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CHAPTER 14

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GENERAL

Thermal anti-icing, electrical anti-icing, ice detection and alerting systems are provided for airplane ice and rain protection. Selections for anti-ice functions are made on the ANTI-ICE panel, located on the overhead panel.

GF1410_001

Ice Detection

Independent ice detection probes (2), located on the fuselage, sense the formation of ice. If ice is detected, the ice detectors automatically turn on the electrical heat to the various probes, signalling the Bleed Management Controllers (BMC) to activate wing anti-ice and operate a relay in the ANTI-ICE Control panel to activate cowl anti-ice.

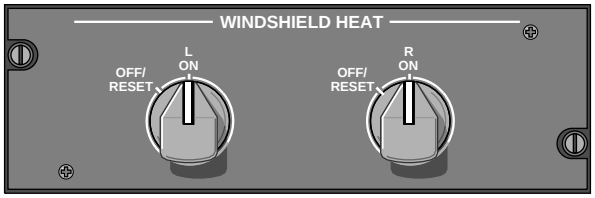
Pneumatic Anti-Icing

Hot air anti-icing, provided by engine bleed air, through piccolo ducting, wing anti-ice valves and cowl anti-ice valves, prevents the formation of ice on the wing leading edge, slats and the engine intake cowls.

Electrical Anti-Icing

Electrical anti-icing is provided for Pitot Static Probes, Ice Detectors, Total Air Temperature (TAT) Probes, Heater/Brake Temperature Monitoring Units (HBMUs) and Angle of Attack (AOA) Vanes.

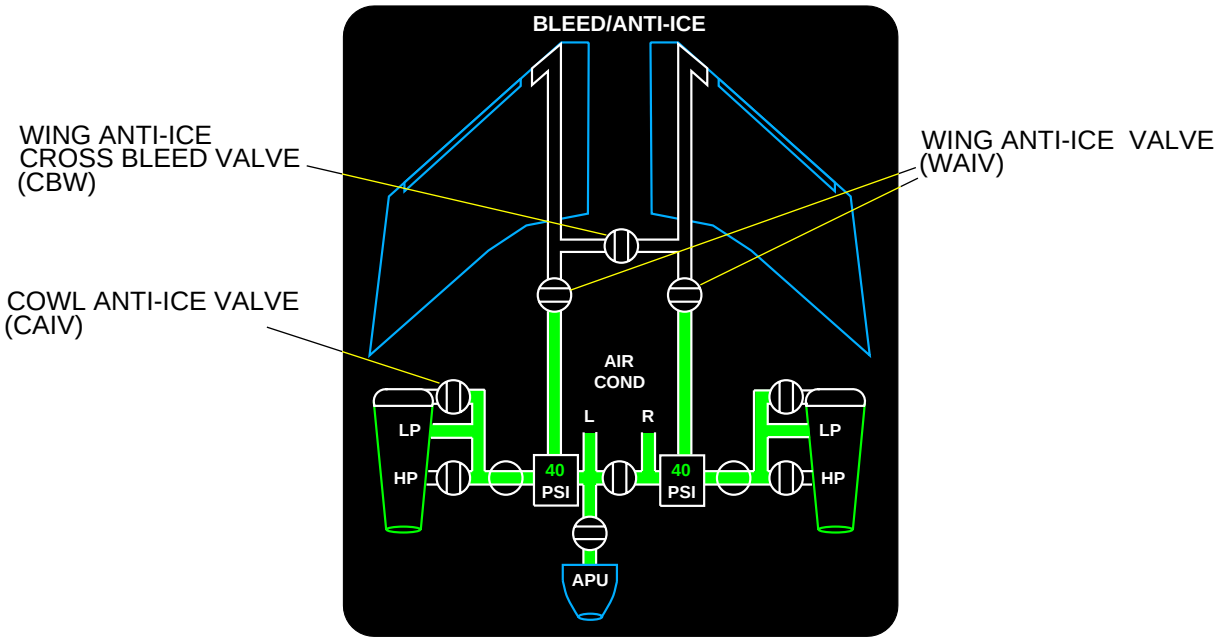
Selections for the Pilot's and Copilot's Windshields and Side Windows heating, are made on the WINDSHIELD HEAT panel, located on the overhead panel.



GF1410_002

Anti-ice system data is displayed on the BLEED /ANTI-ICE synoptic page and any faults or failures are displayed on EICAS and CAIMS.

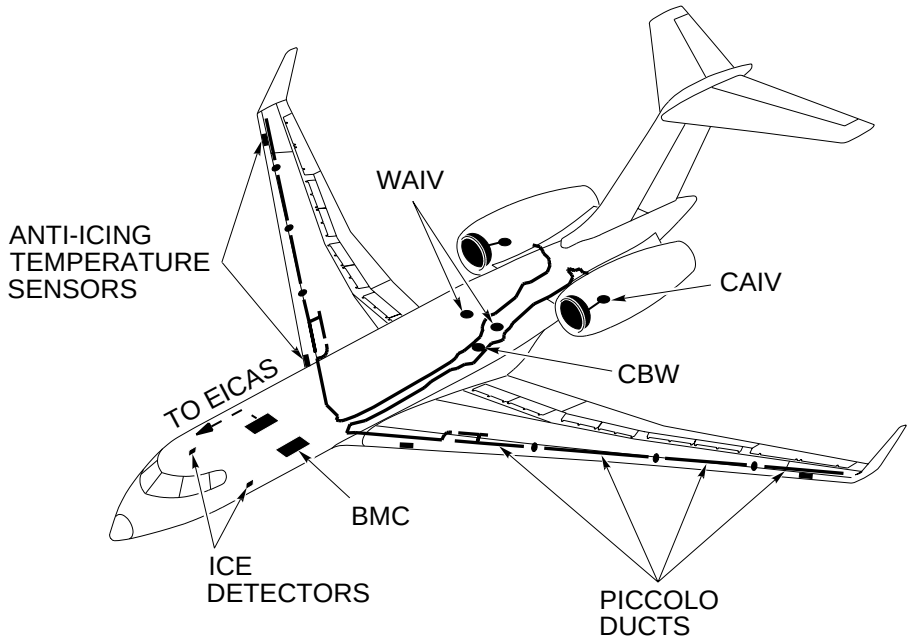
BLEED/ANTI-ICE SYNOPTIC



GF1410_003

For more information on BLEED System, refer to Chapter 2, AIR CONDITIONING and PRESSURIZATION.

COMPONENTS



GF1410_004

ANTI-ICE PANEL

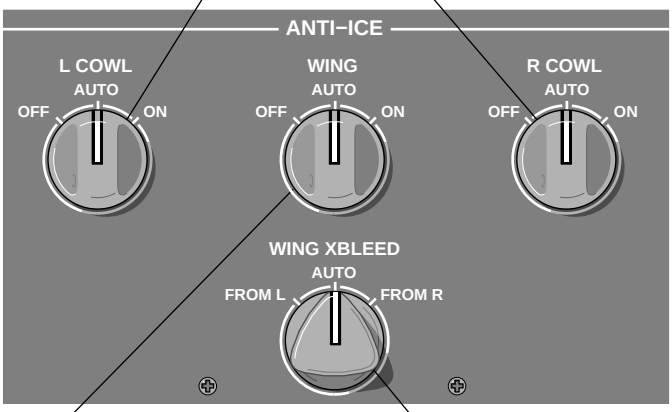
Controls are provided on the ANTI-ICE panel, located on the overhead panel.

L & R COWL Selectors

• **OFF** − Disarms the cowl anti-ice system and closes the associated valves.

• **AUTO** − Arms the cowl anti-ice system, to enable automatic operation, when ice is detected by the ice detector.

• **ON** − Activates cowl anti-ice operation, independent of ice detector signals.



WING Selector

• **OFF** − Disarms the wing anti-ice system and closes the associated valves.

• **AUTO** − Arms the wing anti-ice system, to enable automatic operation, when ice is detected by the ice detector.
System inhibited on the ground until 400 feet above take-off field elevation.

• **ON** − Activates wing anti-ice operation, independent of ice detector signals.

WING XBLEED Selector

• **FROM L** − Closes the RH WAIV and opens the CBW, independent of BMC commands.

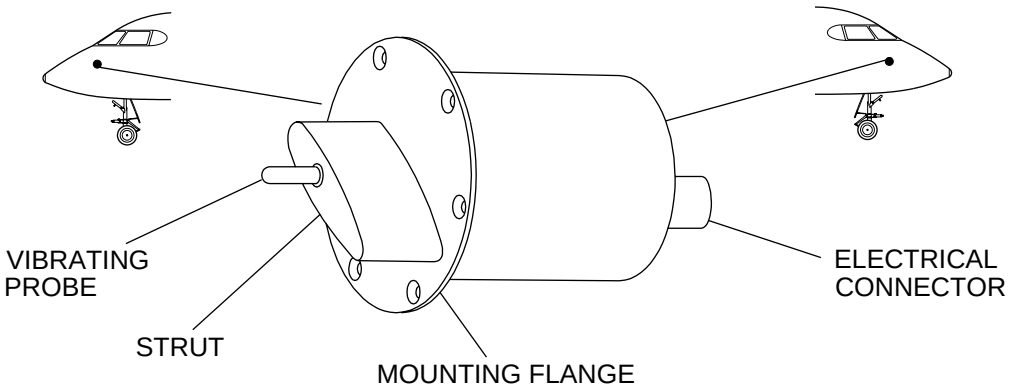
• **AUTO** − Arms the CBW to enable automatic operation in the event of a failure in one WAIV.

• **FROM R** − Closes the LH WAIV and opens the CBW, independent of BMC commands.

GF1410_005

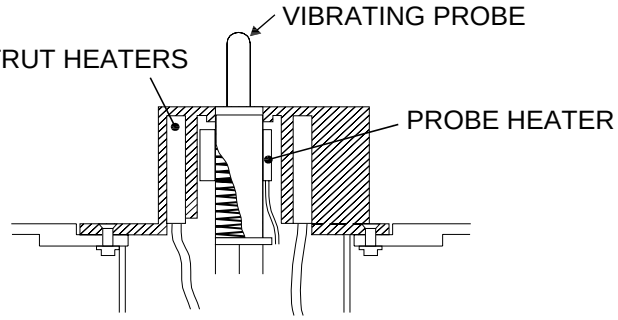
ICE DETECTION

The airplane is fitted with two ice detectors, one on each side of the front fuselage.



The ice detector incorporates a vibrating probe, that maintains a preset frequency (40 KHz), to detect icing conditions. As the ice detector enters an icing environment, ice collects on the vibrating probe. The added mass of ice causes the frequency of the probe to decrease, .010 inch thickness of ice equals a 65 HZ decrease and immediately the ice detector de-ices the strut and the probe through internal heaters. Heater power is applied until the frequency rises to a predetermined set point, plus a time delay factor (60+/− 5 seconds) to ensure complete de-icing. If an additional icing/de-icing cycle occurs during that time interval, the 60 seconds cowl and wing anti-ice activation period is begun again.

SECTIONAL VIEW



The ice detectors emit icing signals to the following:

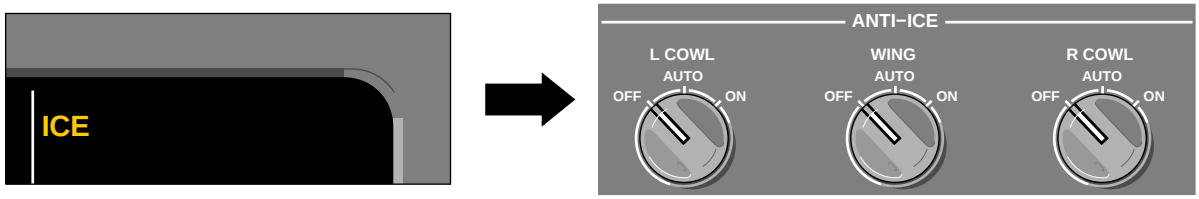
- ANTI-ICE panel (cowl anti-ice relay), for activation of the cowl anti-icing system (AUTO).
- BMC for activation of the wing anti-icing system (AUTO). The AUTO operation of WING ANTI-ICE is inhibited during take-off until the airplane is >400 feet above field elevation.
- Stall protection system, to change stick shaker control, if an ice detector has failed and to the BMC for fault indication. For more information on Stall Protection, refer to Chapter 10 FLIGHT CONTROLS.

Once de-iced, the probe cools within a few seconds and is ready to sense ice buildup again. This cycling process is repeated as long as the ice detector remains in an icing environment.

The ice detectors are not capable of operating at low airspeeds of less than 29 knots IAS, therefore they cannot be used to detect icing when the airplane is on the ground.

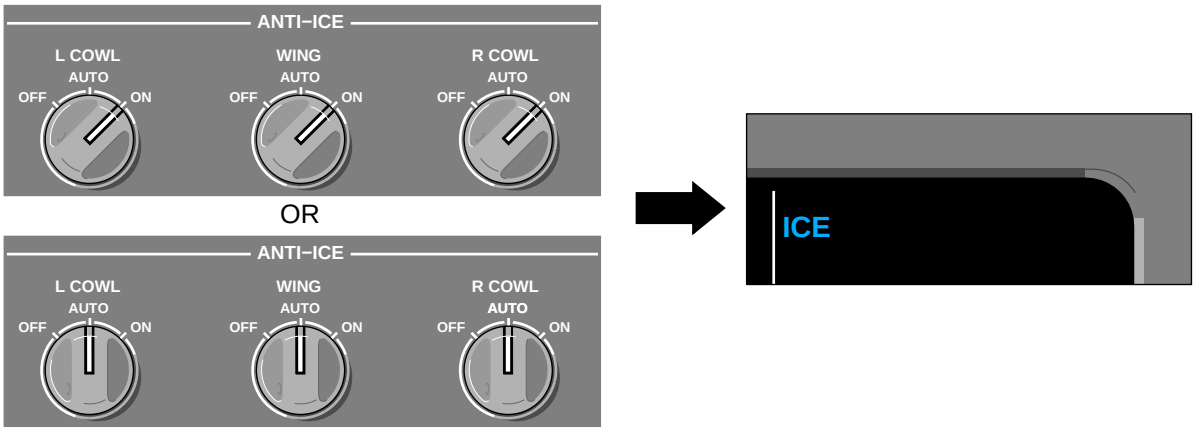
ICE DETECTION INDICATION

If ice is detected and the ANTI-ICE system is turned OFF, a message is displayed on EICAS.



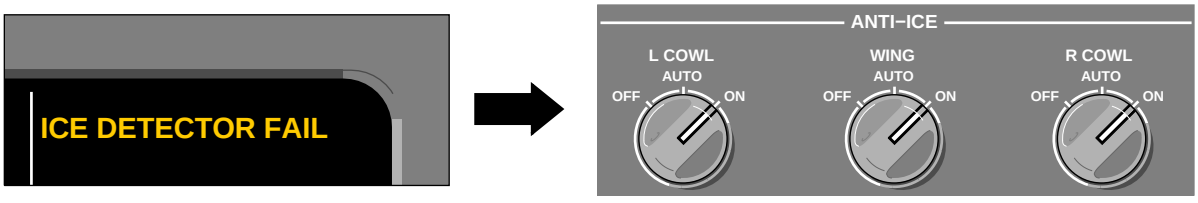
GF1410_008

If ice is detected and the ANTI-ICE system is turned to ON or AUTO, the following message is displayed on EICAS.



GF1410_009

If both ice detectors are failed, a message is displayed on EICAS and the crew must revert to manual selection of cowl and wing anti-ice.



GF1410_010

If a single ice detector fails, a message is displayed on EICAS. If ice is detected by the other ice detector, the Stall Protection system enables a change in stick shaker control and a message is displayed on EICAS.

GF1410_011

PNEUMATIC ANTI-ICING

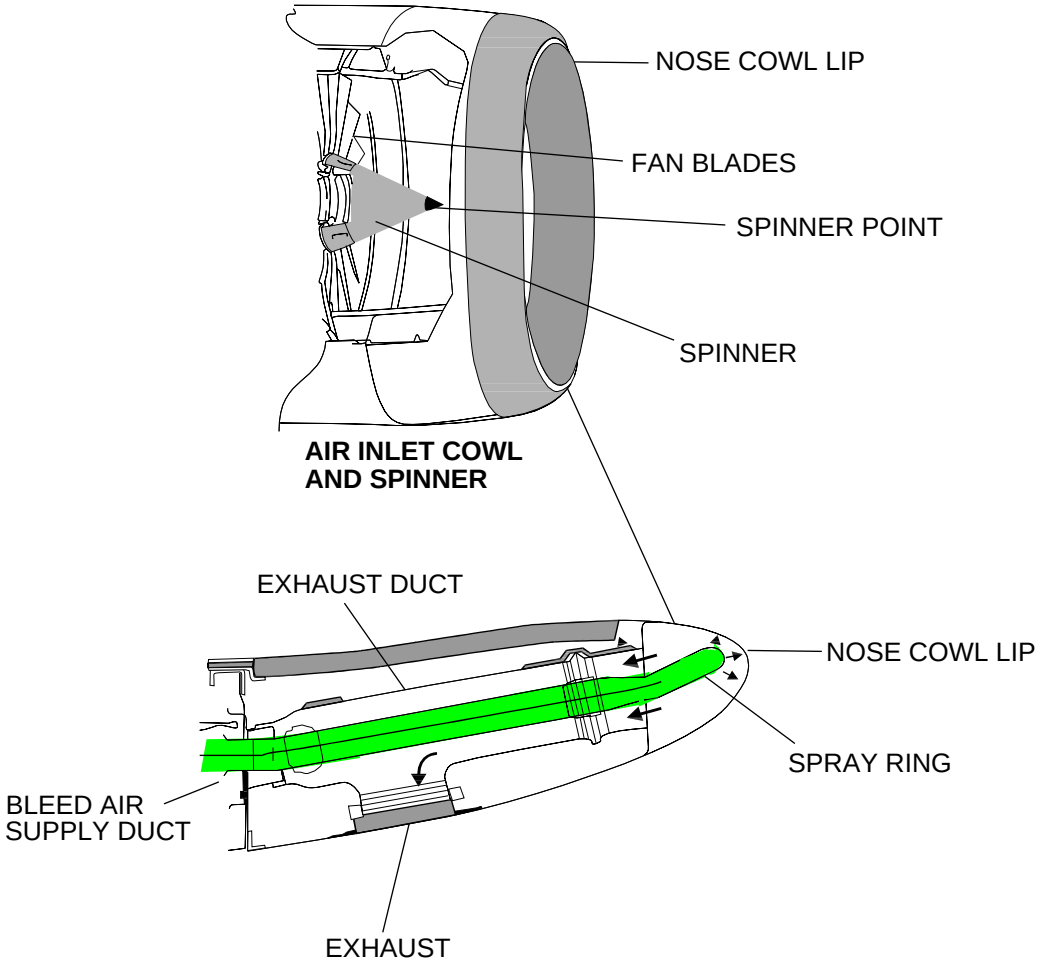
Engine bleed air is used for the following systems:

COWL ANTI-ICING (CAI)

The cowl anti-icing system is used to prevent formation of ice on the nose cowl of the engine. The cowl leading edge uses hot engine bleed air from the low pressure compressor 5th stage to heat the nose cowl. The bleed air is ducted through a spray ring and exhausts to atmosphere, through an exit grill.

Engine Spinner

The engine spinner point is made of soft rubber which will distort during engine running and ice accumulation and will shed any ice buildup. The rear of the spinner and the fan blades use centrifugal force to shed ice after start up, to prevent ice accumulation during engine running.

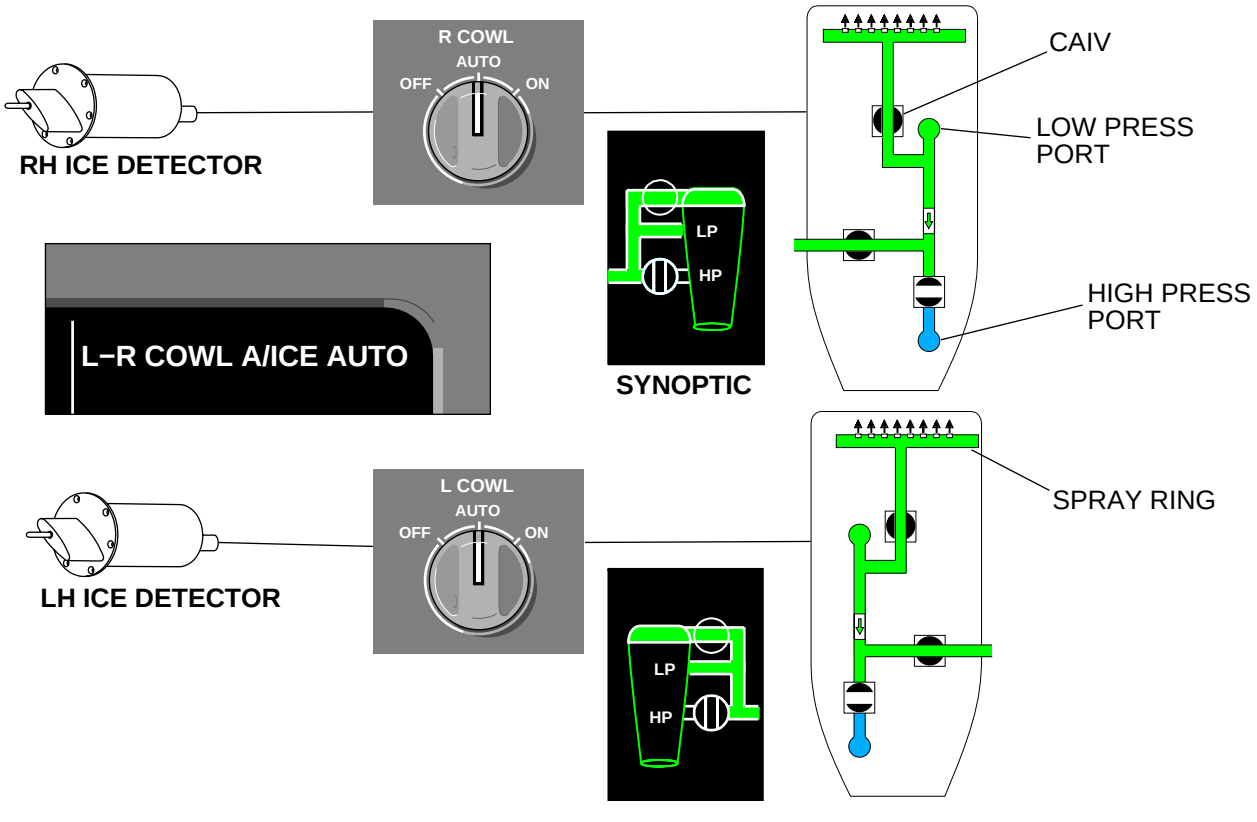


Cowl Anti-Ice Valves

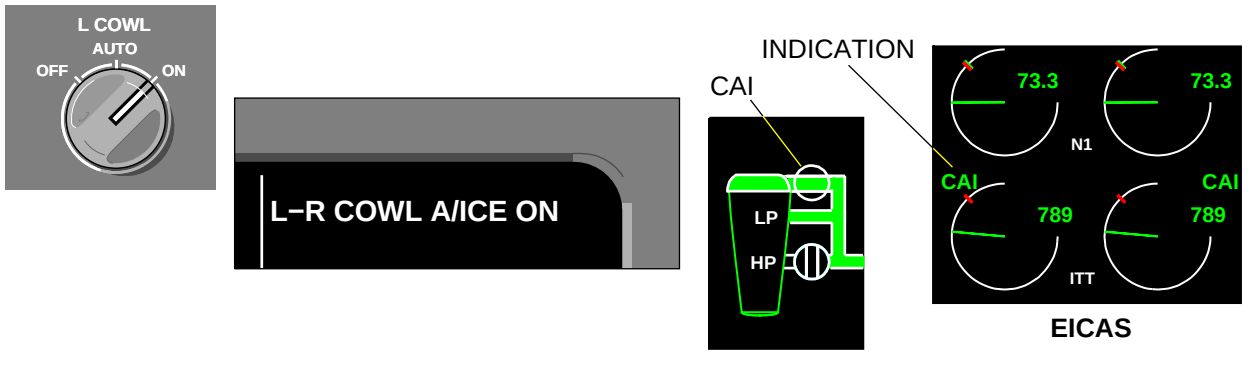
There are two Cowl Anti-Ice Valves (CAIV), which control the flow of engine bleed air to the cowl ducting. The CAIVs are spring-loaded open, pneumatically operated, electrically controlled, pressure regulating and shutoff valves, that are controlled by signals from the ice detecting system. They are either fully open or fully closed.

CAI OPERATION

When the L and/ or R COWL selector is selected to AUTO and ice is detected, the ice detection system sends a signal to a relay in the ANTI-ICE panel, that commands the anti-ice valves open. If an ice detector fails, the other detector will activate both cowl anti-ice valves in AUTO mode. A status message is displayed on EICAS.

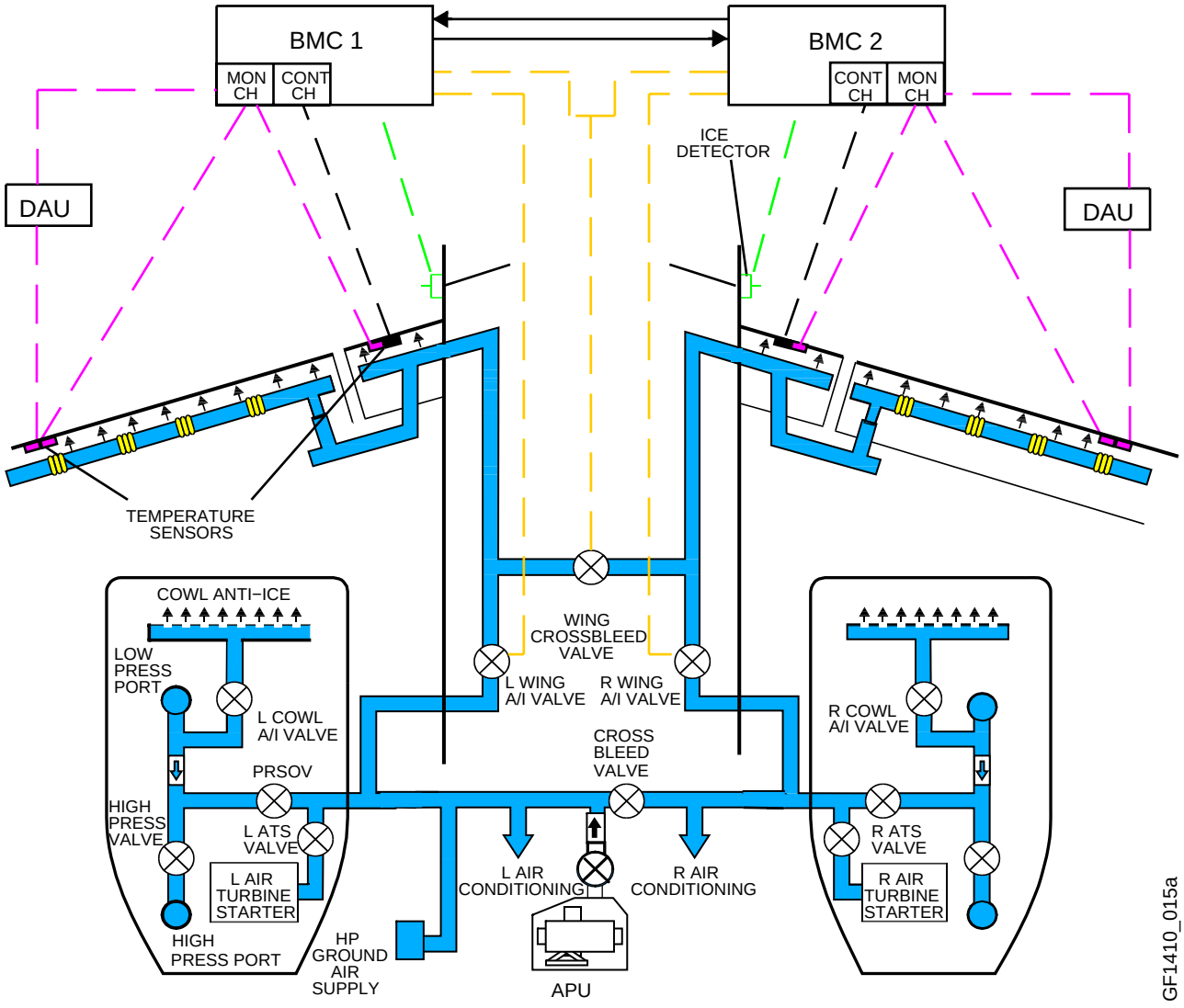


Cowl anti-icing can be manually selected to ON, in which case the CAIVs will open, independent of the ice detection system and a status message is displayed. Whenever cowl anti-ice is activated (AUTO or ON), a **CAI** icon will be displayed on the EICAS page.



WING ANTI-ICING (WAI)

The wing anti-icing system is used to prevent formation of ice on the leading edge of the wing. The wing leading edge uses hot engine bleed air from either the 5th stage or the high pressure compressor 8th stage, of the bleed air system.

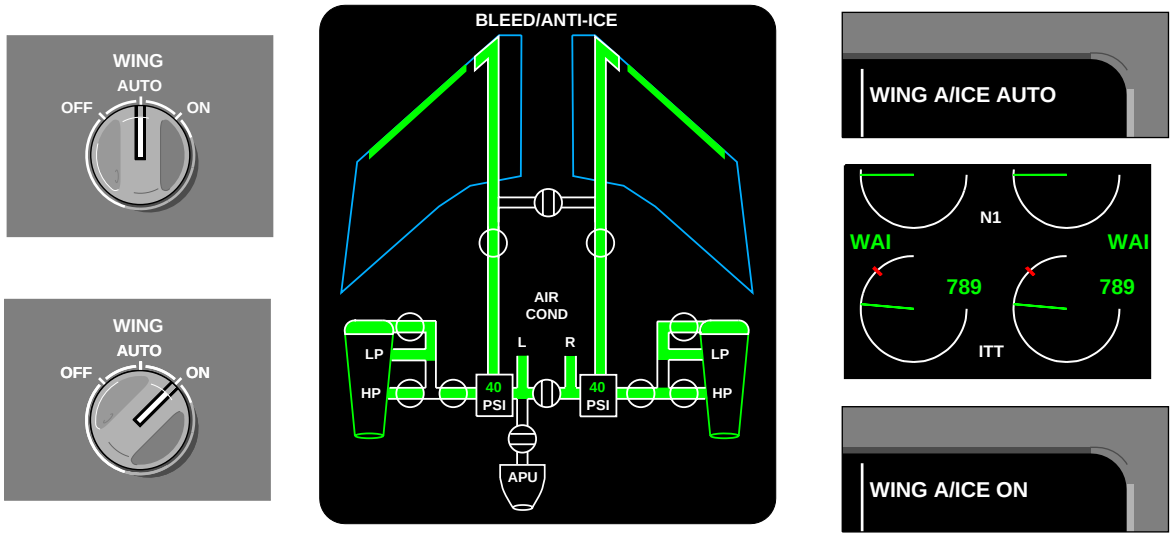


Wing Anti-Ice Valves (WAIV)

Two wing anti-ice valves are electrically controlled, pneumatically operated, spring loaded closed, modulating shutoff valves. The ice detector system will send a signal to the BMC to activate the wing anti-ice system. One temperature sensor, located in the fixed leading edge, provides a signal to the control channel of the BMC, which drives the WAIVs open or closed. A second temperature sensors, located in the fixed leading edge, provide a signal to a monitoring channel in the BMC. One channel controls and the other channel act as a monitor but can assume control in the event of a failure of the control sensor. In the event of complete failure of sensors on one side, the serviceable control sensor on the opposite side, will control the WAIVs.

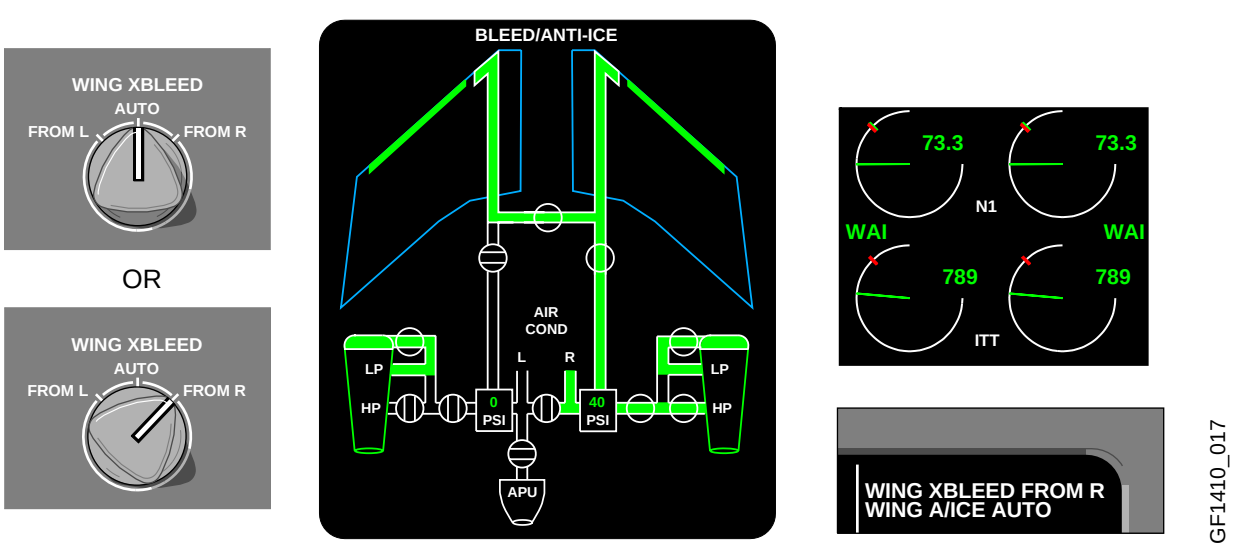
WAI OPERATION

The ice detectors will send a signal to the BMC to activate the wing anti-ice system when selected to AUTO. Wing anti-ice can be manually selected to ON, in which case the WAIVs will open, independent of the ice detection system. Whenever wing anti-ice is activated (AUTO or ON), a **WAI** icon will be displayed on the EICAS page. The ICON colour will vary from amber, green or white, depending on the temperature in the wing and/or its status.



Crossbleed Valve (CBW)

The left and right hand anti-ice systems normally operate independently from one another. In the event of a single engine failure, bleed failure or a failure of wing anti-ice air supply on one side, the left and right systems are interconnected by a CBW. This allows both wings to be fed from a single engine. In case of a failure in AUTO operation, the CBW will automatically open and the affected WAIV will automatically be closed by the BMC. Manual operation of the CBW is provided on the ANTI-ICE panel.

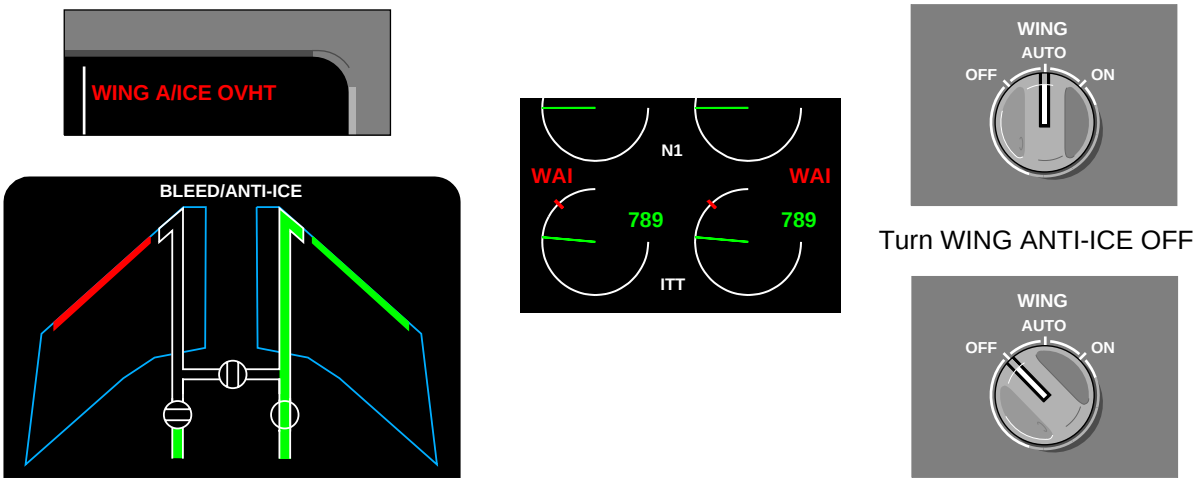


WAI FAILURE INDICATIONS

The WAI failure indications are as follows:

Wing Anti-Ice Overheat

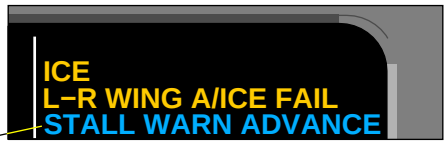
If there is an overheat in the wing anti-ice system, a message is displayed on EICAS.



GF1410_018a

Wing Anti-Ice Fail

If wing anti-ice is failed, a message is displayed on EICAS. If ice is detected during this failure condition, the stall warning trigger points are advanced automatically. Ensure rpm (N2) is above 76% may remove this amber message.



NOTE

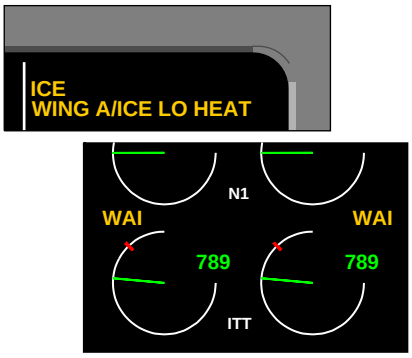
If ice is detected, the stall warning trigger points are advanced automatically.
For more information on stall protection, see Chapter 10, FLIGHT CONTROLS.

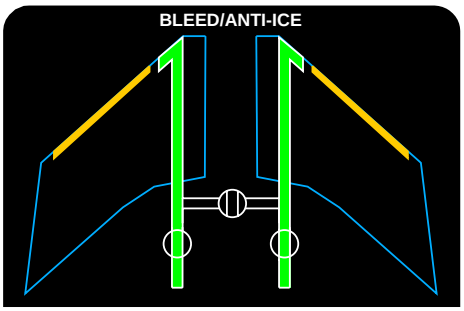
GF1410_019

WAI FAILURE INDICATIONS (CONT'D)

Wing Anti-Ice Low Heat

If there is insufficient heat in the wing leading edge duct, a message is displayed on EICAS.





GF1410_020

SLAT ANTI-ICING

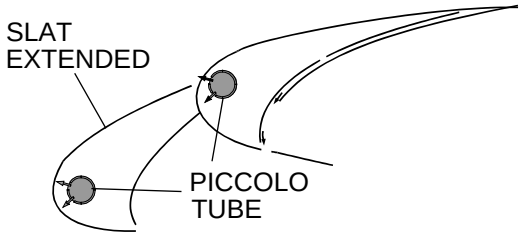
The sections of slat leading edge that are heated, are as follows:

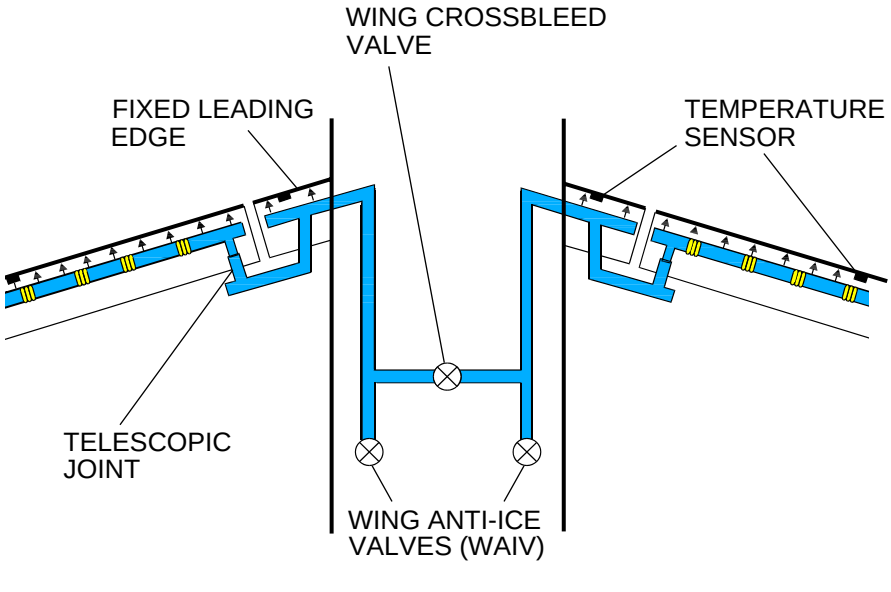
- Inboard fixed leading edge.
- Slat 1, 2, 3 and 4.

Only the short, fixed section outboard of slat 4 and the leading edge of the winglet are not heated.

SLAT ANTI-ICE OPERATION

Air is ducted into the fixed section of the wing leading edge from the forward part of the wing root. From there, it is directed into the wing leading edge slats via a telescopic duct which extends as the slats move to the extend position. Piccolo tubes in both inboard fixed leading edge and outboard at each slat, distribute the air into the inside surface of the wing leading edge for ice protection. Air is then extracted overboard between the slat and main wing.





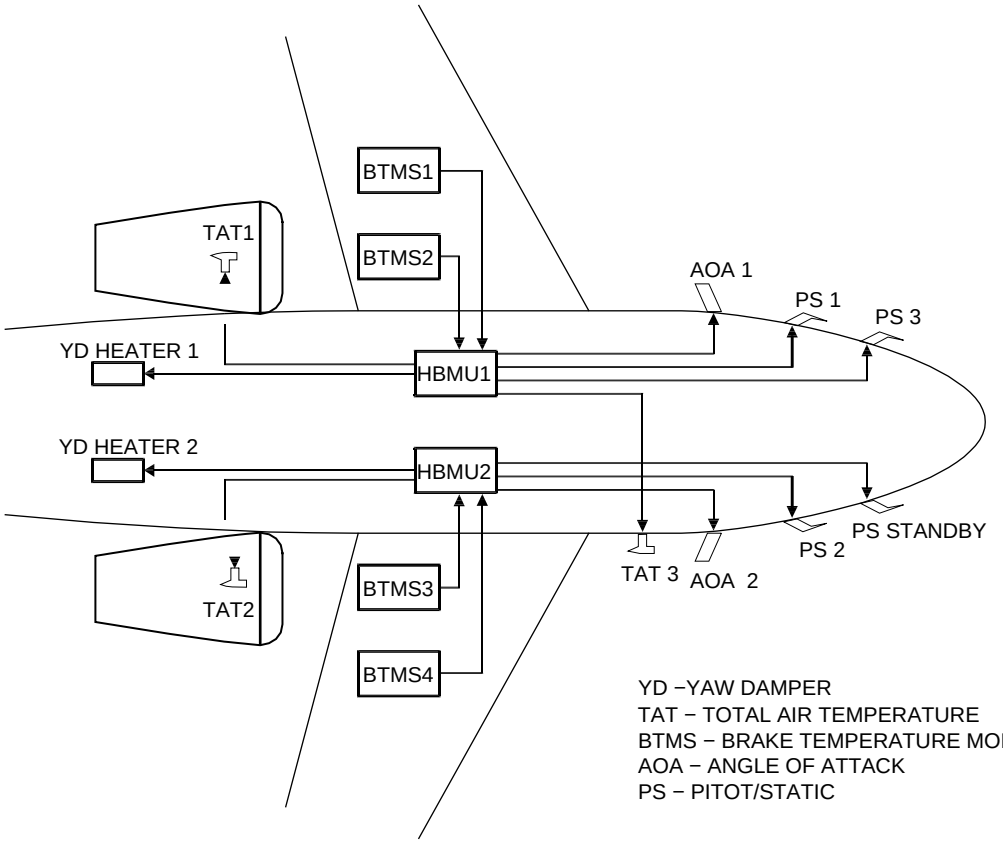
ELECTRICAL ANTI-ICING

Electrical power is used to operate the following:

AIR DATA PROBES AND SENSORS

The air data probes and sensors anti-ice system prevents ice accumulation on the probes and sensors, which could lead to incorrect data transmission to the Air Data Computers (ADC).

The air data probes and sensors anti-ice system is controlled automatically by two Heater/Brake Temperature Monitoring Units (HBMU).



HBMU

- HBMU 1 controls AOA 1, PS 1, PS 3, TAT 1 and YD Heater 1 and monitors BTMS 1 and BTMS 2.
- HBMU 2 controls AOA 2, PS 2, PS Standby, TAT 2, TAT 3 and YD Heater 2 and monitors BTMS 3 and BTMS 4.

  The HBMUs also monitor brake temperature data. The data sent by the Brake Temperature Monitoring System (BTMS), which incorporates four sensors, installed in the brake housings, provides excessive brake temperature warning to EICAS (For more information see Chapter 15, LANDING GEAR). The HBMU also controls heat to Yaw Damper (YD) actuators, to ensure that the standby YD actuator is heated. (For more information see Chapter 10, FLIGHT CONTROLS).

AIR DATA PROBES AND SENSORS (CONT'D)

HBMU (Cont'd)

The HBMU receives data from various airplane systems via the Data Acquisition Units (DAU) to control the heaters. The systems that send data to the DAUs are:

- Electronic Engine Controllers (EEC), for the "all heaters off" logic and for TAT probe on/off logic.
- Fault Warning Computer (FWC), regarding which ADC is selected for cockpit display.
- Automatic Flight Control System (AFCS), regarding which Yaw Damper is in use, for YD heater control logic.
- Air Data Computers (ADC) to provide TAT information to control heat to the Yaw Dampers and airspeed information for "all heaters off" logic.
- Electrical Load Management System (EMS), provides BUS status and ADG information for heater control logic.
- Weight On Wheels (WOW), for "all heaters off" logic and for TAT probe on/off logic.

The heaters are driven to the indicated ON/OFF state based on the following logic:

- AOA 1 Heater Off − AC ESS BUS unpowered and WOW.
- AOA 2 Heater Off − AC ESS BUS unpowered and AC BUS 1 unpowered and WOW.
- PS 1 Heater Off − ADG deployed and ADC 1 not selected or AC ESS BUS unpowered and AC BUS 1 unpowered.
- PS 2 Heater Off − AC BUS 2 unpowered.
- PS 3 Heater Off − ADG deployed and ADC 3 not selected or AC ESS BUS unpowered.
- PS STBY Heater Off − AC ESS BUS unpowered.
- TAT 1 Heater Off − WOW and LH engine Off.
- TAT 2 Heater Off − WOW and RH engine Off.
- TAT 3 Heater Off − WOW or AC BUS 3 unpowered.
- YD 1 Heater On − TAT <−40°C and Yaw Damper 1 not engaged.
- YD 2 Heater On − TAT <−40°C and Yaw Damper 2 not engaged.

The "all heaters off" control function, turns OFF all heaters and overrides the above heater on/off logic equations when :

- L and R engine not running and/or,
- WOW and/or,
- airspeed less than 50 knots.

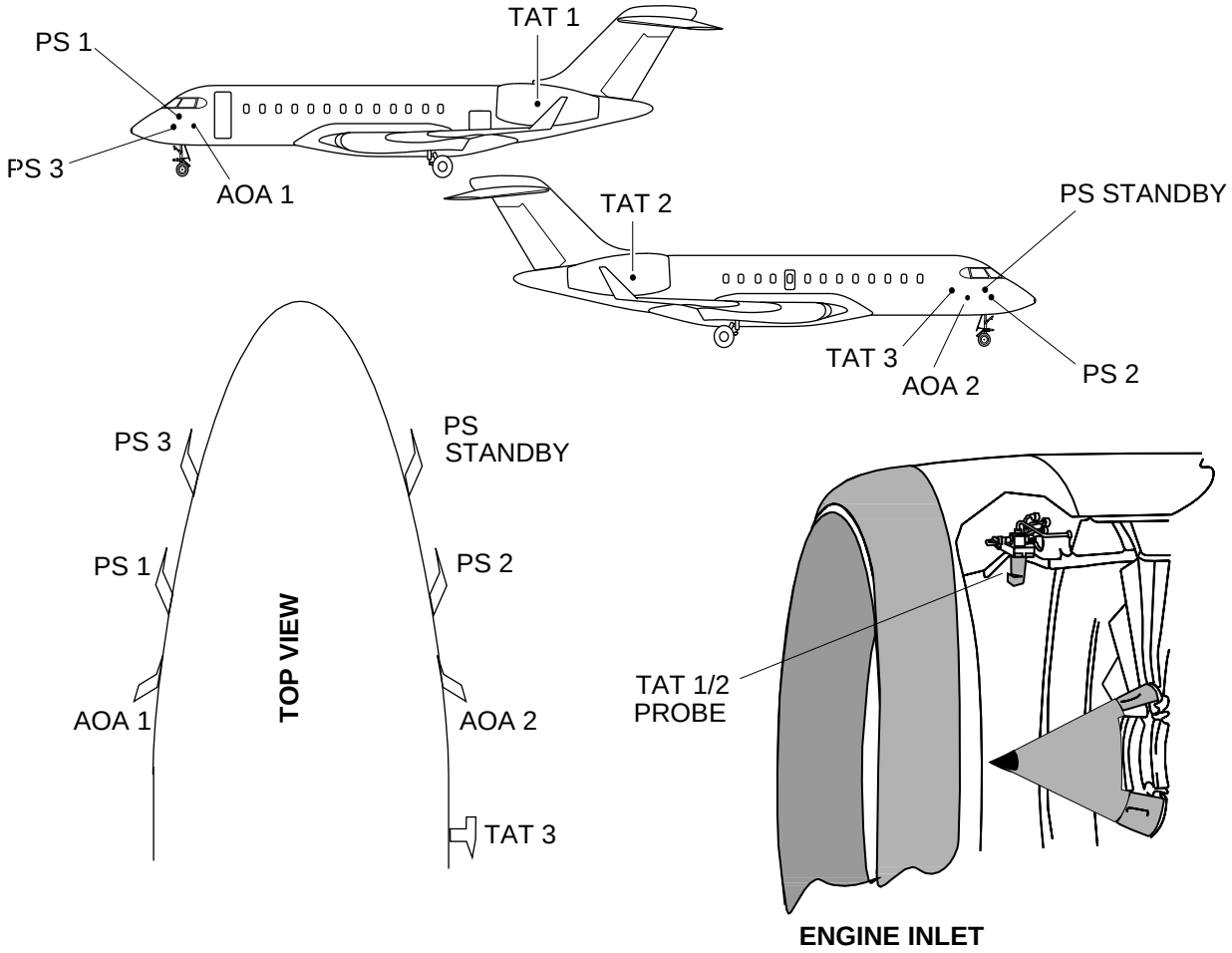
AIR DATA PROBES AND SENSORS (CONT'D)

Probes

There are four Pitot-Static (PS) probes on the side of the fuselage. They supply pitot and static pressure to the air data computers and standby instruments. Heater elements are installed in the PS heads and mounting bases.

There are three Total Air Temperature (TAT) probes, one on the fuselage and one each in the engine inlets.

There are two AOA probes, mounted on the fuselage, one on either side.



The current being drawn by the heater is measured and a heater fault is generated if the current drawn is less than the minimum required by the particular probe. The fault is then transmitted to EICAS.

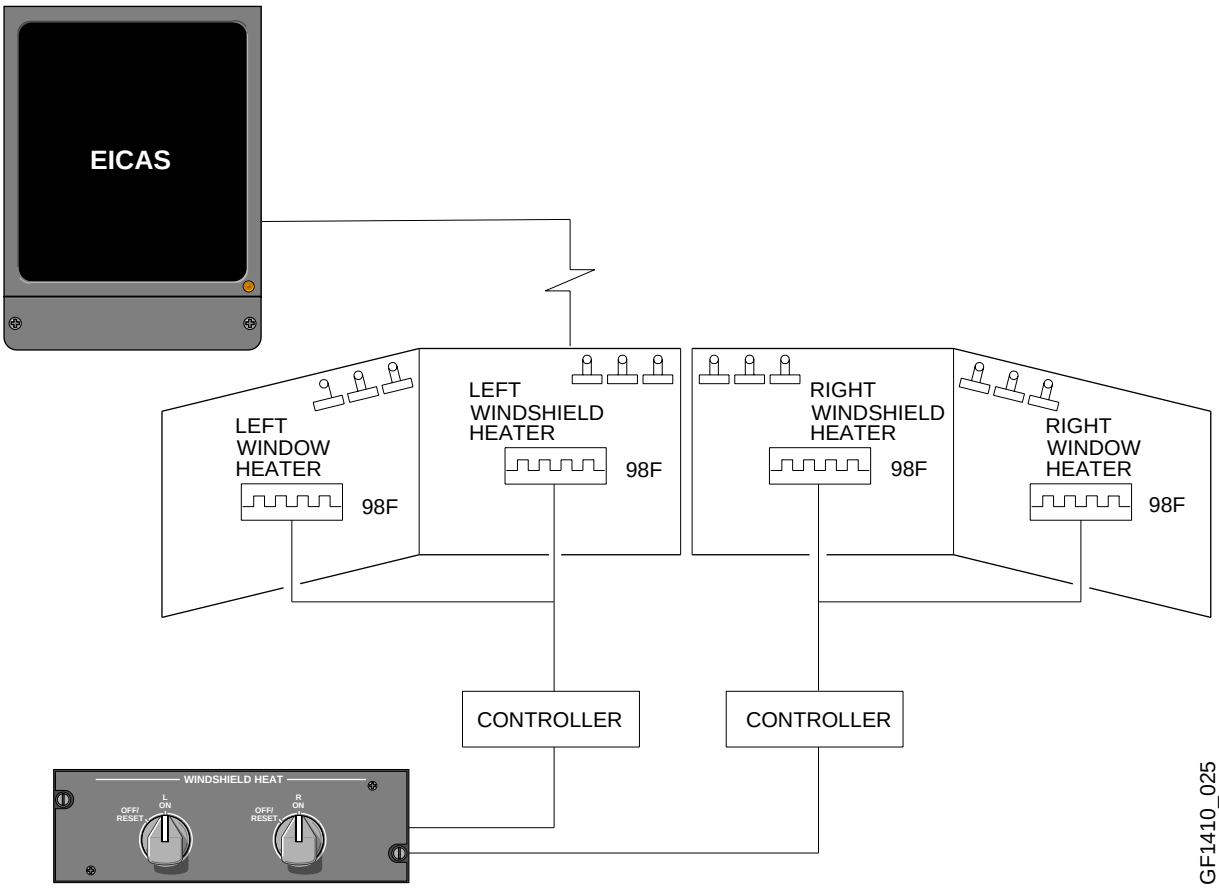
GF1410_024

WINDSHIELD HEAT

The Windshield Temperature Control System provides defog and anti-icing for the Pilot's and Copilot's windshield and side window. The system continuously monitors the temperature of each windshield and side window and maintains the temperature within specified limits.

Windshield Temperature Controller

There are two dual channel Windshield Temperature Controllers (WTC). The left hand WTC controls the left windshield heater and the left side window heater. The right hand WTC controls the right windshield heater and the right side window heater. Both WTCs are interfaced with EICAS via different DAUs.



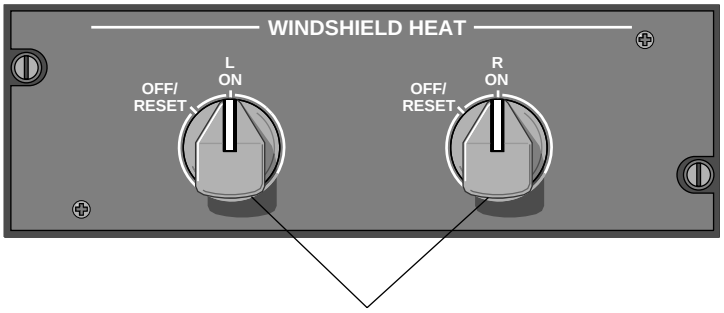
The windshield construction is laminated, stretched acrylic mainplies, which incorporate a gold conductive film as the de-icing heater element. The windshield also includes three temperature sensor elements, one for controlling and monitoring and two spares.

The side window construction is similar to the windshield, except that the stretched acrylic mainplies are thinner. The side window also includes a heating element for defog and three temperature sensor elements, one for control and monitoring and two spares.

WINDSHIELD HEAT (CONT'D)

Windshield Heat Panel

Selections for the Pilot's and Copilot's Windshields and Side Windows heating, are made on the WINDSHIELD HEAT panel, located on the overhead panel.



GF1410_026

Left and Right Windshield Heat selectors

OFF/RESET − Turns windshield/window heat OFF.
− Resets the system, in the event of a failure.
− Inhibits all windshield and window fail messages.

ON − Activates the windshield/window temperature control system.

MODES OF OPERATION

The windshield modes of operation are as follows:

Warm-Up Mode

The warm-up mode is provided to avoid the effect of thermal shock on the windshield. While in the warm-up mode, the windshield heater generates only 33% of nominal heat and lasts for approximately 4 minutes, then is terminated. The warm-up mode is activated on WTC power-up, when the following conditions are met:

- Heat was not applied to the windshield for more than 5 seconds.
- The airplane is Weight On Wheels.

If the airplane is Weight Off Wheels, the warm-up mode is terminated. Once the warm-up mode is terminated, it automatically switches to normal regulating mode.

Normal Regulating Mode

On WTC power-up both channels controlling the windshield and respective side window are energized. Each channel continuously monitors the temperature through its sensor element. If the temperature decreases below a specified low limit, the heater is turned on. If the temperature exceeds a specified limit, the heater is turned off.

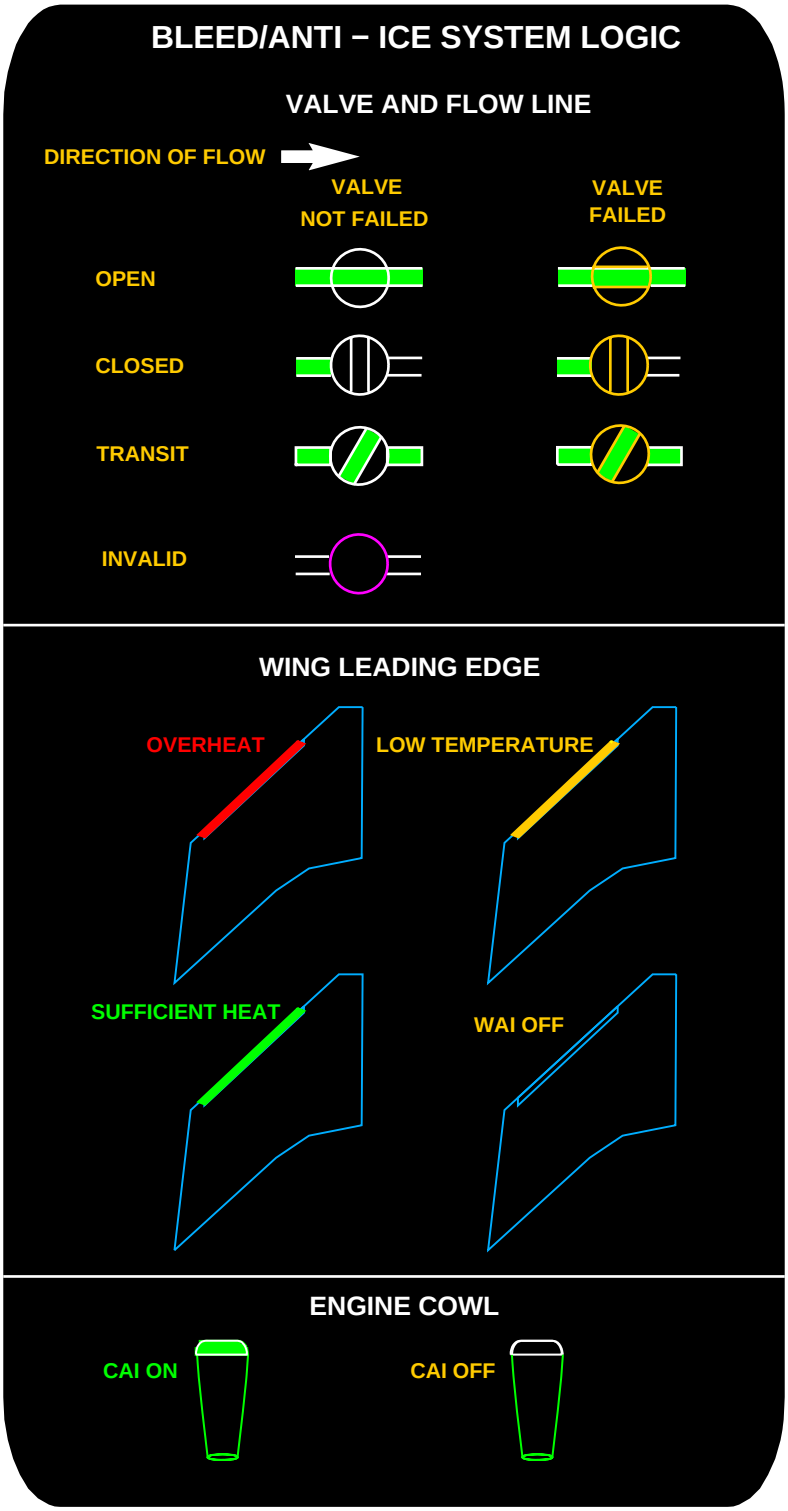
WINDSHIELD/WINDOW FAILURE INDICATION

In the event of a system failure or being turned off, a message is displayed on EICAS.

GF1410_027

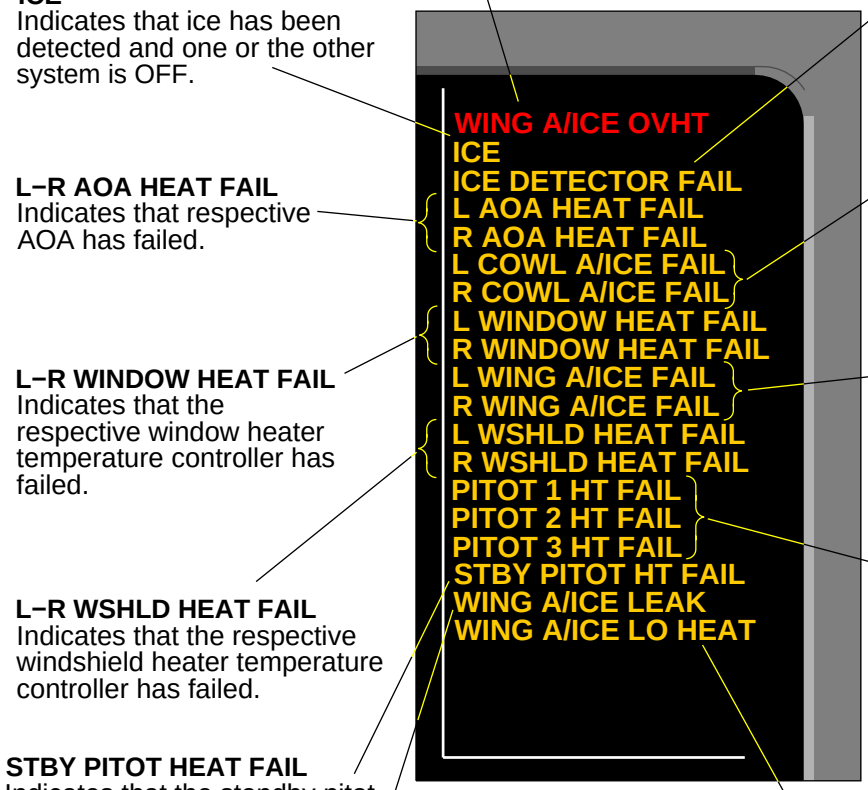
EICAS PHILOSOPHY

The following represents the EICAS symbols and logic for the BLEED/ANTI-ICE synoptic page. The symbols are shown in serviceable and failure conditions.



GF1410_028

ICE AND RAIN EICAS MESSAGES



WING A/ICE OVHT
Indicates that an overtemperature has been detected in the wing anti-ice system.

ICE DETECTOR FAIL
Indicates the loss of both ice detectors.

ICE
Indicates that ice has been detected and one or the other system is OFF.

L−R COWL A/ICE FAIL
Indicates that the cowl anti-ice valve is not in the selected position.

L−R AOA HEAT FAIL
Indicates that respective AOA has failed.

L−R WING A/ICE FAIL
Indicates that the wing anti-ice valve is not in the selected position.

L−R WINDOW HEAT FAIL
Indicates that the respective window heater temperature controller has failed.

PITOT 1−2−3 HT FAIL
Indicates that the respective pitot heater has failed.

L−R WSHLD HEAT FAIL
Indicates that the respective windshield heater temperature controller has failed.

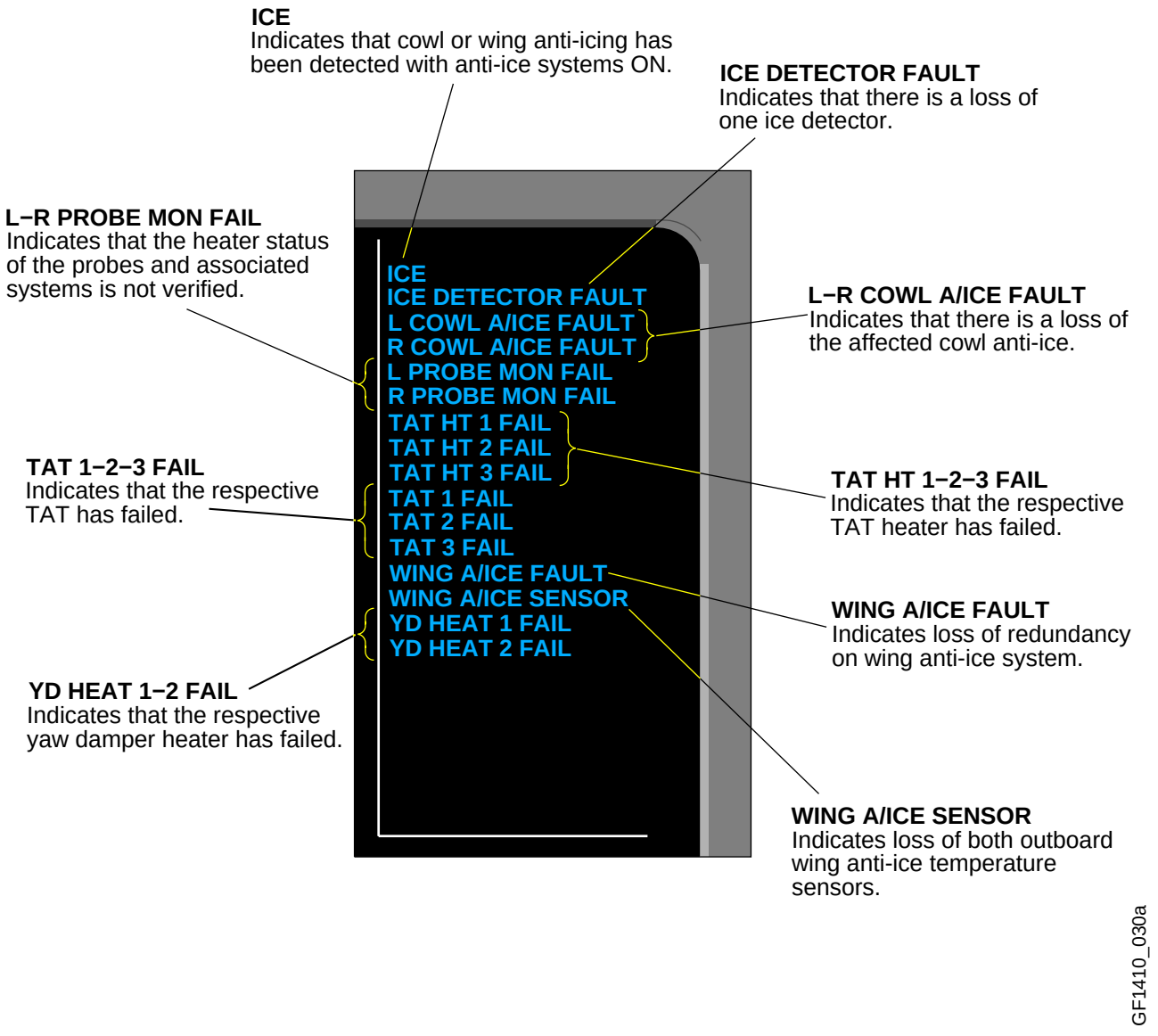
STBY PITOT HEAT FAIL
Indicates that the standby pitot heater has failed.

WING A/ICE LEAK
Indicates that a bleed leak has been detected in the wing anti-ice system.

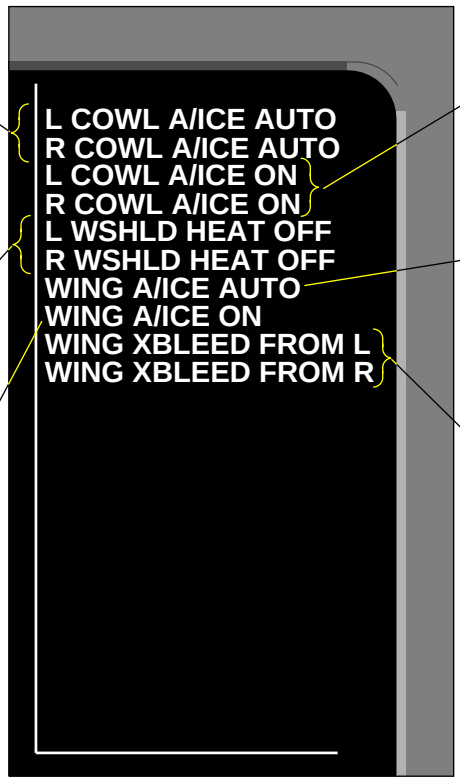
WING A/ICE LO HEAT
Indicates that there is insufficient heat in the wing leading edge duct.

GF1410_029a

ICE AND RAIN EICAS MESSAGES (CONT'D)



ICE AND RAIN EICAS MESSAGES (CONT'D)



L−R COWL A/ICE AUTO
Indicates that the respective cowl anti-ice has been selected to AUTO.

L−R COWL A/ICE ON
Indicates that the respective cowl anti-ice has been selected ON.

WING A/ICE AUTO
Indicates that wing anti-ice has been selected to AUTO.

L−R WSHLD HEAT OFF
Indicates that the respective temperature controller selector is selected to OFF/RESET.

WING XBLEED FROM L − R
Indicates that wing anti-ice is being supplied from the selected side.

WING A/ICE ON
Indicates that wing anti-ice has been selected ON.

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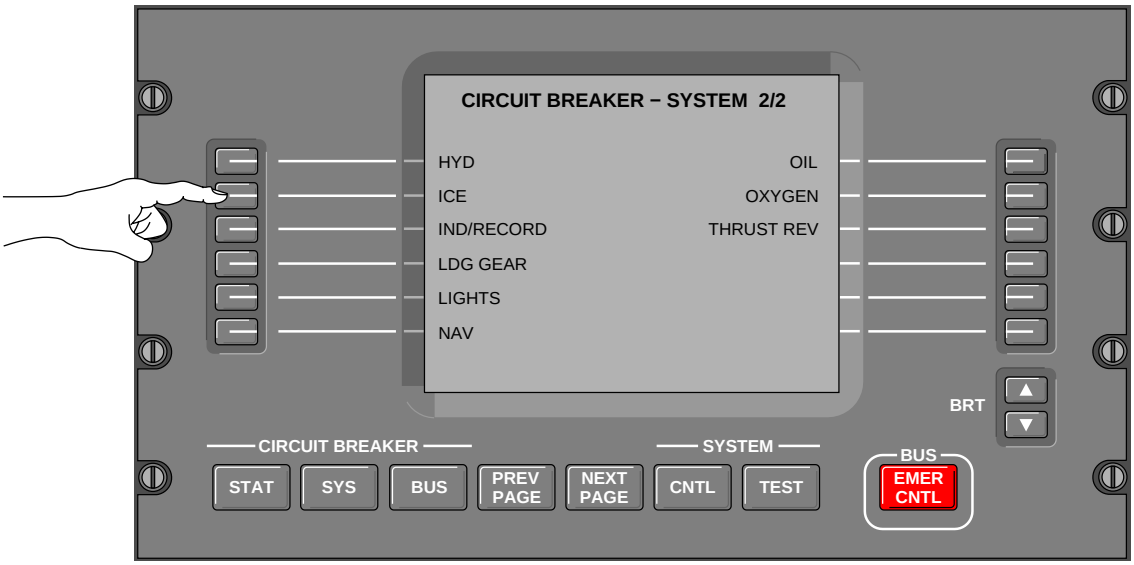
CB - ICE SYSTEM



CB – ICE SYSTEM 1/5

HBMU 1	BATT		IN
HBMU 2	DC ESS		IN
L AOA HEAT	AC ESS	CCBP	IN
L COWL A/ICE VLV	BATT		IN
L ICE DETECTOR	AC ESS	CCBP	IN
L WINDOW HEAT	AC ESS	CCBP	IN

CB – ICE SYSTEM 2/5

L WINDOW HEAT CTL	DC ESS		IN
L WIING A/ICE CTL	DC ESS		IN
L WISHLD HEAT 1	AC 1	CCBP	IN
L WSHLD HEAT 2	AC 1	CCBP	IN
PITOT 1 HT A	AC 1	CCBP	IN
PITOT 1 HT B	AC ESS	CCBP	IN

CB – ICE SYSTEM 3/5

PITOT 2 HT	AC 2	CCBP	IN
PITOT 3 HT	AC ESS	CCBP	IN
R AOA HEAT A	AC 1	CCBP	IN
R AOA HEAT B	AC ESS	CCBP	IN
R COWL A/ICE VLV	BATT		IN
R ICE DETECTOR	AC 1	CCBP	IN

CB – ICE SYSTEM 4/5

R WINDOW HEAT	AC 2	CCBP	IN
R WINDOW HEAT CTL	DC 1		IN
R WING A/ICE CTL	DC ESS		IN
R WSHLD HEAT 1	AC 3	CCBP	IN
R WSHLD HEAT 2	AC 3	CCBP	IN
STBY PITOT HT	AC ESS	CCBP	IN

CB – ICE SYSTEM 5/5

TAT HT 1	AC ESS	CCBP	IN
TAT HT 2	AC ESS	CCBP	IN
TAT HT 3	AC 3	CCBP	IN
WAI XBLEED CTL	DC ESS		IN
WAI XBLEED VLV	DC ESS		IN

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