CHAPTER 15 – ICE AND RAIN PROTECTION SYSTEM

LIST OF ILLUSTRATIONS

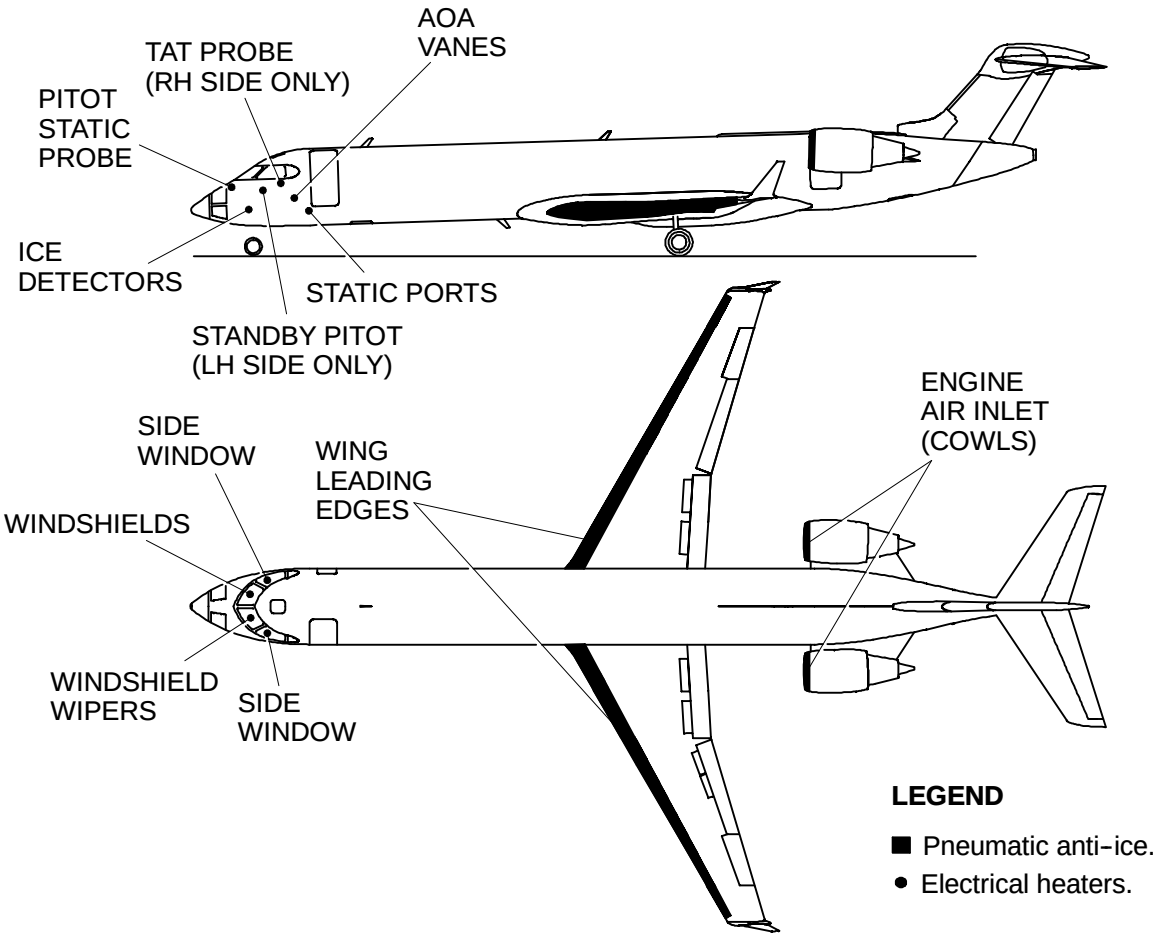
1. INTRODUCTION

Ice and rain protection is provided for the wing leading edges, engine intake cowl, windshields, side windows and the air data probes and sensors. An ice detection system alerts the flight crew of impending icing conditions.

Hot bleed air from the engine compressors is used to anti-ice the wing leading edges and engine intake cowl. Electrical power is used to anti-ice the windshields, side windows, air data probes and sensors. Electrical windshield wipers provide rain removal for the pilot and copilot's windshields.

A bleed air leak detection system monitors the bleed air ducting for leaks and overtemperature (refer to Chapter 19).

Ice and rain protection system warnings and cautions are displayed on the EICAS primary page. Status and advisory messages are displayed on the EICAS status page. A general view of the pneumatic anti-icing system is presented as a diagram on the EICAS A-ICE synoptic page.

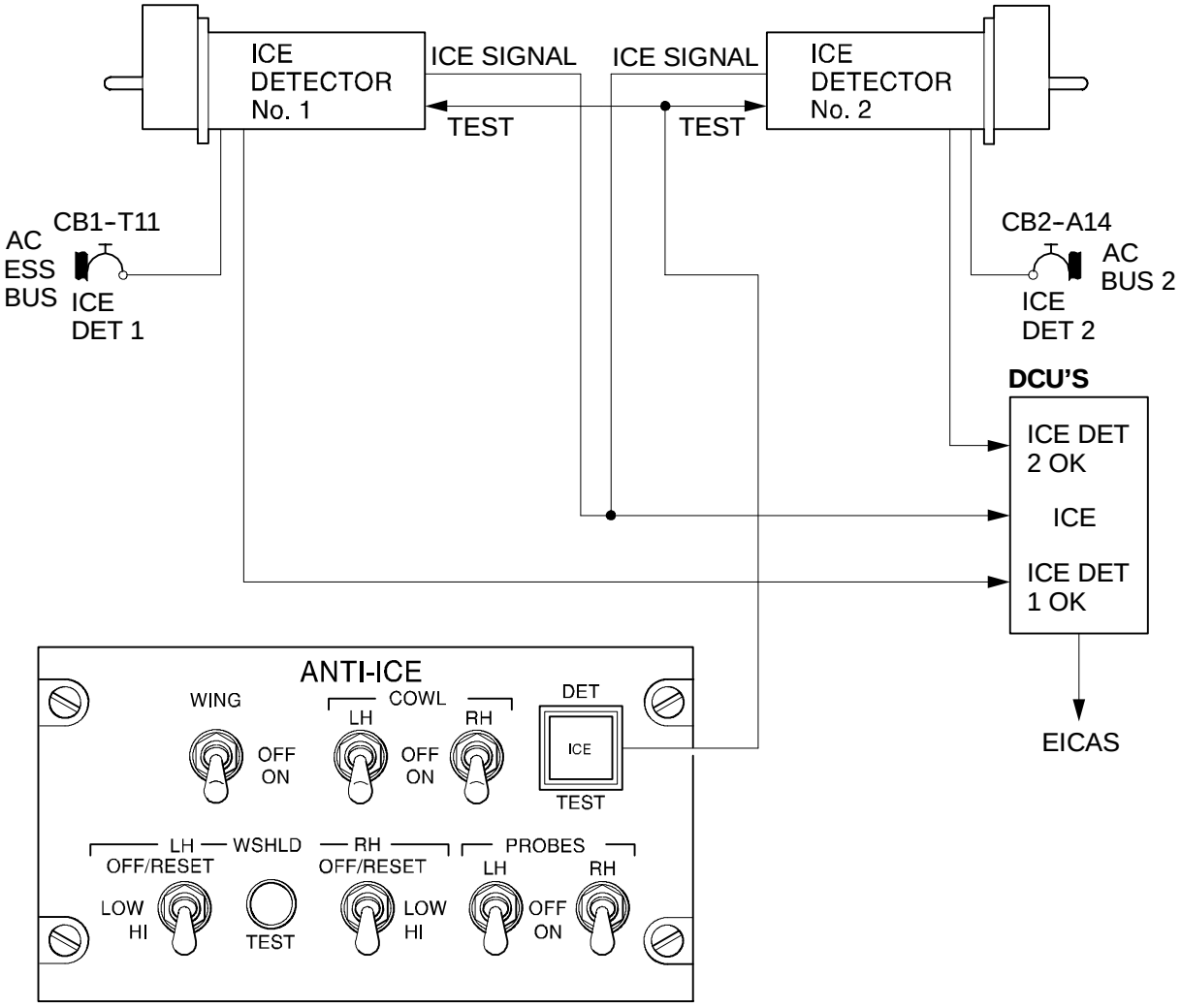


Anti–iced Areas
Figure 15–10–1

1. ICE DETECTION SYSTEM

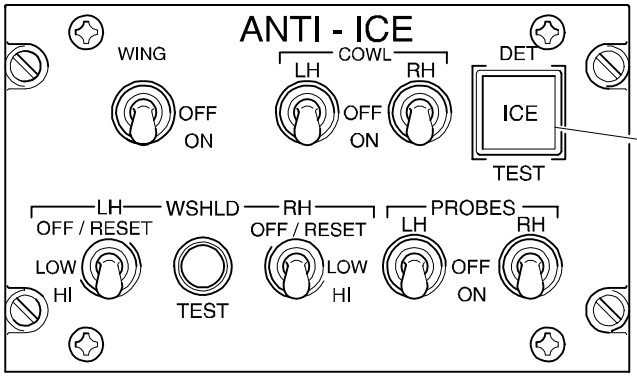
The aircraft is equipped with an ice detection system that alerts the flight crew of impending icing condition. The ice detection system consists of two independent ice detector assemblies located on each side of the forward fuselage. Each detector assembly includes a detector unit and a probe that extends into the airstream. The ice detection system is operational whenever AC power is available on the aircraft.

The ice detectors interface with the data concentrator units (DCU) to provide visual indications of icing conditions. When the probes detect an ice build up, a signal is sent by the unit to the EICAS and at the same time electrical power is used to de-ice the probe. When the probe is de-iced, it is then ready to detect ice formation again.



Anti-Ice Control Panel
Overhead Panel

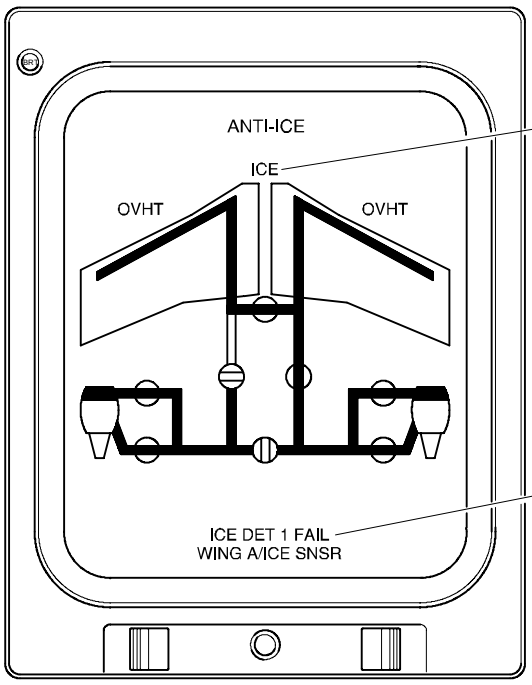
Ice Detection System – Schematic
Figure 15–20–1



Anti-Ice Panel
Overhead Panel

DET / TEST
Used to test the ice detection and air data sensor heating systems. When pressed and held for five seconds; the master caution light flashes, the ICE caution message is displayed on EICAS primary page, the ADS HEAT TEST OK advisory message is displayed on EICAS status page, and the ICE light illuminates on the anti-ice panel.

- ICE (amber) light comes on to indicate that an icing condition has been detected and the wing and/ or cowl anti-ice systems are not selected on.



Anti-Ice Page

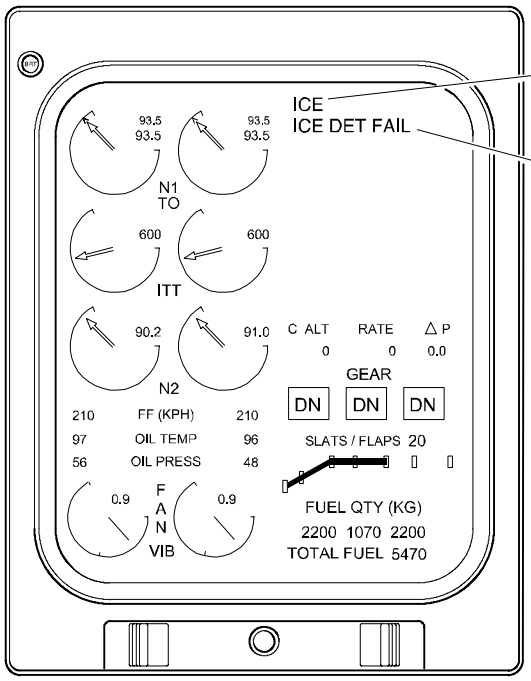
ICE, ICE 1 or ICE 2 (amber)
Indicates that an icing condition has been detected by the respective detector(s) and wing or cowl anti-ice system is selected off or has failed.

ICE, ICE 1 or ICE 2 (green)
Indicates that an icing condition has been detected by the respective detector(s) with wing and cowl anti-ice selected on and operating normally.

ICE DET 1 or 2 FAIL (white)
Indicates that respective ice detector has failed.

ICE DET FAIL (amber)
Indicates that both ice detectors have failed.

Ice Detection System
Figure 15-20-2



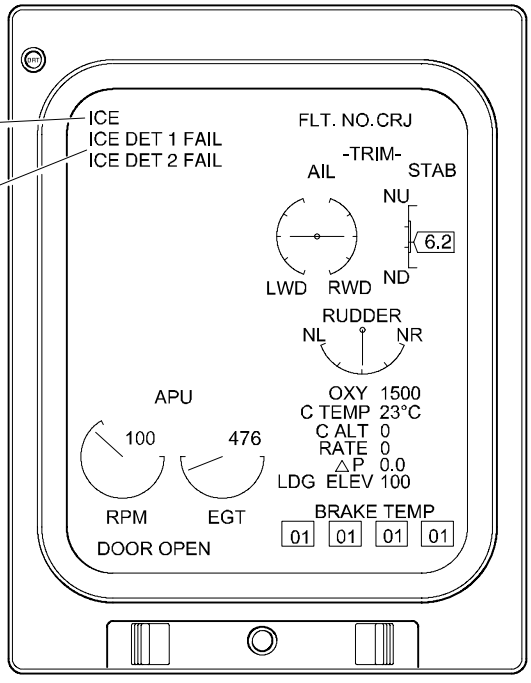
ICE caution (amber)
Indicates that an icing condition is detected and wing or cowl anti-ice system is selected off or has failed.

ICE DET FAIL caution (amber)
Indicates both ice detector systems have failed.

Primary Page

ICE advisory (green)
Indicates that an icing condition is detected with wing and cowl anti-ice selected on and operating normally.

ICE DET 1 or 2 FAIL status (white)
Indicates that respective ice detector system has failed and other system is operating normally.



Status Page

Anti-Ice System EICAS Indications <1001>
Figure 15-20-3

A. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Ice Detection System	Ice Detectors	ICE DET 1	AC ESSENTIAL	1	T11	
		ICE DET 2	AC BUS 2	2	A14	

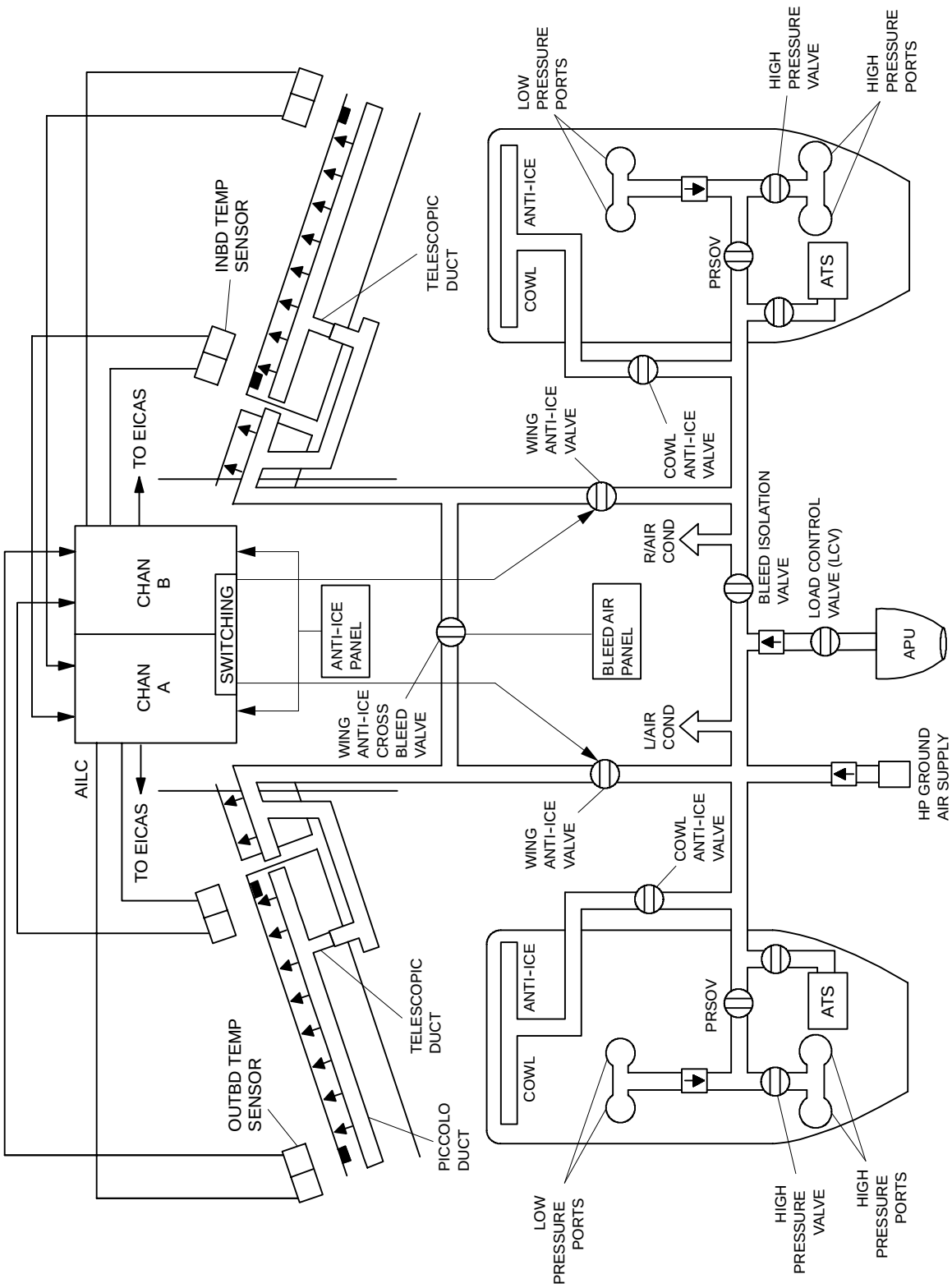
THIS PAGE INTENTIONALLY LEFT BLANK

1. WING ANTI-ICE SYSTEM

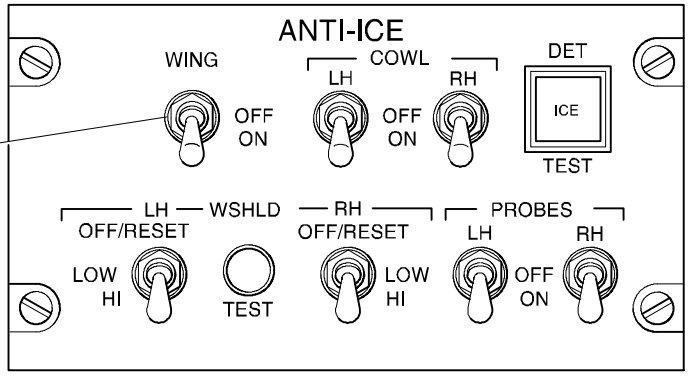
The wing anti-ice system prevents ice formation on the wing leading edge by heating the surface using hot engine bleed air. The hot bleed air is supplied through insulated ducting and released through piccolo tubes to the inner surface of the wing and slat leading edges.

The wing anti-ice system is divided into identical left and right systems. In normal operation, each engine supplies bleed air to its respective wing anti-ice system. The systems are connected by a, normally closed, wing anti-ice cross bleed valve. In the event one system fails, the cross bleed valve is opened to permits cross bleed between systems. This ensures that wing anti-icing is maintained to both systems.

The system is manually activated and is automatically controlled by a dual channel digital anti-ice and leak detection controller (AILC). The AILC controls the wing anti-ice system using electrical inputs received from skin temperature sensors located at each wing leading edge. The AILC modulates the respective wing anti-ice valve open or closed as necessary to prevent ice formation. Each of the two channels of the AILC has the capability to control both left and right anti-ice valves.

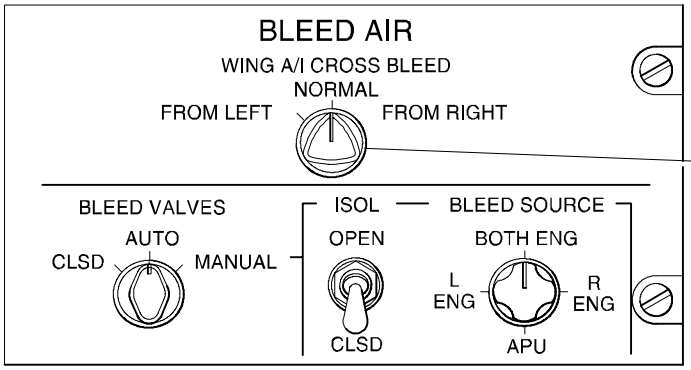


Wing Anti−Ice System Schematic
Figure 15−30−1



WING
Used to control wing anti-ice systems.

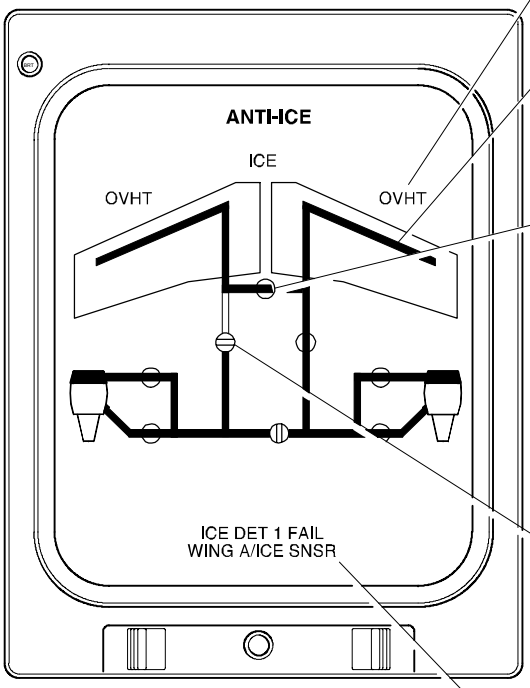
Anti-Ice Panel
Overhead Panel



WING A/I CROSS BLEED
Used to control wing cross bleed valve.
- FROM LEFT - Wing cross bleed valve open and right wing anti-ice valve closed.
- NORMAL - Wing cross bleed valve closed.
- FROM RIGHT - Wing cross bleed valve open and left wing anti-ice valve closed.

Bleed Air Panel
Overhead Panel

Wing Anti-Ice Controls
Figure 15-30-2



Anti-Ice Page

OVHT (red)
Indicates that an overheat condition has been detected in the respective anti-ice system.

Wing Anti-Ice Flow Lines
- Green - System is selected on and is operating normally.
- Amber - Valve failed closed or low temperature detected when anti-ice is selected on
- Red - Bleed leak or overheat condition detected.

Wing Cross-Bleed Valve
Position Indicator

open (white)
closed (white)
failed to attain commanded position (half-intensity magenta)

NOTE

In case of an AILC Channel B failure, as indicated by a WING A/I FAULT status (white) message, the wing cross-bleed valve open position on the A/ICE synoptic page will not be available.

Wing Anti-Ice Valve
Position Indicator

open (white)
failed open (amber)
closed (white)
failed closed (amber)
valve not in selected position (half-intensity magenta)

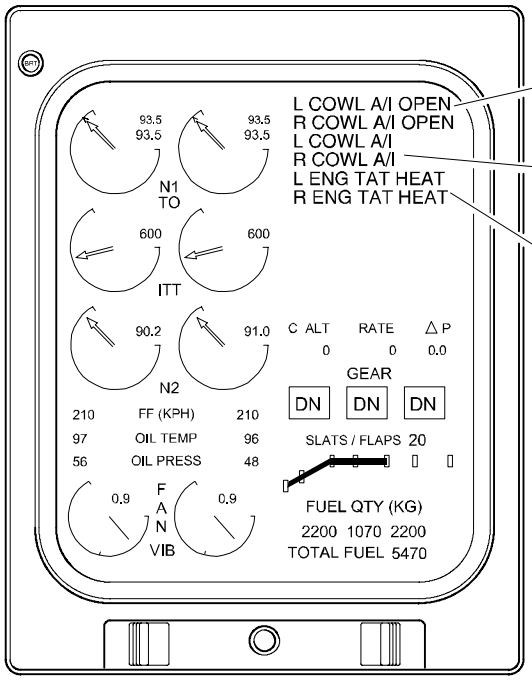
PENDING RECTIFICATION

NOTE

During Wing A/I Cross Bleed operations, both wings flow lines can be displayed amber with a L or R WING A/I caution message.

WING A/ICE SNSR (amber)
Indicates failure of both channels of left or right outboard wing temperature sensors with wing anti-ice selected on.

Anti–Ice Synoptic Page
Figure 15–30–3



L or R COWL A/I OPEN caution (amber)
Indicates that respective cowl anti-ice valve failed to close when selected off.

L or R COWL A/I caution (amber)
Indicates that the respective cowl anti-icevalve failed to open when selected on or valve position can not be determined.

L or R ENG TAT HEAT caution (amber)
Indicates that the respective T2 heater has failed.

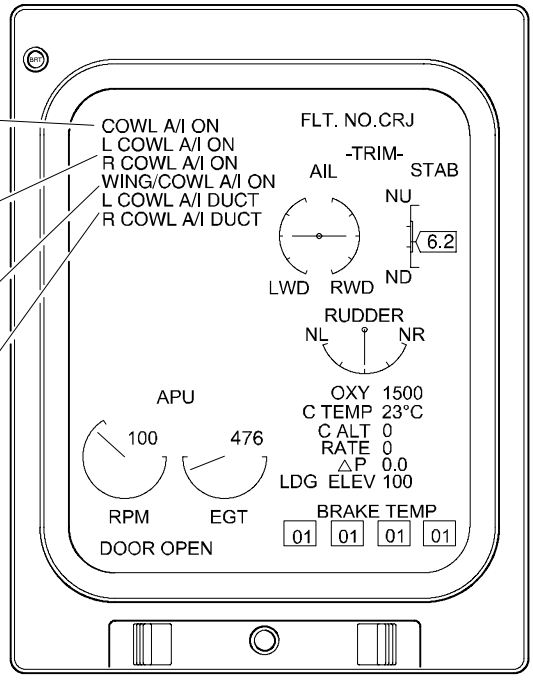
Primary Page

COWL A/I ON advisory (green)
Indicates that both left and right cowl anti-ice valves are open when selected on.

L or R COWL A/I ON advisory (green)
Indicates only the left or the right cowl anti-ice valve is open when both are selected on.

WING/COWL A/I ON advisory (green)
Indicates that both wing and cowl anti-ice systems are on and operating normally.

L or R COWL A/I DUCT status (white)
Indicates that respective cowl duct pressure is less than 3.12 psig or greater than 53.1 psig with battery bus powered.



Status Page

Wing Anti-Ice System EICAS Indications <1001>
Figure 15-30-4

A. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Wing Anti-Ice	Isolation Valve	WING A/ICE ISOL	BATTERY BUS	2	N5	
	Controller	A/ICE CONT CH A	DC BUS 1	1	D7	
		A/ICE CONT CH B	DC ESSENTIAL	2	T1	

1. ENGINE COWL ANTI-ICE SYSTEM

The engine cowl anti-ice system is used to prevent ice formation on the engine intake leading edges. This is done by using hot engine bleed air to heat the leading edge surface. The hot bleed air is supplied to the intake leading edges through respective L/R cowl anti-ice shutoff valves. Bleed air is distributed through insulated ducting and an air mixing tube before entering a double walled duct in the engine cowl leading edge. The inner portion of the duct carries the bleed air. In the event of a rupture of the inner wall, a bleed leak detector transducer mounted in the outer wall supplies a bleed leak signal to the EICAS to illuminate the L/R COWL A/I DUCT warning message.

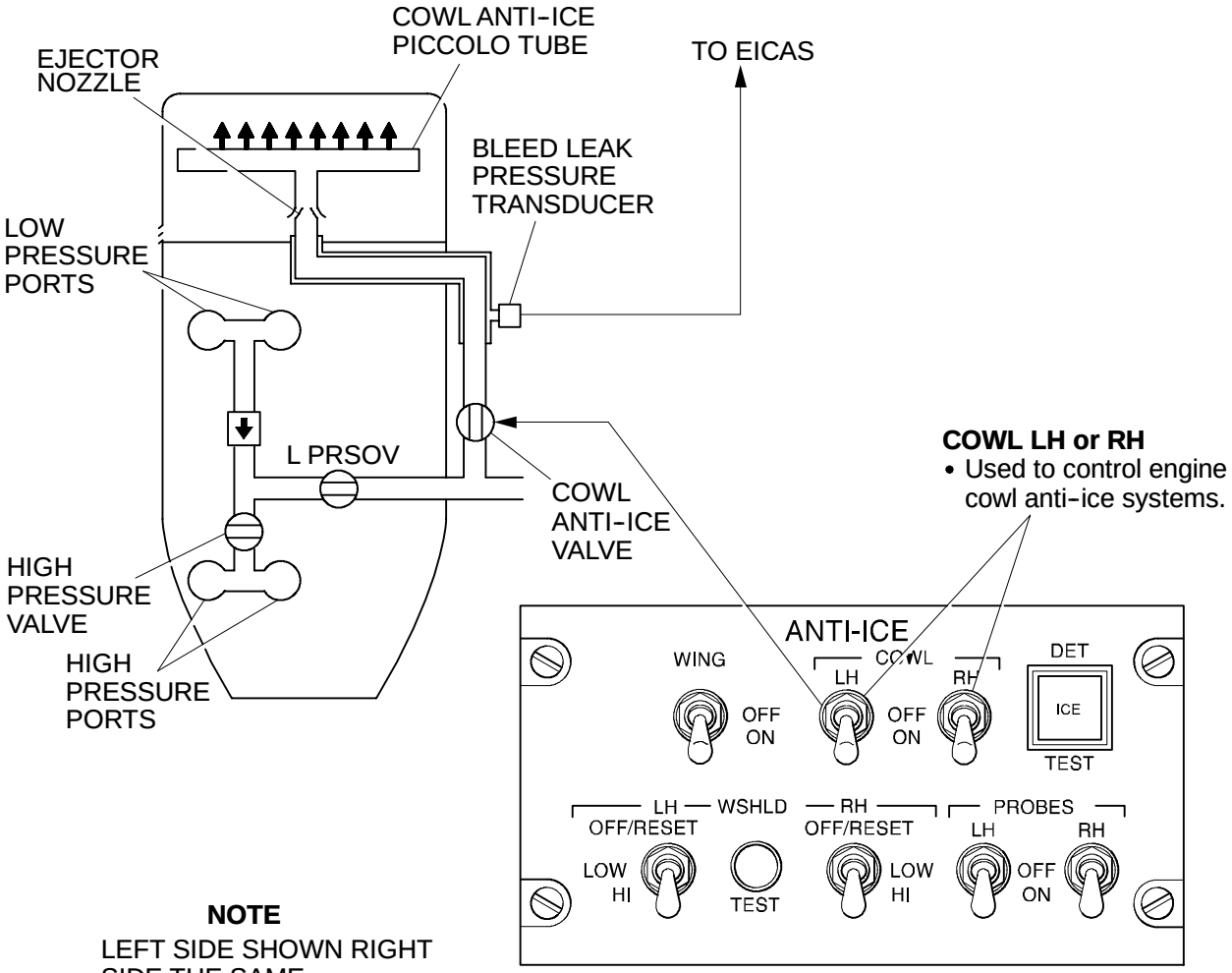
The left and right cowl anti-ice shutoff valves are manually controlled by respective LH and RH COWL switches on the ANTI-ICE control panel. Crew activation of each system, opens the respective engine cowl anti-ice shutoff valve. The shutoff valves are electrically controlled and pneumatically operated. Valve status is displayed on the EICAS, ANTI-ICE synoptic page.

2. T2 SENSOR PROBE ANTI-ICING

A fan inlet temperature sensing probe (T_2), mounted on the engine cowling, is used to provide temperature data to the FADEC. The FADEC uses the information as one of the sensing parameters to set engine power and to control the compressor variable geometry stator vanes. The probe also contains a built-in heating element that is used to anti-ice the probe. Electrical heating power to the probe heating element is controlled by the FADEC.

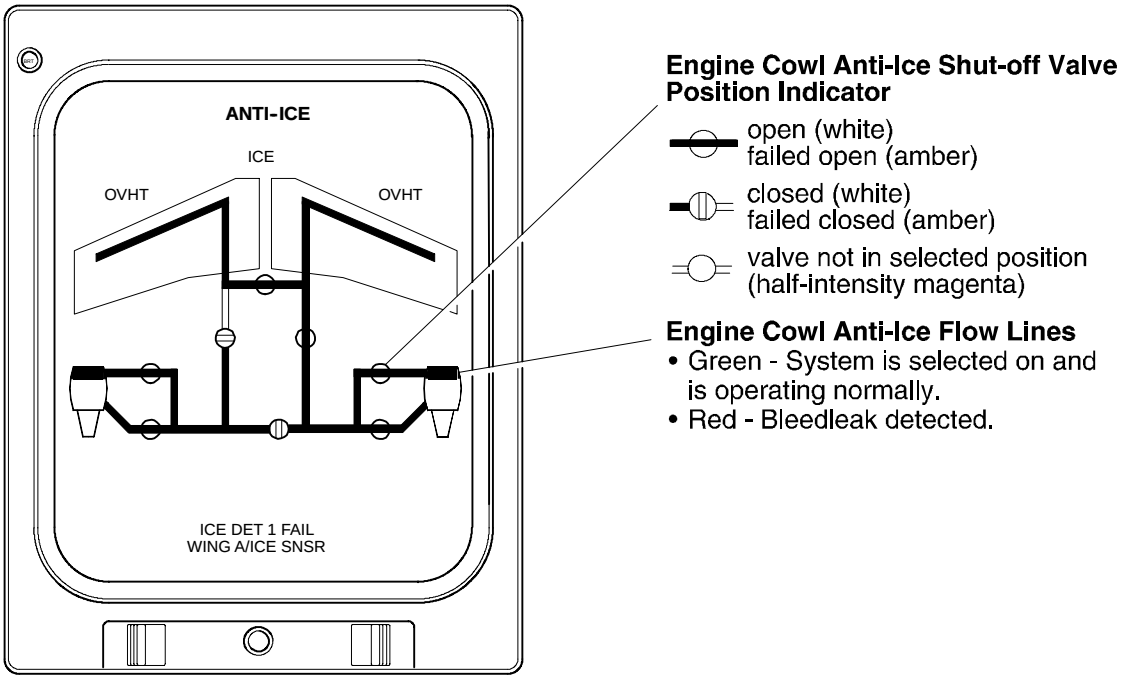
Testing of the T_2 heater function is done automatically by the FADEC, which initiates a system check after engine shutdown on the ground. Following right engine shutdown, electrical power must be maintained on the aircraft for at least one minute to make sure that the FADEC has sufficient time to successfully complete the test. The FADEC verifies T_2 heater function by energizing the heater and looking for an appropriate temperature rise during a 30 second period.

Following a successful test, the next test will be initiated after the next ground engine shutdown. If the FADEC (through channel A) cannot energize the T_2 heater, the FADEC will automatically switch to channel B to conduct the test (after a 30 second time delay). If the T_2 heater test fails on both channels, the respective L/R ENG TAT HEAT caution message will be displayed on the EICAS primary page and the FADEC will not attempt to energize the T_2 heater.



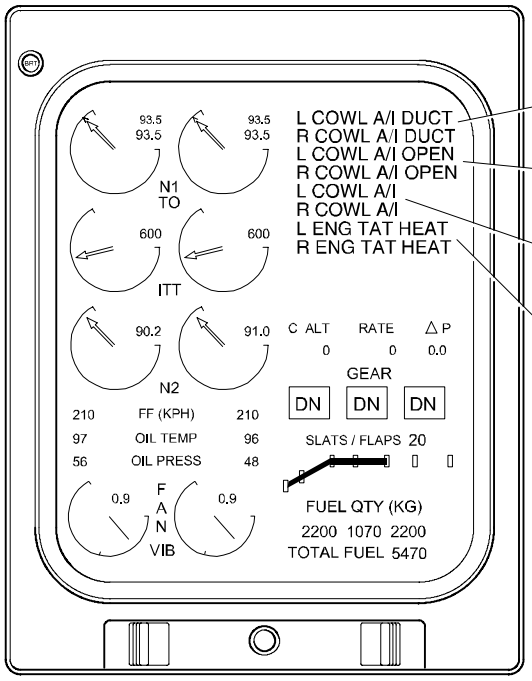
Anti-Ice Control Panel
Overhead Panel

Engine Cowl Anti-Ice System – General
Figure 15-40-1



Anti-Ice Page

Anti–Ice Synoptic Page
Figure 15–40–2



Primary Page

L or R COWL A/I DUCT warning (red)
Indicates that a bleed leak is detected by the leak pressure transducer in the cowl anti-ice duct.

L or R COWL A/I OPEN caution (amber)
Indicates that respective cowl anti-ice valve failed to close when selected off.

L or R COWL A/I caution (amber)
Indicates that the respective cowl anti-ice valve failed to open when selected on or valve position can not be determined.

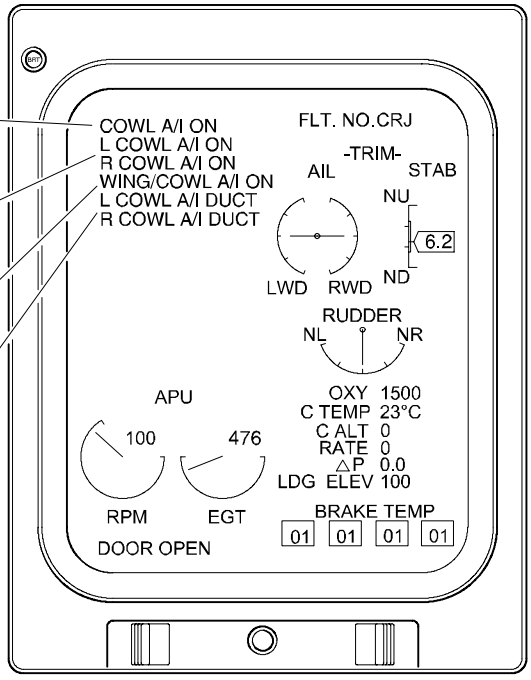
L or R ENG TAT HEAT caution (amber)
Indicates that the respective T2 heater has failed.

COWL A/I ON advisory (green)
Indicates that both left and right cowl anti-ice valves are open when selected on.

L or R COWL A/I ON advisory (green)
Indicates that the left or the right cowl anti-ice valve is open.

WING/COWL A/I ON advisory (green)
Indicates that both wing and cowl anti-ice systems are on and operating normally.

L or R COWL A/I DUCT status (white)
Indicates that respective cowl duct pressure is less than 3.12 psig or greater than 53.1 psig with battery bus powered.



Status Page

Engine Cowl – Anti–Ice EICAS Indications <1001>
Figure 15–40–3

A. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Engine Cowl Anti-Ice	Anti-Ice Valves	A/ICE VALVE L ENG	BATTERY BUS	2	N3	
		A/ICE VALVE R ENG			N4	
	T2 Heaters	T2 HEATER L	DC BUS 1	1	F4	
		T2 HEATER R	DC BUS 2	2	F4	

THIS PAGE INTENTIONALLY LEFT BLANK

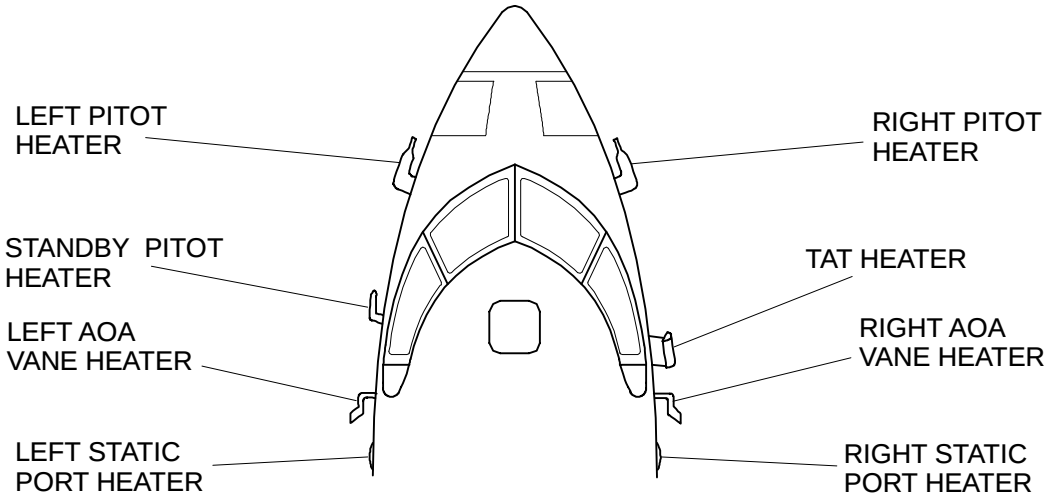
1. AIR DATA ANTI-ICE SYSTEM

Air data probes and sensors are located on the left and right sides of the forward fuselage and extend into the airstream. The air data sensor (ADS) anti-ice system consists of integral, self regulating, heating elements for the air data sensors and probes. The ADS heaters prevent ice formation that may cause erroneous air data information. ADS anti-icing is achieved by electronically controlling the heating elements. The air data sensor heating system is activated automatically on the ground and in flight.

The ground mode has two operational heating modes, automatic and manual. In automatic mode, when either engine generator is on and the LH and RH PROBES switches, (on the ANTI-ICE control panel) are OFF, the LH and RH pitot probes and the standby pitot probe are heated at half power (automatic mode is not functional when the aircraft is being powered by the APU generator or external power). The static ports and the AOA vanes are not powered automatically in the ground mode. For manual mode, the static ports and the AOA vanes can be heated by selecting the LH and RH PROBES switches to ON.

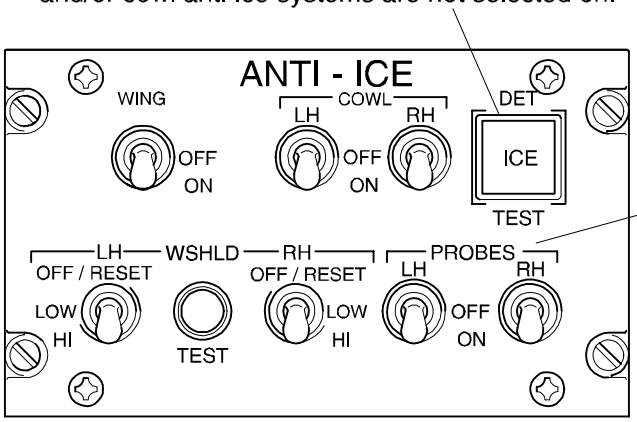
In the flight mode, the automatic control function is completely independent of the control switches. The controllers automatically supply full power to all the air data probes and sensors. The LH and RH PROBES switches have no effect on the function of the controllers.

The air data probes and sensors are monitored and controlled by three independent and identical controllers. Controller 1 monitors the heater elements for the left pitot, left angle of attack (AOA) vane and left static port. Controller 2 monitors the right pitot, right AOA vane and right static port. Controller 3 monitors the standby pitot and total air temperature (TAT) probe.



DET / TEST
Used to test the ice detection and air data sensor heating systems. When pressed and held for five seconds, the master caution light flashes, the ICE caution message is displayed on EICAS primary page, the ADS HEAT TEST OK advisory message is displayed on EICAS status page, and the ICE light illuminates on the anti-ice panel.

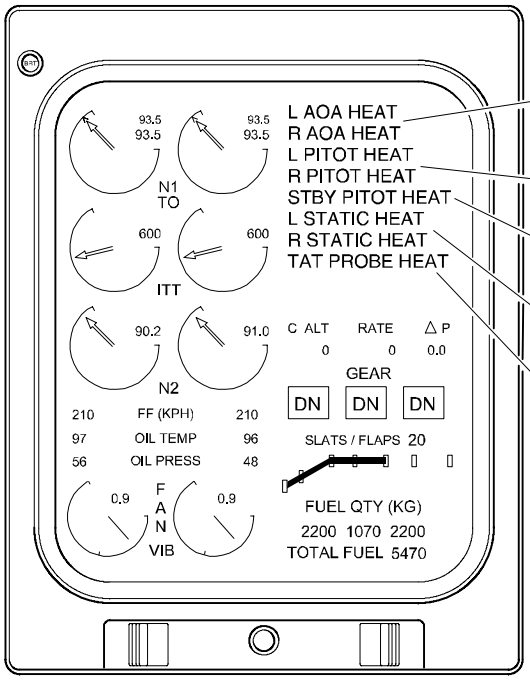
- ICE (amber) light comes on to indicate that an icing condition has been detected and the wing and/or cowl anti-ice systems are not selected on.



PROBES LH and RH
Used to manually activate the air data sensor anti-ice systems. During normal flight operations, all heaters are automatically controlled, regardless of switch position.

Anti-Ice Control Panel
Overhead Panel

Air Data Sensor Anti-Ice System
Figure 15-50-1



Primary Page

L or R AOA HEAT caution (amber)
Indicates that respective angle of attack heater is off or has failed.

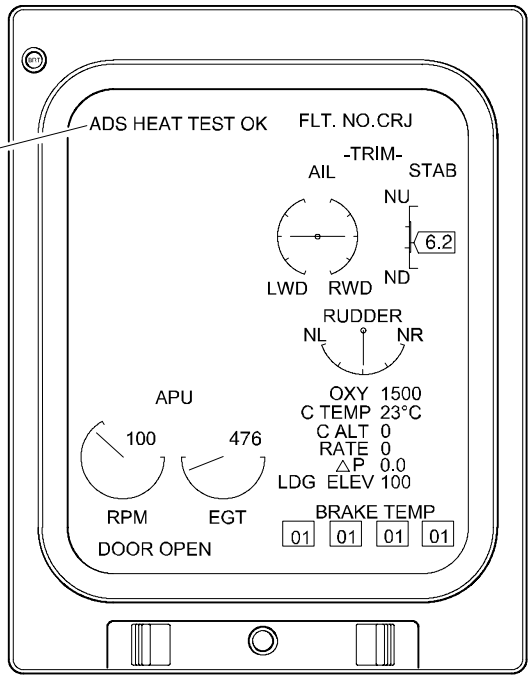
L or R PITOT HEAT caution (amber)
Indicates that respective pitot tip heater is off or has failed. Also indicates that respective pitot base heater is off or has failed in flight.

STBY PITOT HEAT caution (amber)
Indicates that standby pitot heater is off or has failed.

L or R STATIC HEAT caution (amber)
Indicates that respective static port heater is off or has failed.

TAT PROBE HEAT caution (amber)
Indicates that total air temperature probe heater has failed with AC bus 1 powered.

ADS HEAT TEST OK advisory (green)
Indicates that the air data sensor anti-ice system was tested successfully.



Status Page

Air Data Sensor Anti–Ice EICAS Indications <1001>
Figure 15–50–2

A. System Circuit Breakers

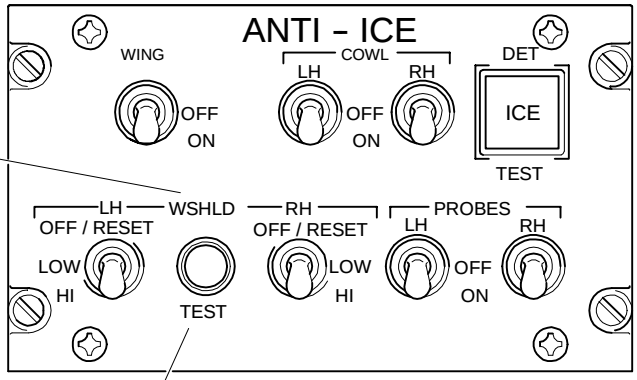
SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Air Data Sensor Anti-Ice	TAT Heater	HEATERS TAT	AC BUS 1	1	A12	
	Pitot Heaters	HEATERS PITOT R			A14	
		HEATERS PITOT L	AC ESSENTIAL		T7	
		HEATERS PITOT STBY			T9	
	AOA Heaters	HEATERS AOA L			T8	
		HEATERS AOA R	AC BUS 1		A13	
	Static Heaters	HEATERS STATIC R	DC BUS 1		G14	
		HEATERS STATIC L	DC ESSENTIAL	2	S1	
	Controllers	HEATERS ADS CONT 1			S2	
		HEATERS ADS CONT STBY			S3	
		HEATERS ADS CONT 2	DC BUS 1	1	G13	

1. WINDSHIELD AND SIDE WINDOW ANTI–ICE SYSTEM

Windshield and side window anti-icing is achieved by electrically heating the windshield and side windows. Each windshield and side window incorporates an electrical heating element and three temperature sensors. One sensor is used for normal temperature control and another is used for overheat detection. The third sensor is a spare, and is used should one of the other sensors fail.

The amount of heat supplied to the windshields and side windows is controlled by four identical temperature controllers, one for each window. The controllers automatically regulate power to the heating elements as selected by the LOW/HI WSHLD switches on the ANTI–ICE control panel. When an overheat condition is detected, the associated controller removes the power to the heater element and posts a caution message on the EICAS primary page.

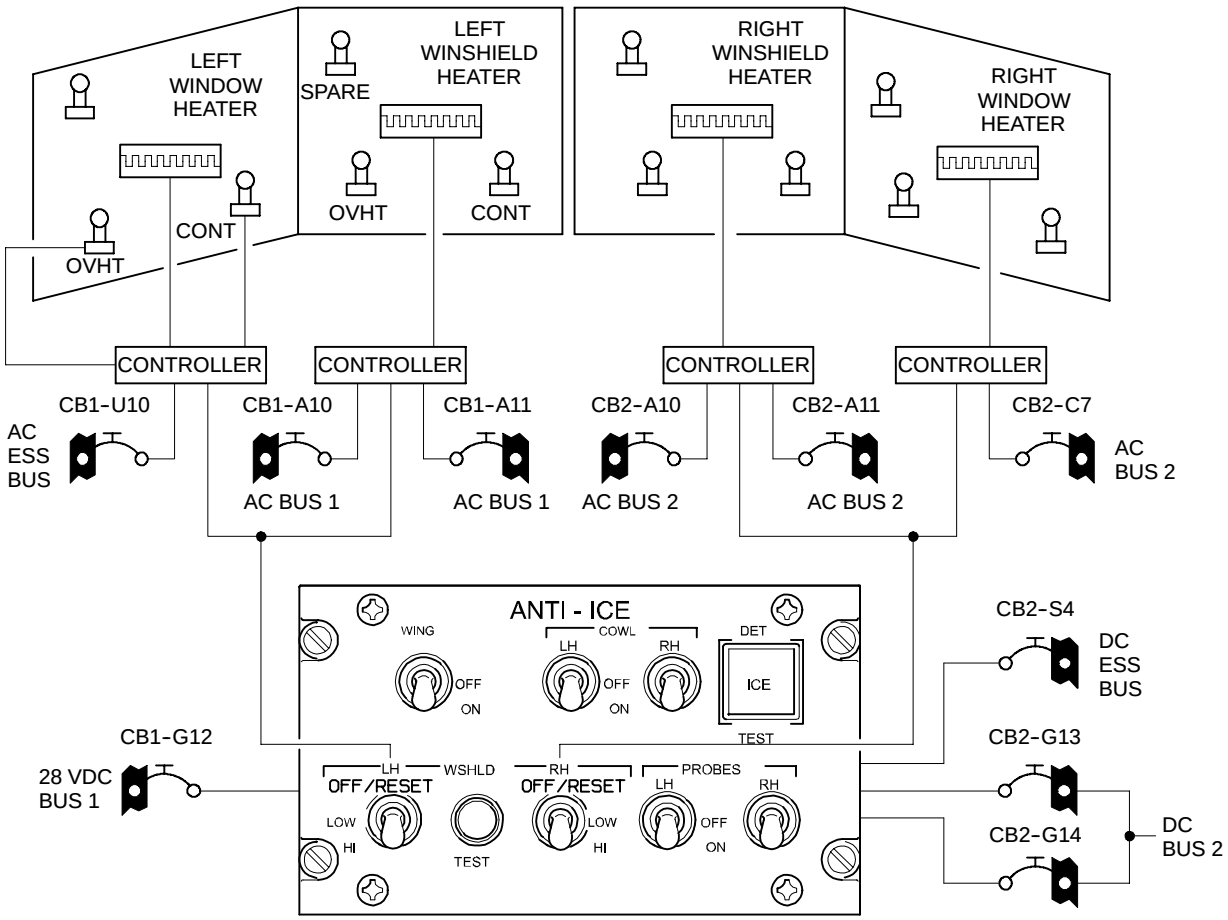
WSHLD LH and RH
Used to control windshield and side window anti-ice systems.
- LOW - Used for de-misting and de-fogging of the windshield and side window.
- HI - Used for de-icing of the windshield only. The side window remains at the low setting.
- OFF/RESET - Removes power and resets the controllers.



Anti–Ice Control Panel
Overhead Panel

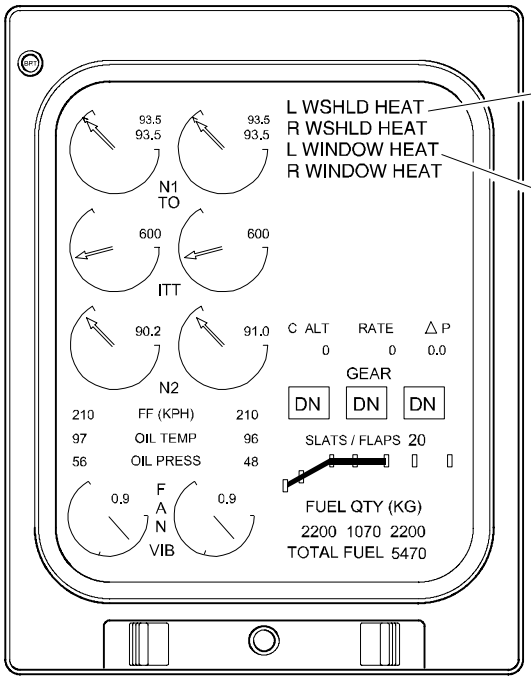
TEST
Used to test the windshield and side window anti–ice system.
Caution messages appear during test.

Windshield and Side Window Anti–Ice Controls
Figure 15–60–1



Anti-Ice Panel
Overhead Panel

Windshield Temperature Control
Figure 15–60–2



L or R WSHLD HEAT caution (amber)
Indicates an overheat or a no heat condition at the respective windshield heater.

L or R WINDOW HEAT caution (amber)
Indicates an overheat or a no heat condition at the respective window heater.

Primary Page

Windshield and Side Window Anti–Ice EICAS Indications <1001>
Figure 15–60–3

A. System Circuit Breakers

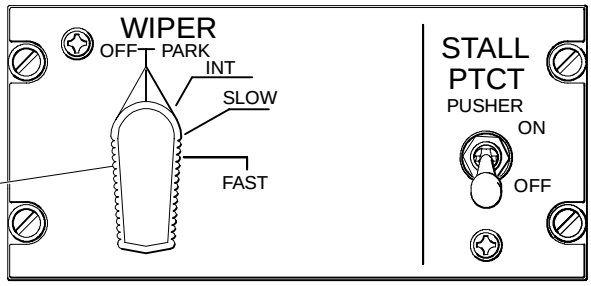
SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Windshield and Side Window Anti-Ice	Heaters	HEATERS L WSHLD	AC BUS 1	1	A10-A11	
		HEATER L WIND	AC ESSENTIAL		U10	
		HEATERS R WSHLD	AC BUS 2	2	A10-A11	
		HEATER R WIND			C7	
	Controllers	HEATERS CONT L WSHLD	DC BUS 1	1	G12	
		HEATERS CONT L WIND	DC ESSENTIAL	2	S4	
		HEATERS CONT R WSHLD	DC BUS 2		G13	
		HEATERS CONT R WIND			G14	

1. WINDSHIELD WIPER SYSTEM

The windshield wiper system is designed to remove rain and/or snow from the pilot and co-pilot's windshields at speeds up to 250 knots.

The windshield wiper system consists of independent pilot and copilot systems. Each system consists of a windshield wiper and motor with both systems being controlled by an electronic control unit. Each pilot has a selector, located on the WIPER control panel that actuates both wipers. Under normal operations, both wipers will operate in the same mode when selected from either panel. If each selector is set to a different mode, the last selection made overrides the previous selection. If one wiper system fails, the remaining system will still be functional.

WIPER
- OFF-PARK - Stows the wiper blades and stops the motors.
- INT - Wipers operate at one cycle every 5 seconds.
- SLOW - Wipers operate at 80 cycles per minute.
- FAST - Wipers operate at 125 cycles per minute.



WIPER CONTROL PANEL

Windshield Wiper Control Panel
Figure 15–70–1

A. System Circuit Breakers

SYSTEM	SUB-SYSTEM	CB NAME	BUS BAR	CB PANEL	CB LOCATION	NOTES
Windshield Wiper System	Wipers	WIPER PILOT	DC BUS 1	1	G5	
		WIPER C/PLT	DC BUS 2	2	G5	