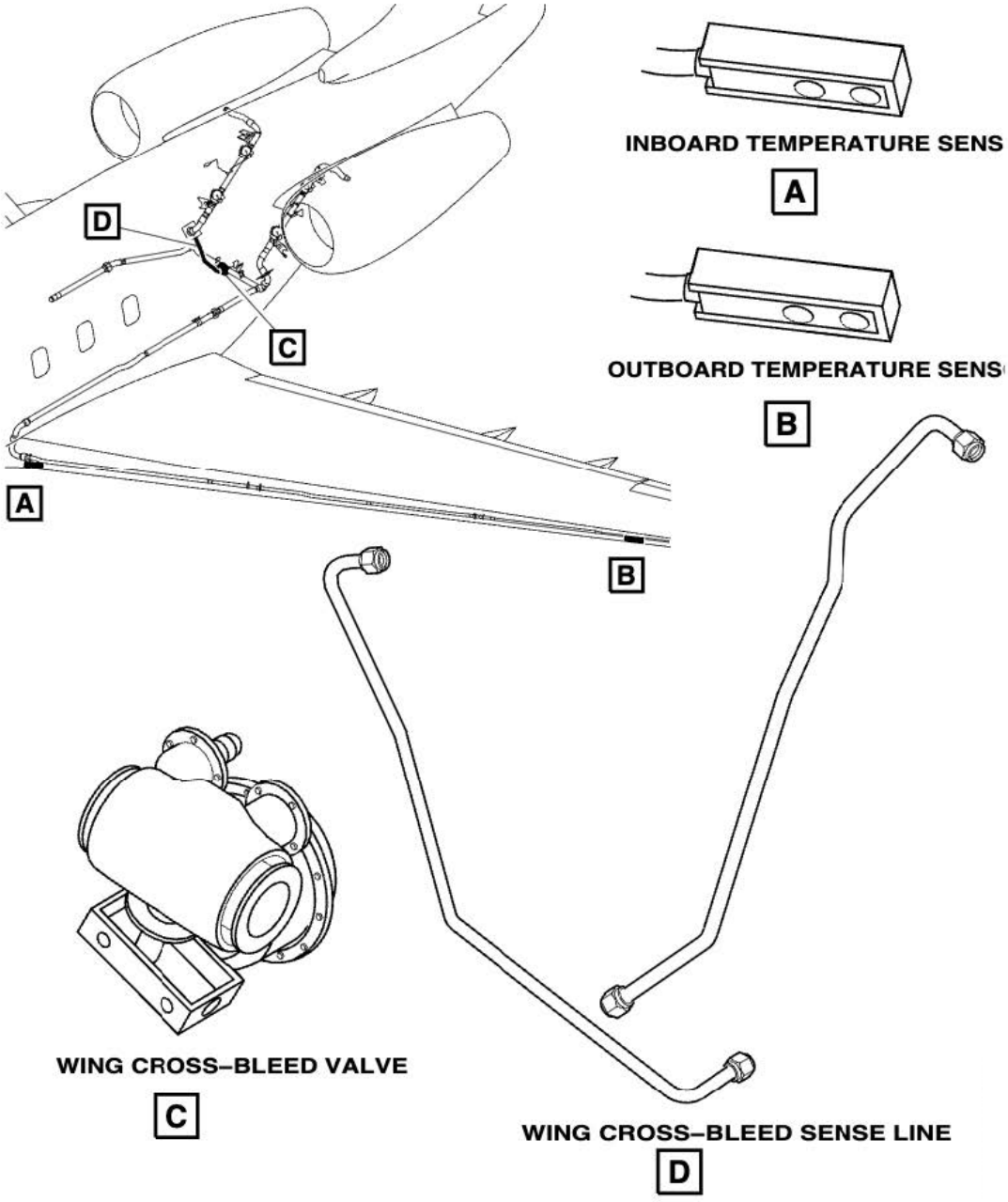
Failure Indications:

- **ICE DETECTOR FAIL** (C) - both detectors failed
- **ICE DETECTOR FAULT** (A) - one detector failed



C. ICE DETECTOR TEST

- Test capability via SYSTEMS TEST panel
- Select ICE DET and push test switch
- Internal check of electronics performed
- Probe heater functionality tested
- CAS message verification included



III. WING ANTI-ICE SYSTEM

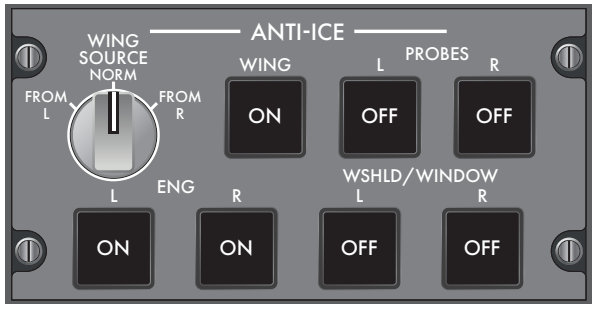
The wing anti-ice system is designed to heat the leading edge of the wing using high-pressure bleed-air from the aircraft's engines to prevent ice accumulation. It is controlled via a WING push button switch and a WING SOURCE rotary switch located on the ANTI-ICE control panel. While each wing is typically heated by its corresponding engine, the system allows for either engine to supply bleed-air to both wings.

The system's operation and leak detection are managed by two dual-channel Integrated Air System Controllers (IASC). These controllers utilize data from dual-temperature sensors, positioned in both the inboard and outboard sections of each leading edge, to precisely regulate the bleed-air supply and ensure the leading edges maintain the appropriate temperature range.

A. SYSTEM DESCRIPTION

- Heats wing leading edges with high-pressure engine bleed air
- Left and right wings normally heated by respective engines
- Capability to supply bleed air from either engine to both wings
- WING push button switch operates the system
- WING SOURCE rotary switch selects bleed air source
- Anti-ice ducting continuously monitored for leakage

B. WING SOURCE SELECTION



NORM Position:

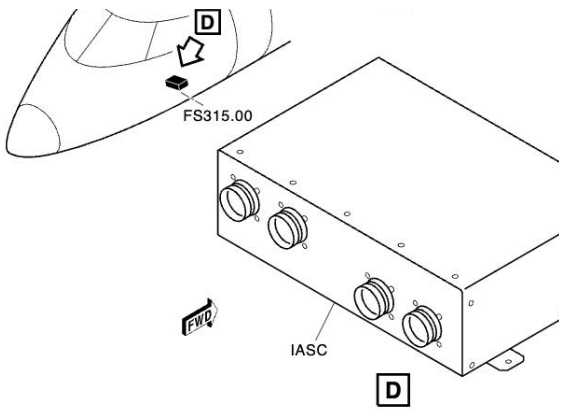
- Left wing heated by left engine
- Right wing heated by right engine
- Normal operational mode

FROM L Position:

- Both wings heated by left engine bleed air
- Right wing anti-ice and high-pressure valves closed
- Crossbleed valve opens

FROM R Position:

- Both wings heated by right engine bleed air
- Left wing anti-ice and high-pressure valves closed
- Crossbleed valve opens



C. INTEGRATED AIR SYSTEM CONTROLLER (IASC)

- Two dual-channel controllers control wing anti-ice operat
- Control leak detection systems
- Receive data from dual temperature sensors
- Located in inboard and outboard sections of each leading
- Independently control bleed air amount to each wing
- Maintain leading edges in correct temperature range

D. BLEED LEAK DETECTION SYSTEM

The bleed leak detection system is a fully automatic system, controlled by Integrated Air System Controllers (IASC), designed to monitor bleed air and anti-ice ducts for leakage. Its primary function is to protect aircraft components and structure from overheating and fire hazards.

The system is divided into eight distinct zones for EICAS presentation, including the left and right bleed ducts, wing anti-ice ducts, pylon ducts, pack ducts, and trim air ducts. Detection is achieved through single loops for areas like the main bleed and trim air ducts, and dual-sensing loops for critical areas such as engine pylons and wing leading edges. The use of dual-sensing loops helps minimize false leak indications and allows for dispatch under certain conditions even if one loop is inoperative.

System Purpose:

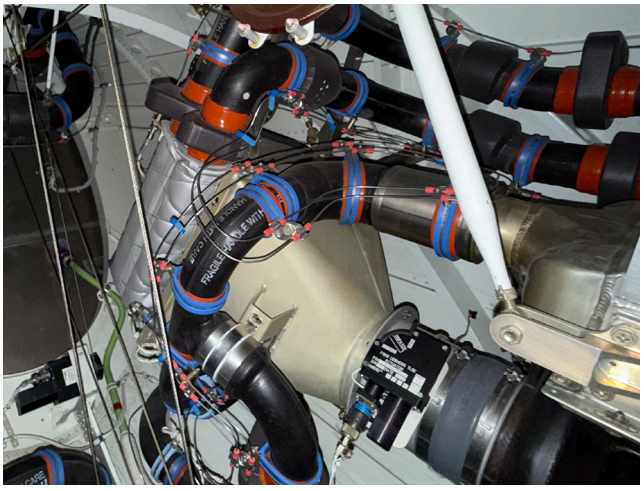
- Detect hot air leaks from bleed system
- Protect components and structure from overheating
- Prevent fire hazards

Detection Zones:

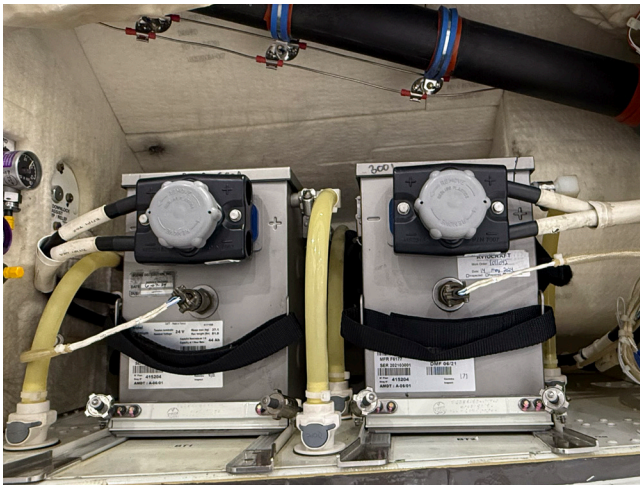
- Right pylon dual loops (powerplant to right IPV and HPV)
- Left pylon dual loops (powerplant to left IPV and HPV)
- Right anti-ice ducting dual loops (downstream of right HPV)
- Left anti-ice ducting dual loops (downstream of left HPV)

Leak Detection Operation:

- Pylon zone leak: **L (R) PYLON BLEED LEAK** (W) message
- Downstream leak: **WING ANTI-ICE LEAK** (W) message
- Automatic valve closure isolates downstream failures
- **L (R) WING ANTI-ICE FAIL** (C) message after isolation



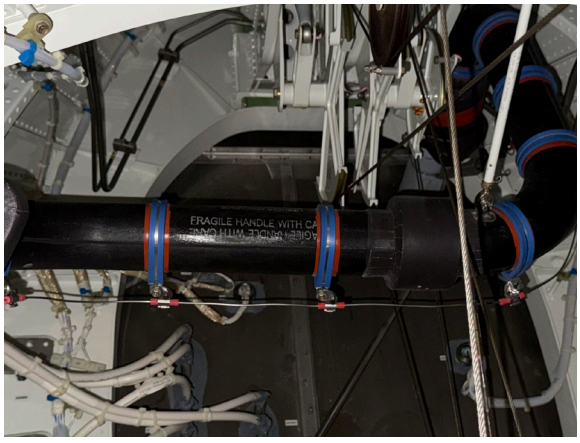
PACK Dual Bleed Loop



Battery Dual Bleed Loop

E. WING TEMPERATURE SENSORS

- Dual temperature sensors provide feedback to IASC
- Two dual sensors in outboard section of each wing
- Two dual sensors in inboard section of each wing
- Channel B of each IASC receives data from one sensor per position
- Outboard sensors monitor for insufficient temperature
- Inboard sensors modulate wing anti-icing valves
- Overheat monitoring with **L (R) WING OVHT** (W) message



APU Single Bleed Loop

F. WING ANTI-ICE VALVES

Valve Operation:

- Located on bleed air manifold in aft equipment bay
- Modulate based on wing temperature when WING switch ON
- Spring-loaded to closed position

Valve Closure Conditions:

- Bleed air supply pressure removed
- Loss of electrical power at valve
- Anti-ice duct failure detected by IASC
- System operated in FROM L or FROM R mode

High Pressure Valves:

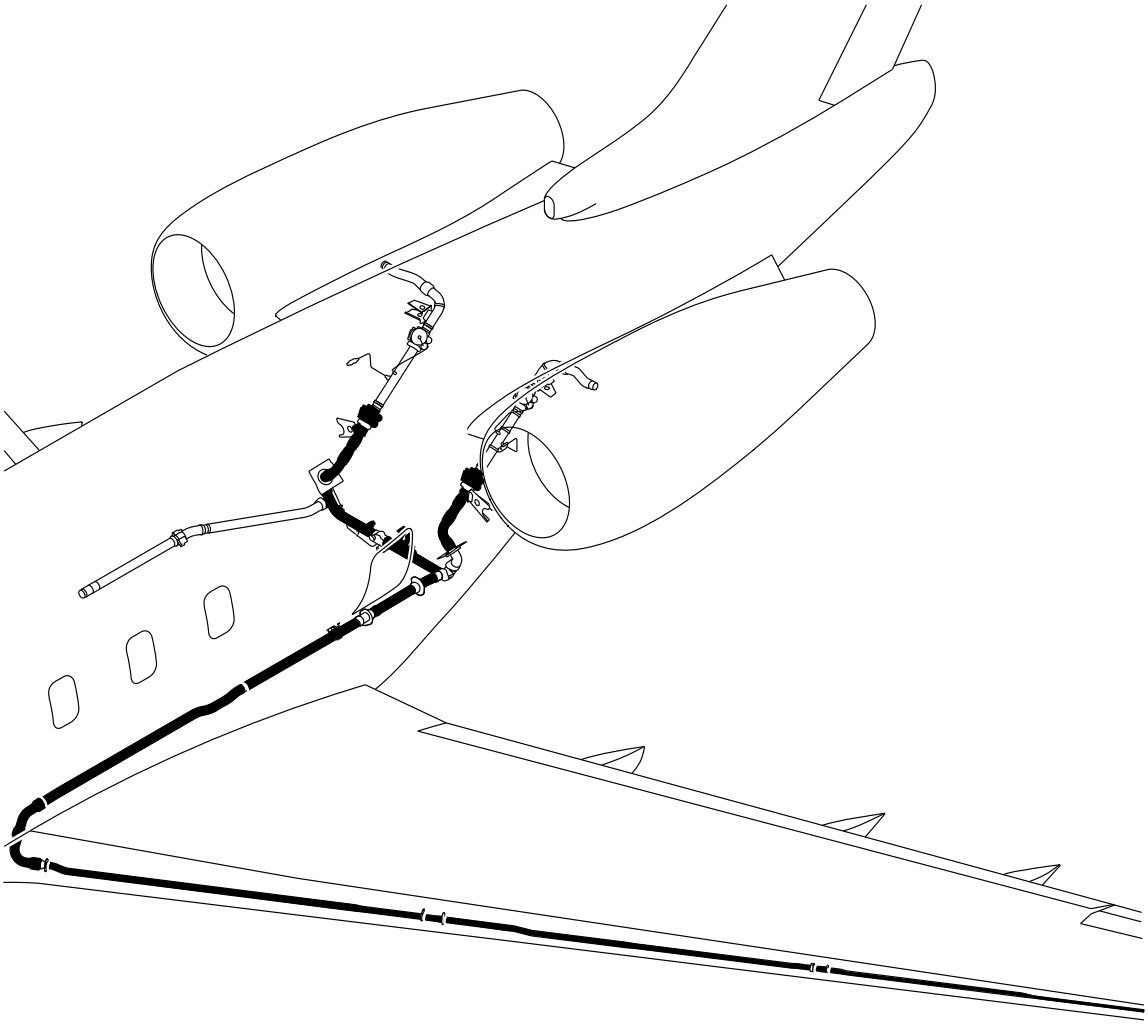
- Limit high stage engine bleed pressure to 36 ±3 psi
- Valve failure with pressure exceeding 46 psi triggers warning
- **L (R) WING A/I PRESS HI** (C) message displayed

G. WING ANTI-ICE DUCTS

- Aft equipment bay and center fuselage ducts supply wings
- Hot air enters wing via piccolo tubes in leading edges
- Piccolo ducts spray hot bleed air onto inner leading-edge surfaces
- Air dissipated through vent holes on bottom wing surface
- Dual sensing loops and temperature sensors monitor ducts
- Discrimination between leak overheat and normal anti-ice temperatures

H. WING OVERHEAT CONDITIONS

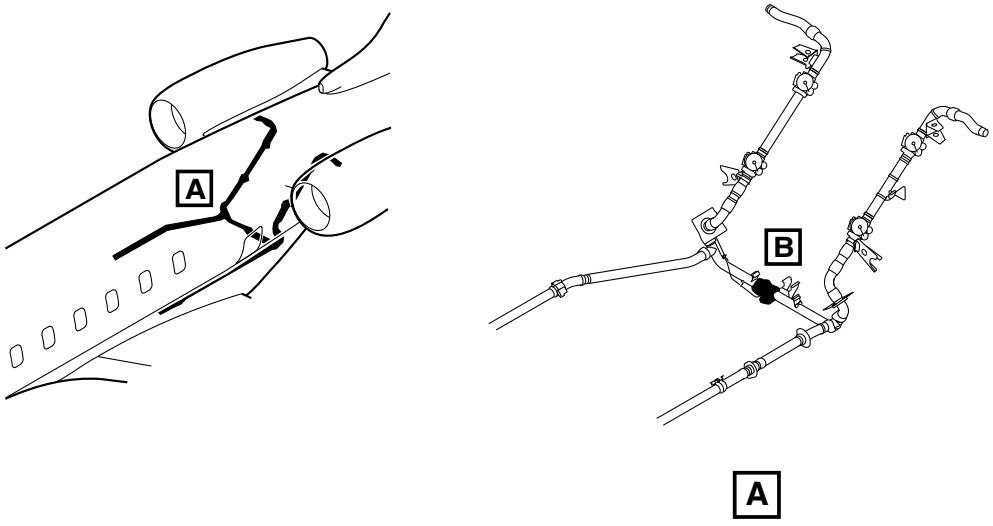
- Overheat Response:
- **L (R) WING OVERHEAT** (W) message illuminates
- Pilot shuts off wing anti-ice system
- Select FROM L or FROM R position
- Select system ON
- Bleed flow modulated by sensor on bleed source side
- Overheated leading edge identified in red on synoptic

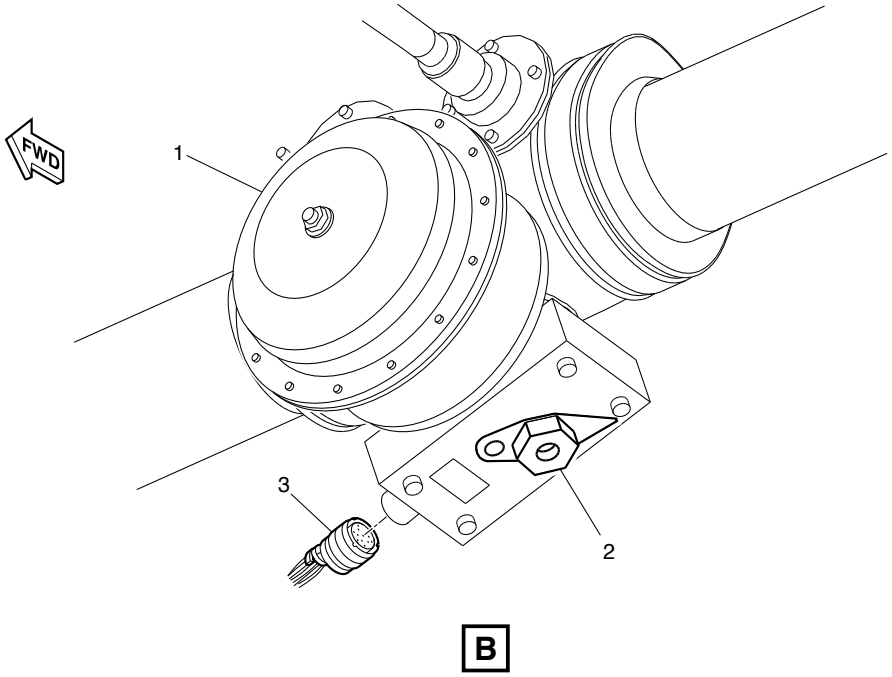


Wing Anti-Ice Ducts

I. WING ISOLATION VALVE

- Crossbleed duct bridges two anti-ice lines
- Pneumatically actuated, electrically controlled
- Normally closed in normal operation
- Automatic opening during engine failure
- Controlled from ANTI-ICE WING SOURCE switch



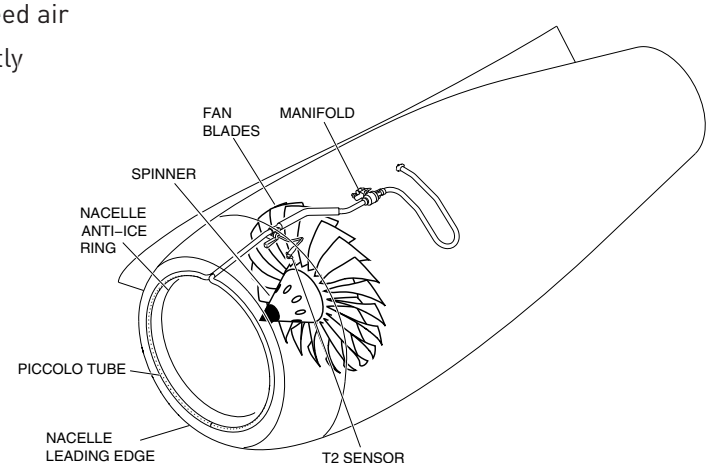


Wing Isolation / Cross-Bleed Valve

IV. ENGINE ANTI-ICE SYSTEM

A. SYSTEM DESCRIPTION

- Engine nacelle inlets anti-iced with engine bleed air
- Left and right systems controlled independently
- L (R) ENG switches on ANTI-ICE control panel
- Located on center pedestal



B. NACELLE ANTI-ICING VALVES

- Located on top of each engine downstream of high-pressure duct
- Electrically operated and pneumatically controlled
- Fail safe open feature incorporated
- Direct hot bleed air to piccolo tube

C. ENGINE NACELLE DUCTING

Air Flow Path:

- Hot bleed air directed to piccolo tube
- Sprayed onto inner surface of nacelle leading edge
- Air discharged overboard through exhaust duct
- Exhaust duct located at bottom of nacelle inlet

D. T2 SENSOR

Sensor Function:

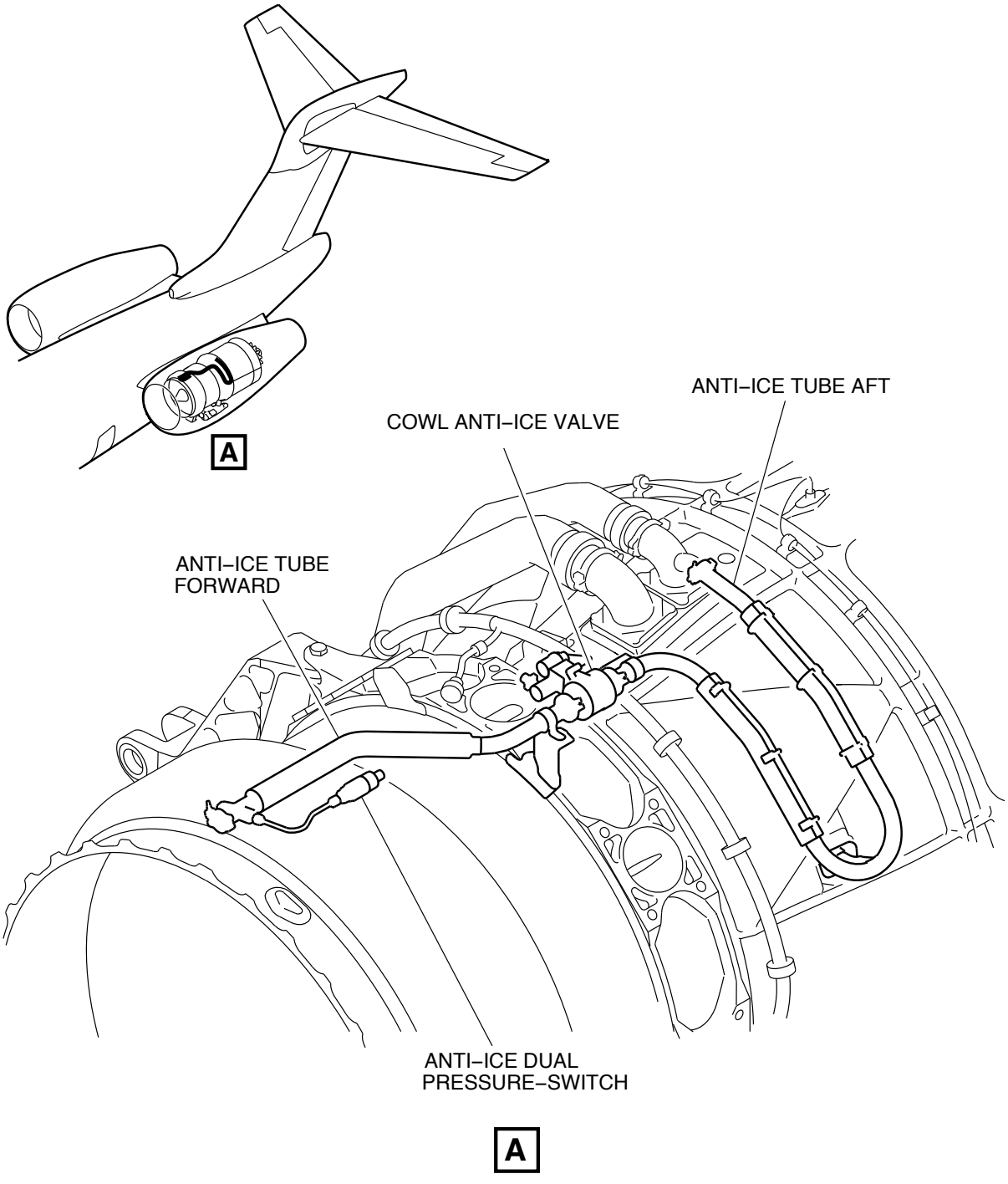
- Installed in inlet housing of each engine
- Senses engine inlet total air temperature (TAT)
- Supplies inlet TAT data to electronic control units (ECU)
- In-control ECU uses TAT data for power control

Sensor Components:

- Two resistance temperature devices
- Heat device for anti-ice protection
- Anti-ice function controlled from L (R) ENG switches

E. ENGINE SPINNER

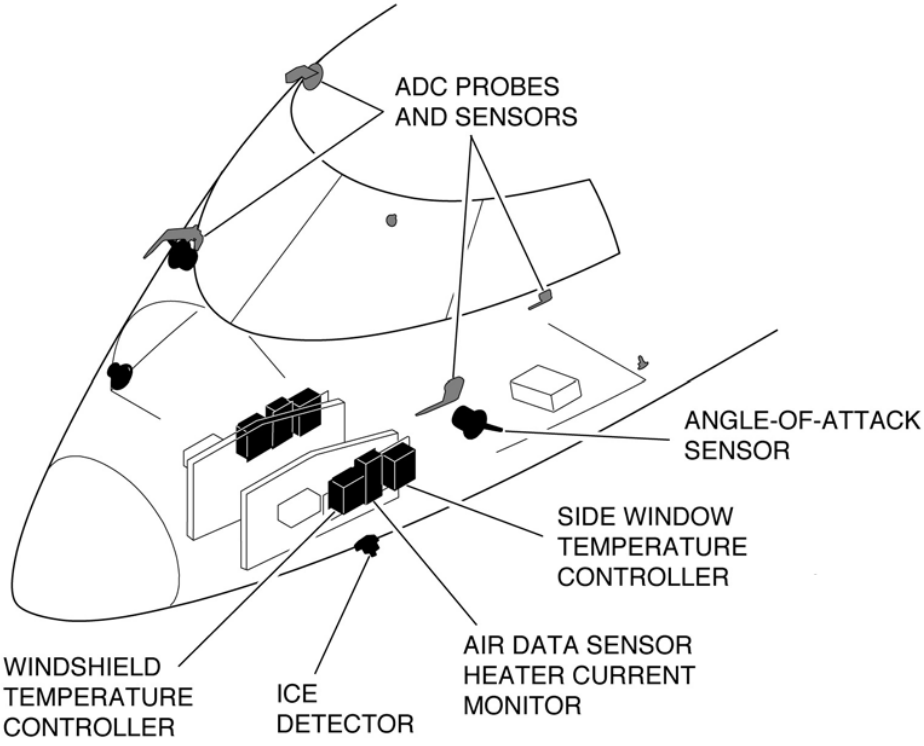
- Two-piece aluminum forging with conical shape
- Provides surface that sheds ice naturally
- Operates without anti-icing heating requirement



V. AIR DATA AND ANTI-ICE SENSORS

A. SYSTEM DESCRIPTION

- Air data probes and sensors located on aircraft nose sides
- Electrically heated to prevent ice formation
- Separate air data sensor heat controllers
- Control and monitoring of probe heaters
- L (R) PROBES switches on ANTI-ICE control panel



B. HEATED COMPONENTS

When PROBES Switch Selected ON:

- Left and right standby static ports
- Left and right AOA sensors
- Left and right pitot-static probes
- TAT probe
- Standby pitot probe
- Failure signals DCU for appropriate EICAS message

Pitot Static Probe

C. PITOT STATIC PROBES

- Two pitot static masts (one per aircraft side)
- Each mast consists of head and mounting base
- Two heaters per mast (head and base)

D. STANDBY PITOT PROBE

- One standby pitot probe on left side of aircraft nose

E. STANDBY STATIC PORTS

- One flush static port located on each aircraft side

F. ANGLE-OF-ATTACK VANES (AOA)

- Located on each aircraft side under side windows
- Positioned behind pitot tubes
- Heated when activated by PROBES switch

G. TOTAL AIR TEMPERATURE PROBE (TAT)

- One TAT sensor on right side of aircraft
- TAT heater operates in flight only

VI. WINDSHIELD ICE AND RAIN PROTECTION

A. SYSTEM DESCRIPTION

- Windshield and side window heating system
- Two windshields and two side windows included
- Embedded heater elements and sensor elements
- Rain resistant coating treatment applied

B. WINDSHIELD AND SIDE WINDOW HEATING

Heater Element Configuration:

- Windshield heater elements segmented into three sections
- Concentration of heating in smaller windshield area
- Visibility maintenance in severe icing conditions
- Side window heater elements without segmentation

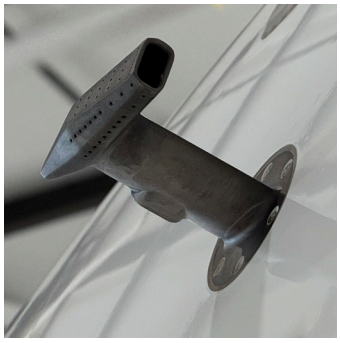
Temperature Control:

- Temperature controllers (one per windshield and window)
- Monitor electrical resistance of embedded temperature sensors
- Cycle power on and off to maintain predetermined temperature
- Super-cooled large droplet icing (SLD) indication possible

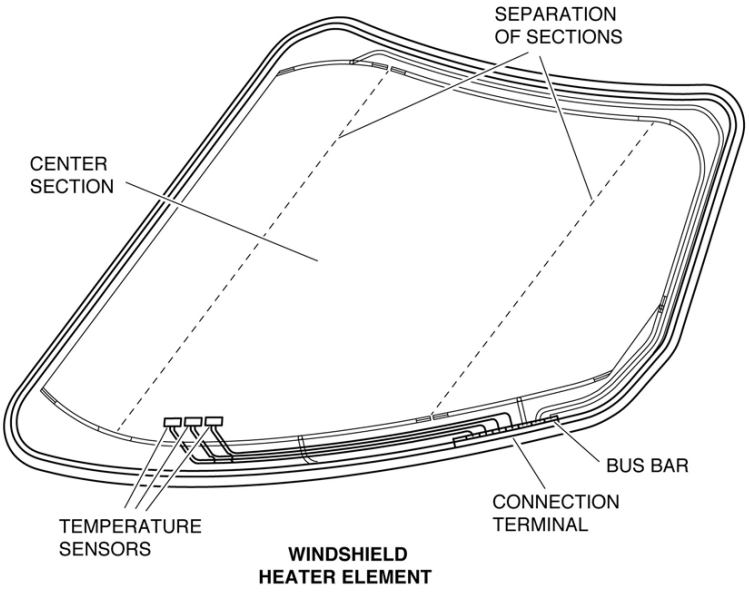
Standby Pitot Tube

Standby Static Port

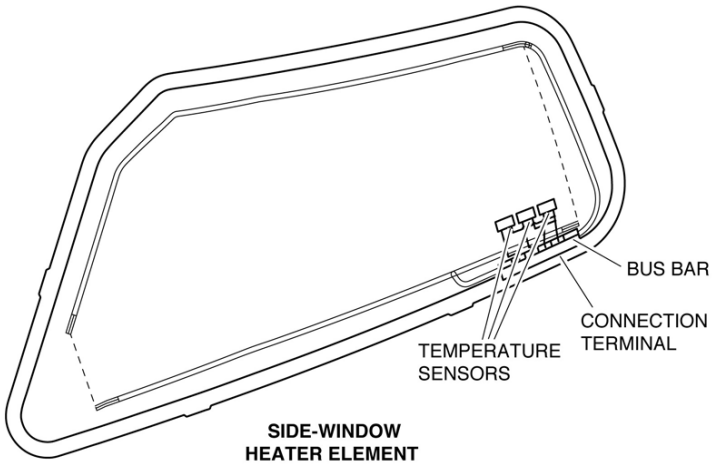
AOA Vane



TAT Probe



WINDSHIELD HEATER ELEMENT

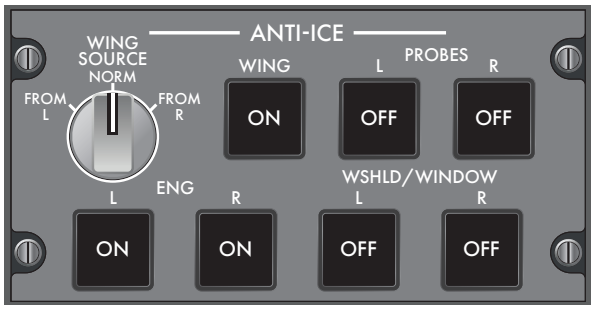


SIDE-WINDOW HEATER ELEMENT

C. CONTROL SWITCHES AND FUNCTION

Switch Operation:

- L WSHLD/WINDOW switch controls left windshield and window
- R WSHLD/WINDOW switch controls right windshield and window
- Switches located on ANTI-ICE panel



Overheat Protection:

- Overheat protection circuits for each surface
- Power removal during overheat condition
- L (R) WSHLD/WINDOW off position de-energizes surface
- Temperature controller reset capability

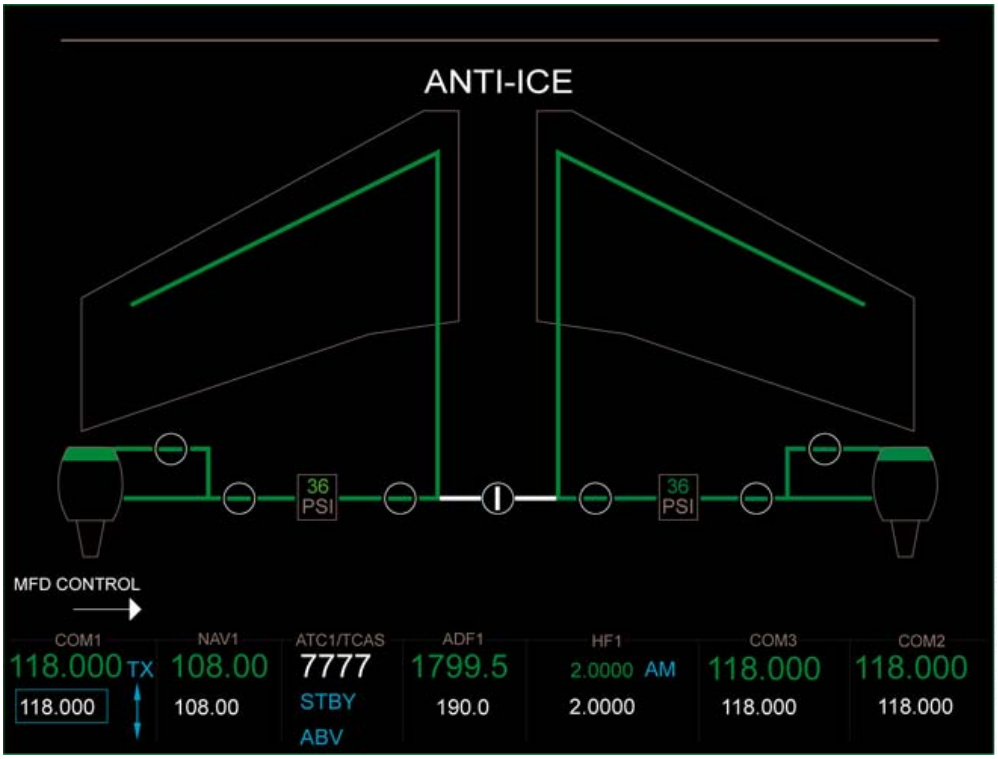
VII. CONTROLS AND INDICATIONS

A. ANTI-ICE CONTROL PANEL

- Located on center pedestal
- Controls operation of anti-ice systems
- WING push button switch
- WING SOURCE rotary switch (FROM L, NORM, FROM R)
- L (R) ENG push button switches
- L (R) PROBES switches
- L (R) WSHLD/WINDOW switches

B. ANTI-ICE SYNOPTIC PAGE

- Monitors pneumatically operated anti-icing systems
- Ice detection system display
- Anti-ice system operation and fault presentation
- Visual confirmation of system status



VIII. EICAS MESSAGES

A. WARNING MESSAGES

WARNING MESSAGES

Immediate crew action required

Message	Meaning	Inhibits
WING ANTI–ICE LEAK	A leak has been detected from the wing anti–ice ducting	TO/LAND
L (R) WING OVERHEAT	A wing anti–ice overheat condition exists in the indicated wing	—

B. CAUTION MESSAGES

CAUTION MESSAGES

Timely crew awareness/action needed

Message	Meaning	Inhibits
L (R) AOA VANE HEAT FAIL	The respective angle–of–attack vane heater has failed	TO/LAND
L (R) ENG ANTI–ICE FAIL	Bleed air pressure to the respective nacelle is too low for effective anti–icing, or the electrically heated T2 heater has failed when the respective L or R ENG switch is ON	TO/LAND
ICE DETECTED	Ice has been detected, and both the engine and wing anti–ice systems are not selected on	TO/LAND
ICE DETECTOR FAIL	Both ice detectors have failed	TO/LAND
L (R) PITOT HEAT FAIL	The respective pilot mast or base heater has failed	TO/LAND
L (R) PROBE HEAT OFF	Probe heat is off	TO/LAND
STBY PITOT HEAT FAIL	The standby pitot heater has failed	TO/LAND
L (R) STBY STAT HT FAIL	The respective standby static heater has failed	TO/LAND
L (R) WING A/I LOW TEMP	Indicates that the respective wing has an anti-ice low temperature condition	TO/LAND
L (R) WING ANTI-ICE FAIL	The respective anti-ice system has failed	TO/LAND
L (R) WINDOW HEAT FAIL	The respective window heat has failed and the temperature is too low or too high. A failure may also be indicated by the formation of condensation (fog) on the window	TO/LAND
WING ANTI-ICE FAULT	Both outboard wing leading–edge sensors have failed	TO/LAND
L (R) WING A/I PRESS HI	The pressure sensed in the wing anti–ice system is too high	TO/LAND
L (R) WSHLD HEAT FAIL	The respective window heat has failed, and the temperature is too low or too high. A failure may also be indicated by the formation of ice or condensation (fog) on the windshield	TO/LAND

C. ADVISORY MESSAGES

ADVISORY MESSAGES

Crew awareness - no immediate action required

Message	Meaning	Inhibits
L (R) AOA CASE HEAT FAIL	The respective angle–of–attack case heater has failed	TO/LAND
L (R) ENG A/ICE FAIL ON	The respective engine nacelle anti–ice has failed ON. If the T2 probe heater has failed ON, an amber "T2" icon will be displayed on the anti–ice synoptic. If engine anti–ice bleed air has failed ON, a green flow line will be displayed downstream of the failed anti–ice valve on the synoptic	TO/LAND
ICE DETECTED	Ice has been detected, and both the engine and wing anti–ice systems are selected on	TO/LAND
ICE DETECTOR FAULT	One ice detector has failed; the other should continue to operate normally	TO/LAND
L (R) PROBE HT CTRL FAIL	The respective probe heat controller has failed. The probe heat will fail ON	TO/LAND
TAT HEAT FAIL	The total air temperature probe heater has failed	TO/LAND
WING SOURCE–XBLEED	Wing crossbleed valve is open and wing source selection is in NORM	TO/LAND
WING ANTI–ICE FAULT	One channel has failed on the outboard wing leading–edge sensor. The wing anti–ice should work normally	TO/LAND
WING A/ICE LOOP FAIL	One wing anti–ice leak detection loop has failed	TO/LAND

D. STATUS MESSAGES

STATUS MESSAGES		
Information only - no crew action required		
Message	**Meaning**	**Inhibits**
L (R) ENG ANTI–ICE ON	The respective (or both) ENG ANTI–ICE switch(es) is/are ON	—
ENG ANTI–ICE ON	The respective (or both) ENG ANTI–ICE switch(es) is/are ON	—
PROBE HEAT TEST OK	Air data probe heat test (PROBES test) completed successfully — separate from ICE DET test	—
WING ANTI–ICE ON	The WING ANTI–ICE switch is selected ON	—
WING/ENG ANTI–ICE ON	The wing and both engine anti–ice systems are ON	—
WING SOURCE–XBLEED	Either FROM L or FROM R has been selected on the ANTI–ICE WING SOURCE switch	—

NOTES

- All warning messages are accompanied by a triple chime
- All caution messages are accompanied by a single chime
- "TO/LAND" indicates the message is inhibited during takeoff and landing phases
- L (R) notation indicates the message can appear for either left or right engine/system
- Ice detection is provided by two vibrating probe detectors for redundancy
- Wing anti-ice system uses high-pressure engine bleed air for heating
- Probe heating systems are electrically powered
- Windshield heating elements are segmented into three sections per windshield

IX. LIMITATIONS

A. OPERATION IN ICING CONDITIONS

Condition	Requirement
Flap Extension	Do not hold in icing conditions with flaps extended
SLD Icing Indication	Flight in super-cooled large droplet icing (SLD) may be indicated by side window ice accretion
When Side Window Icing Observed	Wing and engine anti-icing systems must be ON
SLD Icing Action	Leave icing conditions as soon as possible

B. ENGINE ANTI-ICE LIMITATIONS

Ground Operations	
Temperature	Engine anti-icing system must be ON when OAT 10°C (50°F) or below
Moisture	Visible moisture present (fog, rain, snow, sleet, ice crystals)
Visibility	Fog with visibility one mile (1,500 m) or less
Surface	Operating on surfaces with snow, ice, water, or slush

In-Flight	
Temperature	Engine anti-icing system must be ON when OAT 10°C (50°F) or below and visible moisture present
Ice Crystals	Ice crystals are encountered

C. WING ANTI-ICE LIMITATIONS

Ground Operations	
Temperature	Wing anti-icing system must be ON for takeoff when OAT 5°C (41°F) or below
Moisture	Visible moisture present (fog, rain, snow, sleet, ice crystals)
Visibility	Fog with visibility one mile or less
Surface	Operating on surfaces with snow, ice, water, or slush

In-Flight	
Temperature	In-Flight: Icing conditions exist when TAT is 10 °C (50 °F) or below and visible moisture in any form is encountered (clouds, rain, snow, sleet, or ice crystals), except when SAT is -40 °C (-40 °F) or below. Wing anti-icing system must be ON when below 210 KIAS and in icing conditions or anytime when the ICE DETECTED CAS message is on."

D. WING ANTI-ICE PRESSURE LIMITATIONS

Parameter	Limitation
High Pressure Valve Limit	High pressure valves limit pressure to 36 ±3 psi
Pressure Warning Threshold	Caution message at pressure exceeding 46 psi

X. ICE and RAIN SYSTEM CIRCUIT BREAKERS

Ice and Rain System Circuit Breakers

CB Name	Bus	Location
WING A/I VALVE L	LEFT ESS	CB1-H1
WING A/I VALVE R	RIGHT ESS	CB2-H1
ENGINE A/I L	LEFT ESS	CB1-H2
ENGINE A/I R	RIGHT ESS	CB2-H2
PITOT HEAT L	LEFT ESS	CB1-H3
PITOT HEAT R	RIGHT ESS	CB2-H3
AOA HEAT L	LEFT ESS	CB1-H4
AOA HEAT R	RIGHT ESS	CB2-H4
STATIC HEAT L	LEFT ESS	CB1-H5
STATIC HEAT R	RIGHT ESS	CB2-H5
WINDSHIELD HEAT L	LEFT MAIN	CB3-H6
WINDSHIELD HEAT R	RIGHT MAIN	CB4-H6
WINDOW HEAT L	LEFT ESS	CB1-H7
WINDOW HEAT R	RIGHT ESS	CB2-H7

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XI. ICE and RAIN QUIZ

1. How many ice detectors are installed on the Challenger 350?

    A) One detector
    B) Two detectors
    C) Three detectors
    D) Four detectors

2. What type of technology do the ice detectors use?

    A) Infrared sensing
    B) Vibrating probe
    C) Capacitive sensing
    D) Optical detection

3. What is the source of anti-icing for the wing leading edges?

    A) Electrical heating elements
    B) Hot oil circulation
    C) High-pressure engine bleed air
    D) Hydraulic fluid heating

4. How many zones are monitored by the bleed leak detection system?

    A) Two zones
    B) Four zones
    C) Six zones
    D) Eight zones

5. What controls the operation of the wing anti-ice system?

    A) Single-channel controller
    B) Dual-channel IASC
    C) Manual pilot control only
    D) Engine ECU

6. At what pressure do the high pressure valves limit engine bleed air?

    A) 30 ±3 psi
    B) 33 ±3 psi
    C) 36 ±3 psi
    D) 39 ±3 psi

7. How many heater sections are in each windshield?

    A) Two sections
    B) Three sections
    C) Four sections
    D) Five sections

8. What happens when a leak is detected downstream of the high pressure valve?

A) Manual pilot action required
B) System continues operating
C) IASC automatically closes wing anti-ice valves
D) Engine shutdown required

9. Which probe heater operates in flight only?

A) Pitot probe heater
B) AOA vane heater
C) Static port heater
D) TAT probe heater

10. What is the maximum OAT for mandatory engine anti-ice operation on the ground?

A) 5°C (41°F)
B) 10°C (50°F)
C) 15°C (59°F)
D) 20°C (68°F)

11. How many temperature sensors monitor each wing section?

A) Single sensor
B) Dual sensors
C) Triple sensors
D) Four sensors

12. What indicates super-cooled large droplet icing conditions?

A) Wing leading edge ice
B) Engine inlet ice
C) Side window ice accretion
D) Pitot probe ice

13. What type of valve operation is used for nacelle anti-icing valves?

A) Hydraulically operated
B) Pneumatically operated
C) Electrically operated and pneumatically controlled
D) Manually operated

14. Which EICAS message indicates both ice detectors have failed?

A) ICE DETECTOR FAULT
B) ICE DETECTOR FAIL
C) ICE DETECTION LOST
D) ICE SYSTEM FAIL

15. What happens to wing anti-ice valves when electrical power is lost?

A) Valves remain in last position
B) Valves open fully
C) Valves close (spring-loaded closed)
D) Valves cycle continuously

16. How is the engine spinner protected from ice?

A) Electrical heating
B) Bleed air heating
C) Hot oil circulation
D) Conical shape sheds ice naturally

17. What triggers a L (R) WING A/I PRESS HI caution message?

A) Pressure below 30 psi
B) Pressure below 36 psi
C) Pressure exceeding 46 psi
D) Pressure exceeding 50 psi

18. Which component provides inlet TAT data to the ECU?

A) Pitot probe
B) Static port
C) AOA vane
D) T2 sensor

19. What should be done when side window icing is observed?

A) Continue normal operations
B) Turn off anti-ice systems
C) Turn on anti-ice systems and leave icing conditions
D) Land immediately

20. How many pitot static masts are installed on the aircraft?

A) One mast
B) Two masts
C) Three masts
D) Four masts

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